FIT'NG
Fetal, Infant, & Toddler Neuroimaging Group

Program

Annual Conference

Fetal, Infant, & Toddler Neuroimaging Group Conference

September 7 & 8, 2025
The Dublin Royal Convention Centre
Dublin, Ireland

fitng.org

@FIT_NGIn
www.fitng.org
#fitng2025

Program At-A-Glance

Time	Sunday 7-Sep	Monday 8-Sep
8:30AM	Registration/Information Desk Open	Registration/Information Desk Open
8:45 AM	**Welcome & FIT'NG Society Updates**	**Symposium Session** Understanding sensory development with task functional neuroimaging in the perinatal period 8:30am - 10:00am
9:00 AM	**Methods: Acquisition and Processing** *Invited Speaker Gang Li* 8:45am - 10:15am	
9:15 AM		
9:30 AM		
9:45 AM		
10:00 AM	Break 10:15am - 10:45am	Break 10:00am - 10:30am
10:15 AM		
10:30 AM	**Symposium Session** Imaging Neurodevelopment at Unconventional Field Strengths: Revolutionising Insights into Early Human Brain Development 10:45am - 12:15pm	**Think Tank: Elephants in the Room** 10:30am - 12:00pm
10:45 AM		
11:00 AM		
11:15 AM		
11:30 AM		
11:45 AM		
12:00 PM	**Lunch Break** *Provided onsite* 12:15pm - 1:45pm **Lunch with Professors** *pre registered event*	**Lunch Break** *Provided onsite* 12:00pm - 1:30pm
12:15 PM		
12:30 PM		
12:45 PM		
1:00 PM		
1:15 PM		
1:30 PM		**Clinical Questions** *Invited Spaker: James Boardman* 1:30pm - 3:00pm
1:45 PM	**Keynote Presentation** *Margot Taylor* 1:45pm - 2:45pm	
2:00 PM		
2:15 PM		
2:30 PM		
2:45 PM	**Flash Talks** (2:45pm - 3:05pm)	**Flash Talks** (3:00pm - 3:20pm)
3:00 PM	**Poster Session #1 and coffee break** 3:05pm - 4:30pm	**Poster Session #2 and coffee break** 3:20pm - 4:45pm
3:15 PM		
3:30 PM		
3:45 PM		
4:00 PM		
4:15 PM		
4:30 PM	**Cogntitive Development** *Invited Speaker: Karla Holmboe* 4:30pm - 6:00pm	**Social, Emotional and Language Development** *Invited Speaker: Victoria Leong* 4:45pm - 6:15pm
4:45 PM		
5:00 PM		
5:15 PM		
5:30 PM		
5:40 PM		
5:45 PM		
6:00 PM		**Closing and Awards** (6:15pm - 6:30pm)
6:15 PM		
6:30 PM		
6:45 PM		
7:00 PM		
7:15 PM		
7:30 PM		
7:45 PM		
8:00 PM	**Trainee Committee Social Event** *Porterhouse Temple Bar* 8pm	
8:15 PM		
8:30 PM		
8:45 PM		
9:00 PM		

About FIT'NG

The Fetal, Infant, & Toddler Neuroimaging Group (FIT'NG) was founded in the Fall of 2018 by Drs. Marisa Spann (CUIMC), Dustin Scheinost (Yale), Alice Graham (OHSU), and Lilla Zöllei (MGH/HMS). It is composed of interdisciplinary scientists and clinicians who have an interest in elucidating neurodevelopmental processes, the role of the preconceptional, prenatal and postnatal influences on the developing brain, and linkages between early neural phenotypes and subsequent behaviors and health outcomes.

The network provides a forum for that supports this goal through bringing together scientists and clinicians across multiple disciplines (e.g. neuroscience, computer science, biomedical engineering, psychology, psychiatry, and public health), career stages, and geographic regions to encourage collaboration and innovation.

We have three core focus areas: methodological development, education/training advancement, and data sharing and integration. A primary objective spanning these areas is to encourage the establishment and dissemination of guidelines to support best practices for methods used to study the developing brain, including EEG, fNIRS, MRI, MEG, OCT, histology, DOT, ultrasound, and others. These methods are rapidly evolving and present unique challenges when applied to the study of fetal, infant and toddler brains.

FIT'NG Vision

Advancing understanding of early brain development represents an imperative for basic science and for improving capacity to support lifelong health and prevention neuropsychiatric disorders. As there are unique challenges associated with studying early brain development, we believe the FIT'NG network provides an optimal setting for interdisciplinary efforts to solidify the field and methods garnering a sound position in within the larger scientific and medical community.

Program Contents

Welcome!

Dear members of the FIT'NG community,

Welcome to the Annual Conference of The Fetal, Infant, and Toddler Neuroimaging Group (FIT'NG)! We are delighted to host you in the vibrant city of Dublin, Ireland, as we come together to share our science and passion for the science of early brain development.

We are incredibly proud of the remarkable progress we have made since our launch in 2018 toward fulfilling our mission: uniting an interdisciplinary community to advance the understanding of early brain development and behavior. Our inaugural meeting in Paris, France, in 2022 was a major milestone in the development of FIT'NG. The momentum continued with our 2023 and 2024 meetings in Santa Rosa and Baltimore, USA, which saw a significant increase in attendance and engagement. By 2025, ***our membership spans 27 countries***, with diverse representation across imaging modalities and scientific disciplines, reflecting the dynamic nature of our community.

In 2024, we ***expanded our Executive Board***, welcoming *Tomoki Arichi* and *Lindsay Bowman* to join our founders – *Marisa Spann*, *Dustin Scheinost*, *Lilla Zöllei*, and *Brittany Howell*. In 2025, we strengthened the board further with the election of *Rhodri Cusack*, *Courtney Filippi*, *Chad Sylvester*, and *Nadège Roche-Labarbe*.

We hosted successful workshops and FIT'NG Together events and have been truly inspired by your enthusiasm and support. We are ***especially proud of the pivotal role our trainees*** have played in driving these efforts and fostering connections across career stages and scientific disciplines. Their ongoing passion and engagement highlight just how vital this community is for those dedicated to advancing our understanding of early brain development. Each of you is essential to the success of the FIT'NG community, and we are deeply grateful for your continued involvement!

In just a few short years, FIT'NG has begun to reshape the landscape of our field, as reflected in a ***growing body of publications***. We were also proud to launch the first FIT'NG special issue in *Developmental Cognitive Neuroscience*, featuring ten original articles stemming from the 2023 conference. A second special issue, highlighting the 2024 meeting, is scheduled for publication this fall.

These collective accomplishments reflect the strength and shared vision of our society. ***FIT'NG exists because of you, our members and partners, and there is a role and opportunity for everyone in this community***: reach out to join a committee, contribute to a workshop, bring forward new ideas. We are excited to shape the future of FIT'NG together!

Once again, this year, our annual conference highlights the innovative work of our members as well as newcomers to the community, and of invited speakers James Boardman, Karla Holmboe, Victoria Leong, and Gang Li, who honor us by sharing their unique vision of Fetal, Infant, and Toddler Neuroimaging research.

We are honored and excited to have ***Professor Margot Taylor*** as our keynote speaker. She is the Director of Functional Neuroimaging, Diagnostic & Interventional Radiology and Senior Scientist at the Hospital for Sick Children in Toronto, Canada, and Professor in Medical Imaging and Psychology at the University of Toronto. Her research focuses on the neural bases of social-cognitive development using a variety of functional and structural neuroimaging techniques, from early childhood into adulthood, in typically developing, autistic and very preterm-born populations. After being at the forefront of cognitive science with highly impactful works with event-related potentials, her current focus is on pioneering the application of OPM-MEG to investigate emerging neural signatures of autism in young children.

We are proud to recognize this year's ***Young Investigator Award*** winners, listed later in this brochure. The Program Committee received 50 applications from outstanding early-career scientists, making the selection process highly competitive! 15 awards were granted. The recipients reflect the diversity of the FIT'NG community, representing a wide range of techniques, methodologies, fundamental and clinical research topics. Congratulations to all our awardees!

FIT'NG continues to thrive in a supportive and collaborative environment thanks to the vital support of our institutions, partners and sponsors.

To our institutional partners ***Columbia University***, ***Trinity College Dublin*** and ***Trinity College Institute of Neuroscience***, and ***Yale School of Medicine***: thank you for your belief in our mission and for providing the foundational support that moves our vision forward. To our new and returning sponsors ***BrainProducts, Magstim EGI***, ***MindWare Technologies***, ***NIRx***, and ***OptoAcoustics***: we are deeply grateful for your contributions, which help make this year's annual meeting possible. Your support brings together researchers committed to advancing early brain science and truly supports a better future for human health and development. We are proud of how far we have come and even more excited about what lies ahead. Thank you for being with us.

For this society to flourish, ongoing and continued support of our scientific mission is essential. The ***National Institutes of Health*** (*Eunice Kennedy Shriver National Institute of Child Health and Human Development and National Institute of Drug Abuse; R13 HD108938*) and ***Burroughs Wellcome Fund*** provide multi-year grant support for the conference.

Finally, we are deeply grateful to ***Podium Conferences***. From the start, they believed in our mission and have been equipping us with the skills to grow into a sustainable society. Their guidance and expertise have been invaluable. Special thanks to ***Marischal De Armond***, president and founder, for providing ongoing resources, and to ***Tori Lunden*** for her patience, support, and superb organization in preparing this year's meeting.

We would like to extend our warmest thanks to all the members of our committees, who throughout the year give their time to support and develop the society, offer training resources and scientific events that bring us together, and animate our community. Please feel free to contact them at any time to thank them… or to join them!

Our **Program Committee** co-chairs, Lindsey Powell and Nadège Roche-Labarbe. Lindsey and Nadège worked with the scientific program committee of Kiho Im, Rebecca Schwarzlose and Sobanawartiny Wijeakumar, as well as Emily Chen and Paige Nelson (Trainee committee liaisons), Tomoki Arichi and Rhodri Cusack (Board liaisons), and the amazing Tori Lunden, our conference manager at Podium. Together, they designed a program spanning methodologies, age ranges, and scope. The content aims to showcase the outstanding work being conducted across the FIT'NG community, and reflects the breadth of our field. We are also deeply grateful to our ***dedicated abstract reviewers***, acknowledged later in this brochure, who ensured that each submission received three thorough reviews, guiding the committee's selection of the highest-quality oral presentations.

We are so proud of our exceptional **Trainee Committee** chaired by Áine Travers Dineen and co-chaired by Shelby Leverett, with active members Olivia Allison, Emily M. Chen, Istvan N. Huszar, Marta Korom, Emma Margolis, Paige Nelson, Huili Sun and Tristan Yates, and Board liaisons Lindsay Bowman, Dustin Scheinost and Chad Sylvester. This year, they expanded the success of FIT'NG Together, a publicly available and free virtual programming series for FIT researchers, by continuing to host events highlighting research and methods at the forefront of advances of FIT neuroimaging. The committee continued the 'Practicals Series' which showcases software specialized for neuroimaging with FIT populations, the 'Modality Introductions Series', and author-led Journal Clubs. In total, the committee hosted 8 FIT'NG Together events, reaching over 600 registrants across 45 countries. Their efforts have been invaluable for building our community and working towards our goal of creating shared resources and best practices for FIT'NG research. The Trainee Committee also contributed to society publications, last year's 'Elephants in the Room' Think Tank conference discussions organized by the Trainee Committee led to 3 papers for an upcoming special issue in Developmental Cognitive Neuroscience involving trainee and senior authors across 35 institutions. Building on efforts to foster mentorship networks, promote trainee-focused conference programming, and advance professional development initiatives in FIT'NG, this year's conference will feature three events organized by the Trainee Committee.

The **Communications Committee**, co-chaired by Sahar Ahmad and Tara Rutter, has continued to expand our membership and reach this year. In response to our community's evolving preferences, we have expanded beyond X (@FIT_NGIn) and are now active on Bluesky (@fitngin.bsky.social) and LinkedIn. Please follow and engage with us on your preferred platform using #FITNG2025. We launched the Member Spotlight

Series to highlight the FIT'NG members, and additional initiatives are underway to further strengthen and support our research community. Sign up for our mailing list to stay updated and connected with our community. If you are interested in joining the Communications Committee or sharing your ideas with us, please reach out to us at communications@fitng.org

The **Vision & Visibility (V&V) Committee** was established in 2022 to ensure that diverse perspectives and imaging modalities were adequately represented within the society. The V&V Committee continues to identify community needs and address them in ways that enhance FIT neuroscience and training. This committee is chaired by Courtney Filippi. It includes exceptional EEG and fNIRS faculty from across the globe, including Sobana Wijeakumar, Laura Pirazzoli, Chiara Bulgarelli, Joscelin Rocha Hidalgo, and Lindsay Bowman as the Board's liaison. We are writing articles on accompanying content to increase dissemination and visibility of these important topics for our field. We are always looking to add to our already multifaceted group and encourage all to reach out at vision@fitng.org if you want to join us and have ideas for initiatives that further support diversity and visibility in society!

The **Scholarly Works Committee** was reformulated this year to facilitate and spearhead the realization of scholarly works such as group papers, and coordinating the annual meeting special issue. The committee is led by Cat Camacho and Johanna Bick, with members Brittany Howell, Sarah Shultz, Marisa Spann, Marta Korom, Emma Margolis, Kathrine Skak Masden, and Kirsty Donald. The SWC has overseen and supported scholarly works by coordinating special issues featuring innovative work presented at our annual FIT'NG conference. We also support initiatives for collaborative papers on seminal topics published by the FITN'G group and lead authors. This past year, the committee has assisted with the final publication of the 2023 FIT'NG Meeting Special Issue, based on the meeting held in Santa Rosa, CA. The issue appeared in Developmental Cognitive Neuroscience in February of 2025. We are actively assisting with the 2024 Meeting Special Issue, which showcases innovative work from our invited speakers and award-winning presenters from our meeting held in Baltimore, MD. Initial planning for the special issue for the 2025 meeting in Dublin, Ireland, is under way. The committee is excited to expand membership in the coming year to support more scholarly initiatives from FIT'NG members!

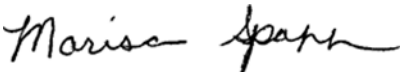
Members can be at any career stage. Please reach out if you are interested by emailing scholarlyworks@fitng.org.

The **Sustainability and Advancement Committee** was established after the 2023 annual meeting, with the primary goal of securing funding to support our society's long-term growth and financial stability. The committee is chaired by Kathrine Skak Madsen, with committee members Courtney Filippi, Lilla Zöllei, Emma Duerden, Áine Travers Dineen, and Brittany Howell actively contributing to the committee's efforts. Over the past year, the committee has focused on developing sponsorship structures, identifying funding opportunities, and building strategies for long-term sustainability. Generous multi-year support from the ***Burroughs Wellcome Fund***, secured ahead of last year's meeting, laid a strong foundation for this work and continues to support core FIT'NG activities. Looking ahead, the committee aims to expand its efforts to secure further support, strengthen partnerships, and explore new opportunities to ensure the continued growth of our society. We welcome all FIT'NG members to share ideas or get involved in shaping a sustainable future for our community, at sustainability@fitng.org.

As we come together in Dublin, let us celebrate the dedication and shared achievements of our community. Your contributions drive the society forward and we are excited to see the connections you will make and the discoveries that lie ahead. We wish you an inspiring and enjoyable conference!

Sincerely,

For the Executive Board and Committee Chairs



Marisa Spann, PhD, MPH
Founding President and Founding Member
Associate Professor with Tenure
Vagelos College of Physicians and Surgeons,
Columbia University

FIT'NG Leadership & Committees

FIT'NG BOARD

Marisa N. Spann	President (Founding Member), Columbia University, USA
Tomoki Arichi	Vice President, King's College London
Lindsay Bowman	Secretary, University of California, Davis
Dustin Scheinost	Treasurer (Founding Member), Yale University, USA
Lilla Zöllei	Bylaws Officer (Founding Member), Massachusetts General Hospital / Harvard Medical School, USA
Rhodri Cusack	Board Member, Trinity College, University of Dublin
Courtney Filippi	Board Member, New York University Grossman School of Medicine
Brittany Howell	Board Member, Virginia Tech, USA
Nadège Roche-Labarbe	Board Member, University of Caen Normandy
Chad Sylvester	Board Member, Washington University in St. Louis
Alice Graham	Founding Member, Oregon Health & Science University, USA

VISION & VISIBILITY COMMITTEE

Courtney Filippi	(Chair) – New York University
Lindsay Bowman	University of California, Davis
Chiara Bulgarelli	Birkbeck, University of London
Sam McCann	King's College London
Joscelin Rocha Hidalgo	Pennsylvania State University
Sobana Wijeakumar	University of Nottingham

COMMUNICATIONS COMMITTEE

Tara Rutter	(Co-chair) – Oregon Health & Science University
Sahar Ahmad	(Co-chair) – University of North Carolina at Chapel Hill
Gavkhar Abdurokhmonova	University of Maryland
Olivia Allison	(Trainee Liaison) – University of Virginia
Holly Bradley	University of Toronto, Mississauga
Claudia Lugo-Candelas	Columbia University Irving Medical Center / New York State Psychiatric Institute
Roxane Licandro	Massachusetts General Hospital, Harvard Medical School / Medical University of Vienna
Alice Massera	NYU Langone Health
Ogy Nwana	University of Texas Health Science Center at Houston
Kelly Vaughn	Children's Learning Institute, University of Texas Health Science Center at Housto

TRAINEE COMMITTEE

Áine Travers Dineen	(Chair) – Trinity College Dublin
Shelby Leverett	(Co-chair) – Washington University in St. Louis
Juliette Champaud	University College London
Claudia Adelita Carreno	Virginia Tech
Istvan N. Huszar	Massachusetts General Hospital / Harvard Medical School
Olivia Allison	University of Virginia

Emily M. Chen	Stanford University
Huili Sun	Yale University
Marta Korom	National Institute of Mental Health
Paige Nelson	University of Iowa
Emma Margolis	Northeastern University
Tristan Yates	Columbia University

2025 SCIENTIFIC PROGRAM COMMITTEE

Nadege Roche-Labarbe	(Co-chair) – University of Caen Normandy
Lindsey Powell	(Co-chair) – University of California, San Diego
Tomoki Arichi	(Board Liaison) – King's College London
Paige Nelson	(Trainee Liaison) – University of Iowa
Emily M. Chen	(Trainee Liaison) – Stanford University
Kiho Im	Harvard Medical School / Boston Children's Hospital
Sobanawartiny Wijeakumar	University of Nottingham
Rebecca Schwarzlose	Washington University in St. Louis
Rhodri Cusack	(Board Member) – Trinity College, University of Dublin

SCHOLARLY WORKS COMMITTEE

M. Catalina Camacho	(Co-Chair) – Washington University in St. Louis
Sarah Shultz	(Co-Chair) – Emory University
Dustin Scheinost	(Co-Chair) – Yale University
Brittany Howell	(Board Liaison) – Virginia Tech
Emma Margolis	(Trainee Liaison) – Northeastern University
Marta Korom	National Institute of Mental Health

SUSTAINABILITY AND ADVANCEMENT COMMITTEE

Kathrine Skak Madsen	(Chair) – Danish Research Centre for Magnetic Resonance
Marisa Spann	(Co-Chair) – Columbia University
Brittany Howell	Virginia Tech
Áine Travers Dineen	Trinity College Dublin
Courtney Filippi	New York University
Emma Duerden	Western University
Lilla Zöllei	Harvard University

ASSOCIATION SECRETARIAT & CONFERENCE MANAGEMENT

(fitng@podiumconferences.com)

Podium Conference Specialists

Michelle Smith

Marischal De Armond

Tori Lunden

2025 FIT'NG Young Investigator Award Winners

Sponsored by Trinity College Dublin, Coláiste na Tríonóide, Baile Átha Cliath, The University of Dublin

Trinity College Institute of Neuroscience

Congratulations to the FIT'NG Young Investigator Award winners! Look for them with the award winner ribbon on their name badge and congratulate them on their award.

Gavkhar Abdurokhmonova	University of Maryland, College Park
Parvaneh Adibpour	Kings College London
Hilyatushalihah Audah	University of Turku
Chiara Capparini	Université Libre de Bruxelles
Tommaso Ciceri	IRCCS Eugenio Medea
Flora Faure	University College of London
Claudio Ferre	Boston University
Jessica Gemignani	University of Padova
Lisa Gorham	Washington University in St. Louis
Yvonne Kuo	University of Notre Dame
Blakely Lockhart	Virginia Tech
Leonie Loehn	University of Waikato
Emma Margolis	Northeastern University
Sian Wilson	Harvard Medical School
Farah Ghosn Yassine	University of London

General Conference Information

Venue

Radisson Blu Royal Hotel & Dublin Royal Convention Centre
Golden Lane, Dublin 8, D08 VRR7, Ireland

All conference sessions will take place at this location.

Registration

Conference registration fees include access to all sessions, invited speaker presentations, coffee breaks, lunches, poster sessions, and Think Tank discussions.

Name Badges

Your name badge is your admission ticket to the conference sessions, coffee breaks, lunches, and receptions. Please always wear it. At the end of the conference, we ask that you recycle your name badge in one of the name badge recycling stations or leave it at the Registration Desk.

Registration & Information Desk Hours

The FIT'NG Registration and Information Desk, located in the pre-conference lobby on the lower ground floor, will be open during the following times:

- Sunday, September 7, 2025: 7:30am – 6:00pm
- Monday, September 8, 2025: 8:00am – 6:30pm

If you need assistance during the conference, please visit the Registration Desk.

Staff

FIT'NG staff from Podium Conference Specialists can be identified by orange ribbons on their name badges. Feel free to ask any of our staff for assistance. For immediate help, please visit the Registration Desk.

Internet Services

Wireless Internet will be available to delegates at no charge. Simply select the event WiFi network (**Dublin Royal Convention Centre**, no password needed) and follow the on-screen instructions to connect. Kindly note, the WiFi is suitable for email and web browsing but may not support streaming video or heavy media use.

If you are active on social media, use the hashtag **#FITNG2025** and tag **@FIT_NGIn** when referring to the meeting. Please respect the policy of no live-tweeting of presentations without prior approval from the speakers/authors. Social posts about the conference are encouraged to help grow our online community.

Poster Information

There will be **two Poster Sessions** during the conference. Posters are assigned to either Session 1 or Session 2 based on theme. Presenters must set up and remove posters during the times below.

- **Poster Session 1**

Set-up:	Sunday, September 7 between 8:30am and 10:30am
Poster Hours:	Sunday, September 7 3:05pm – 4:30pm
Remove:	Sunday, September 7 no later than 6:45pm

- **Poster Session 2**

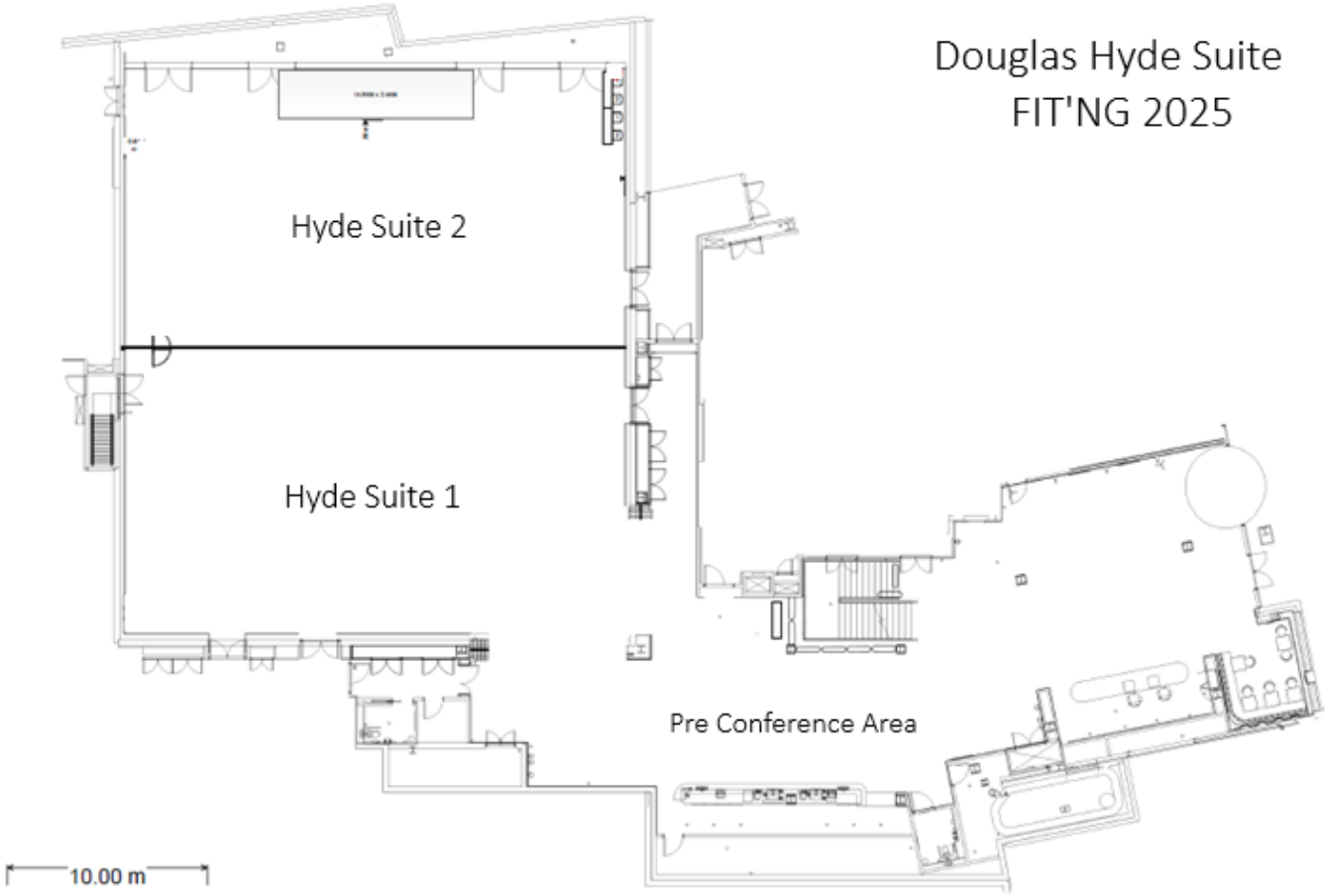
Set-up:	Monday, September 8 between 8:30am and 10:30am
Poster Hours:	Monday, September 8 3:20pm – 4:45pm
Remove:	Monday, September 8 immediately following the poster session

Any posters not removed by the deadlines will be held at the Registration Desk until the end of the conference. Posters unclaimed by the end of the conference will be disposed of.

Information on Poster Authors (Lead), Poster Numbers and Poster Titles begins on page 31.

Floor Plan

Radisson Blu Royal Hotel, Dublin



BINGO

Talk to someone from a different country	Join a FIT'NG Trainee-Led Event	Attend a session outside your main area	Take a selfie with someone in your field	Hear the word "longitudinal"
Share a photo on social media with #FITNG2025	Recommend a paper to someone	Mention your own research in conversation	Learn about a new soft ware/toolbox	Contribute to a Think Tank Discussion
Take notes during the symposium	Give feedback on a poster		Take a photo with something unmistakably Irish	Add a new paper to your reading list
Submit a brain joke for kids: tinyurl.com/brainjoke	Take a walk along the River Liffey	Share a challenge you're facing in research	Learn about a dataset you hadn't heard before	Discuss a pipeline or preprocessing method
Try an Irish food or drink	Give a high-five to a FIT'NG committee member	Ask a question after a talk	Talk to an exhibitor at a booth	Learn the origin of an Irish word/name

INSTRUCTIONS

Fill out your bingo card throughout the conference to win prizes! Complete **any row or column** to earn a FIT'NG sticker -- find a Trainee Committee member or stop by the registration desk to claim. Complete the **entire board** to be entered to win a grand prize!

FIT'NG 2025: Annual Conference Detailed Daily Schedule

Dublin Royal Convention Centre, Hyde Suite

SUNDAY SEPTEMBER 7, 2025

07:30 **Registration Desk Open**
Morning Coffee

08:30 – 08:45 **Welcome & FIT'NG Society Updates**

08:45 – 10:15 **Session 1: Methods: Acquisition and Processing**
Chairs: Lilla Zöllei, *Massachusetts General Hospital*
Emma Margolis, *Northeastern University*

Artificial Intelligence Techniques for Baby Brain MRI Analysis
Gang Li, *University of North Carolina at Chapel Hill*

Early human development of cerebellar and cerebro-cerebellar connectivity
Nina Treder, *King's College London*

Optically pumped magnetometers can measure brain responses to sensory information already in the fetus
Chiara Capparini, *Université Libre de Bruxelles*

Development of controllability in fetuses and infants is supported by synaptic density
Huili Sun, *Yale University*

10:15 – 10:45 **Coffee Break**

10:45 – 12:15 **Symposium Session 1: Imaging Neurodevelopment at Unconventional Field Strengths: Revolutionising Insights into Early Human Brain Development**
Chairs: Chiara Casella, *King's College London*
Niall Bourke, *King's College London*

Ultra-low field MRI of the neonatal brain: An unconventional field strength with conventional applications?
Daniel Cromb, *Evelina Children's Hospital, Guy's and St Thomas' NHS Trust & King's College London*

The impact of antenatal maternal anaemia on child brain development in South Africa: neuroimaging findings from high (3T) and ultra-low field (64mT) MRI
Jessica Ringshaw, *University of Cape Town & King's College London*

Illuminating fine-grain functional development of the human brain using ultra-high field MRI
Jucha Willers Moore, *King's College London*

Mapping metabolic maturation in the neonatal brain with ultra-high field MRI to predict outcomes following extremely preterm birth
Inge van Ooijen, *University Medical Center Utrecht*

12:15 – 13:45 **Lunch Break (provided onsite)**

12:15 – 13:45 **Lunch with Professors (pre registered trainee event)**

13:45 – 14:45 **Keynote Presentation**

Chair: Nadege Roche-Labarbe, *University of Caen Normandy*

Expanding the frontiers of neuroimaging in toddlers with wearable OPMMEG
Margot Taylor, Hospital for Sick Children and University of Toronto

14:45 – 15:05 **Flash Talks #1**

Chairs: Dustin Scheinost, *Yale University*
Huili Sun, *Yale University*

Combining functional ultrasound and high-density diffuse optical tomography for whole brain connectivity imaging in the neonate (WIP)
Flora Faure, *University College of London*

Cortical morphology in very preterm born neonates with intraventricular hemorrhage
Lingkai Tang, *Western University*

The Role of the Neonatal Hypothalamus in Early Sleep Development
Katharina Pittner, *Charité – Universitätsmedizin Berlin*

The association of prenatal maternal depression and neonatal white matter microstructure: The moderating role of maternal exposure to childhood maltreatment
Fiona O' Donovan, *Charité - Universitätsmedizin Berlin*

15:05 – 16:30 **Poster Session 1 and Coffee Break**

16:30 – 18:00 **Session 2: Cognitive Development**

Chairs: Rhodri Cusack, *Trinity College, The University of Dublin*
Áine Dineen, *Trinity College*

Early executive functions – what have we learned in the lab, from parents, and by measuring brain activity?
Karla Holmboe, *School of Psychological Science, University of Bristol*

Intrinsic timescales in the infant brain shorten from 6 to 18 months and relate to the alpha brain rhythm
Anna Truzzi, *Queen's University Belfast*

Features learned from an infant's perspective are more aligned with the infant brain
Cliona O Doherty, *Trinity College Dublin*

Simultaneous EEG-fMRI investigation of sound sequence processing in neonates
Parvaneh Adibpour, *Kings College London*

20:00 **Trainee Committee Social Event**

Location: Porterhouse Temple Bar, 16-18 Parliament Street

MONDAY SEPTEMBER 8, 2025

07:30 **Registration Desk Open**
Morning Coffee

08:30 – 10:45 **Symposium Session 2: Understanding sensory development with task functional neuroimaging in the perinatal period**
Chairs: Julia Moser, *University of Minnesota*

Investigating multisensory integration in third trimester fetuses using fMEG
Dimitrios Metaxas, *University of Tübingen*

Auditory oddball habituation and risk for anxiety in neonates
Maria Catalina Camacho, *Washington University in St. Louis*

Mapping the key components of caregiving: Early brain responses to gentle caress and speech
Isabella Mariani Wigley, *University of Turku*

Neural encoding of phonetic features at birth and in 3 month-old infants using EEG
Claire Njoo, *Université Paris-Sud*

10:00 – 10:30 **Coffee Break**

10:30 – 12:00 **Think Tank: Elephants in the room**
Join us for small group discussions led by faculty in the field!

- How can we best characterize/measure the effect of early environments on brain development, and how can we account for genetic confounds?
- Do we only study chill babies? How infant temperament and emotional states shape FIT neuroimaging
- Adding to the cognitive developmentalist's toolkit: FIT imaging to test alternative explanations
- Methodology gap: Which critical methods are still missing to study early brain development
- Clinical thresholds: Distinguishing atypicality from adaptive variability in early brain development

12:00 – 13:30 **Lunch Break (provided onsite)**

13:30 – 15:00 **Session 3: Clinical Questions**
Sponsored by: MindWare TECHNOLOGIES
Chairs: Tomoki Arichi, *King's College London*
Marta Korom, *National Institute of Mental Health*

The gutbrain axis in early life
James Boardman, *Centre for Clinical Brain Sciences, University of Edinburgh*

Early postnatal cortical microstructural development and its association with early psychopathology risk
Yanbin Niu, *Vanderbilt University*

Does Fetal Sex Modulate Risk and Resilience in Brain Development in Congenital Heart Disease: A Multi-site MRI Study
Sian Wilson, *Harvard Medical School*

Dose-dependent effects of prenatal opioid exposure on infant neurodevelopmental trajectories
Janelle Liu, *Cedars-Sinai Medical Center*

15:00 – 15:20 **Flash Talks**

Chairs: Brittany Howell, *Virginia Tech*
Shelby Leverett, *Washington University in Saint Louis*

The Roles of prenatal disadvantage and postnatal enrichment on structural development of the cortex from birth to age three
Lisa Gorham, *Washington University in St. Louis*

Mapping the functional organization of the neonatal basal ganglia and thalamus
Samantha Blake, *Washington University in St. Louis*

Early brain development of functional networks and impact of preterm birth
Qianwen Chang, *King's College London*

Development of manual skills and lateralized brain activity during infancy: A longitudinal fNIRS study
Claudio Ferre, *Boston University*

15:20 – 16:45 **Poster Session 2 and Coffee Break**

16:45 – 18:15 **Session 4: Social, Emotional, and Language Development**

Chairs: Lindsey Powell, *University of California*
Juliette Champaud, *University College London*

Understanding early development through the parentchild interactome
Victoria Leong, *Nanyang Technological University*

Associations between frontolimbic white matter organization and inhibition to novelty in infancy
Alexander Dufford, *Oregon Health & Science University*

Electrophysiological maturation predicts speech processing in infancy: Evidence from neural tracking of naturalistic speech
Tineke Snijders, *Tilburg University*

Investigating newborns' representations of language prosody with NIRS-EEG
Jessica Gemignani, *University of Padova*

18:15 – 18:30 **Closing and Awards**

FIT'NG Oral Abstracts

SUNDAY, SEPTEMBER 7

SESSION 1: METHODS: ACQUISITION AND PROCESSING

Chairs: Lilla Zöllei, *Massachusetts General Hospital*
Huili Sun, *Yale University*

INVITED SPEAKER

Artificial intelligence techniques for baby brain MRI analysis

Gang Li, *Department of Radiology and Biomedical Research Imaging Center, University of North Carolina at Chapel Hill*

The increasing availability of baby MR imaging data allows us to track the extremely dynamic and critical early brain development. However, most existing computational tools for neuroimaging analysis, which are mainly developed for adult brains, are inapplicable for early developing neuroimages, due to the unique challenges associated with the dynamic, spatiotemporally nonuniform changes in imaging contrast, appearance, brain size, morphology, and function. In this presentation, I will introduce our developed computational techniques and tools, deep learning models, 4D brain atlases and parcellation maps, dedicated to precise processing, alignment, analysis, and mapping of the challenging early developing neuroimages. I will also show their neuroscience applications in revealing the spatiotemporally fine-grained, dynamic developmental patterns of brain structure and function during infancy.

CONTRIBUTED TALKS

O1-1 Early human development of cerebellar and cerebro-cerebellar connectivity

Nina Treder[1], Sunniva Fenn-Moltu[1], Dimitar Kostadinov[1], Tomoki Arichi[1], Grainne Mcalonan[1], Dafnis Batalle[1]

[1]*King's College London*

Summary: We aim to understand intrinsic cerebellar and cerebro-cerebellar functional connectivity in neonates. Since early brain networks are linked to later development, mapping these connections may help us identify how conditions like autism emerge and when differences in brain organisation first appear.

Details: The cerebellum's extensive connectivity with cerebral regions follows a distinct topographic organization, supporting diverse functional roles across the lifespan. Altered cerebellar connectivity has been linked to social, emotional, and sensorimotor difficulties observed in autism1 and related neurodevelopmental conditions. Investigating the cerebellum's early functional organisation may thus enable us to better understand developmental trajectories that contribute to neurodevelopmental conditions. Here, we examine cerebellar and cerebro-cerebellar connectivity in neonates by delineating intrinsic connectivity networks (ICNs).

We analysed resting-state functional magnetic resonance imaging (MRI) data with full cerebellar coverage from the developing Human Connectome Project (dHCP)2: 77 term-born healthy neonates (33 females), gestational age at birth (GA) 37.5-42 weeks, postmenstrual age at scan (PMA) 38.5-44.5 weeks. First, cerebellar ICNs at the individual level were obtained using group-level independent component analysis (ICA)3 of cerebellar voxels. Second, core ICN strength was calculated as mean β-parameter value in each ICN for each subject. Third, correlation analyses were performed between the timeseries of all cerebellar voxels and the average timeseries of cerebral ICNs, previously defined using ICA on cerebral voxels, registered into each subject's functional data (Figure 1).

We identified 13 cerebellar ICNs within the anterior and posterior lobe, vermis, dentate nucleus and medial and lateral portions of Crus I and II (Figure 2). Preliminary analyses showed increasing core network strength with PMA at scan in the Left Crus I/II ($r^2 = 0.059$, $p = 0.0339$; $r^2 = 0.051$, $p = 0.0477$) and Right Crus I/II ($r^2 = 0.064$, $p = 0.0264$) (Figure 3). Correlations between cerebral ICNs and the cerebellum showed a recurrent pattern of cerebellar connectivity with motor-related networks, including sensorimotor, lateral motor and motor association ICNs ($r = 0.1 – 0.199$) (Figure 4).

This study provides an initial characterization of the cerebellar connectome in neonates, revealing distinct ICNs in the cerebellum and patterns of cerebro-cerebellar connectivity. Our findings highlight the presence of early cerebellar networks that are functionally connected with cerebral motor networks. The identified networks establish the foundation for future work on cerebellar connectivity in infancy and early childhood, and if departures from the typical topology are associated with neurodevelopmental conditions such as autism and ADHD.

1) D'Mello, A. M., & Stoodley, C. J. (2015). Cerebro-cerebellar circuits in autism spectrum disorder. Frontiers in Neuroscience, 9. https://doi.org/10.3389/fnins.2015.00408

2) Edwards, A. D., Rueckert, D., Smith, S. M., Abo Seada, S., Alansary, A., Almalbis, J., Allsop, J., Andersson, J., Arichi, T., Arulkumaran, S., Bastiani, M., Batalle, D., Baxter, L., Bozek, J., Braithwaite, E., Brandon, J., Carney, O., Chew, A., Christiaens, D., … Hajnal, J. V. (2022). The Developing Human Connectome Project Neonatal Data Release. Frontiers in Neuroscience, 16. https://doi.org/10.3389/fnins.2022.886772

3) Beckmann, C. F., & Smith, S. M. (2004). Probabilistic independent component analysis for functional magnetic resonance imaging. IEEE Transactions on Medical Imaging, 23(2), 137–152. IEEE Transactions on Medical Imaging. https://doi.org/10.1109/TMI.2003.822821

O1-2 Optically pumped magnetometers can measure brain responses to sensory information already in the fetus

Chiara Capparini[1], Pierre Corvilain[1], Vincent Wens[1], Zachary Langford[1], Maxime Ferez[1], Xavier De Tiège[1], Julie Bertels[1]

[1]*Université Libre de Bruxelles*

Summary: This work presents an unprecedented adaptation of a wearable MEG system based on optically pumped magnetometers (OPM-MEG) to record fetal brain responses to sensory stimuli during the third trimester of pregnancy. As opposed to cryogenic MEG, OPM-MEG is more scalable and sensors configuration can be easily adapted to the participant's needs.

Details: The human fetus, particularly in the last trimester of gestation, already exhibits the remarkable capacity to detect and process external sensory information. Investigating the neural basis of this fetal perceptual ability has traditionally relied on cryogenic magnetoencephalography (MEG), a technique suited to non-invasively measure fetal brain activity through the maternal womb. However, the widespread adoption of fetal MEG has been hindered by the high cost, logistical complexity, and scarcity of cryogenic systems suited to pregnant participants, which remain confined to a couple of specialized research laboratories worldwide.

In the present work, we introduced a novel, cryogenic-free MEG system based on optically pumped magnetometers (OPM-MEG). The OPM sensors are lightweight and wearable, making them an ideal candidate for a flexible and scalable MEG application with fetal and infant populations. The aim of the present work was to demonstrate the possibility to record brain activity in response to sensory stimulation already in utero adopting a wearable OPM-MEG solution. To do so, OPM sensors were organized into an adaptable abdominal belt. Of note, sensor placement was tailored to the fetal head position. We recorded fetal brain activity in response to auditory stimuli (500 Hz tones) in a group of 20 pregnant participants in their late third trimester (35-40 weeks of gestation). The same auditory paradigm was also conducted with on-scalp OPM-MEG with a subgroup of participants who came back with their 1-month-old newborn. Our results demonstrated that OPM-MEG can successfully detect fetal auditory evoked responses, with group-level signals peaking around 300 ms post-stimulus onset. In newborns, responses to auditory stimuli appeared with shorter latencies in magnetometer data compared to the fetal group, indicating rapid postnatal maturation of auditory processing. In a second experiment, we are also recording fetal brain activity in response to visual stimulation (flashes of red light) in a group of pregnant women in their third trimester (32-36 weeks of gestation). Visual stimuli are presented in two locations over the maternal abdomen, according to the fetal head position and orientation. Data collection for this latter fetal paradigm is currently ongoing, and results will be presented at the meeting. Overall, the findings from the fetal and newborn OPM-MEG acquisitions establish the feasibility of this novel MEG approach to record brain responses to sensory stimuli already before birth. By enabling non-invasive and scalable studies across the prenatal and perinatal period, OPM-MEG holds a promise as a lifespan-compliant neuroimaging tool for tracking neural development from the womb onwards.

O1.3 Development of controllability in fetuses and infants is supported by synaptic density

Huili Sun[1], Dustin Scheinost[1]

[1]*Yale University*

Summary: The brain's capacity to regulate internal dynamics—controllability—emerges rapidly during the perinatal period. Yet, its trajectory and biological underpinnings remain unclear. Using multimodal imaging, machine learning, and primate models, we uncover how brain controllability develops and aligns with synaptogenesis and maternal-fetal coordination.

Details: Understanding how the brain regulates dynamic functions early in life is central to mapping normative and altered development. Network control theory provides a framework for measuring the brain's capacity to regulate state transitions, quantified as controllability. Nevertheless, how controllability matures during the perinatal period and what biological processes drive it remain unknown. In this study, we leveraged human neuroimaging, machine learning, and non-human primate models to characterize the developmental trajectory of controllability and its association with synaptic density.

We first examined the developmental trajectory of controllability across the perinatal period (20.86-45.14 weeks of gestation, n=217 fetuses and 642 infants). We identified a robust U-shaped curve in whole-brain average controllability, with a minimum at 35.24 weeks ($F=77.01$, $p<2e-16$) using generalized additive models. Most networks exhibit a similar trend to the overall developmental trajectory of the whole brain. The trajectories of the visual ($F=35.78$, $p<2e-16$) and dorsal attention network ($F=50.49$, $p<2e-16$) are more curved. Those of the subcortical ($F=4.82$, $p=2.24e-4$) and ventral attention ($F=4.23$, $p=8.02e-5$) networks are more flat. We compared in-utero and ex-utero developmental trajectories using connectome-based predictive modeling. Predictive models of age trained on fetal brain controllability generalized to infant data ($r=0.61$, $p=2.21e-67$, MAE=10.29 weeks), and vice versa ($r=0.48$, $p=7.65e-15$, MAE=10.23 weeks), suggesting shared in-utero and ex-utero developmental patterns. To test the impact of preterm birth, we compared fetuses and preterm infants matched on week-by-week gestational age. No significant group differences were observed between 26 and 28 weeks. However, from 33 weeks onward, preterm infants exhibited significantly higher controllability than fetuses, peaking at term-equivalent ages, highlighting a divergence linked to premature environmental exposure. Animal models were employed to investigate the underlying biological mechanisms of controllability changes. We quantified synaptic density using SV2A PET imaging ([^{11}C]UCB-J and [^{18}F]SynVesT-1) in seven third-trimester rhesus macaque fetuses. At the same developmental stage of human fetuses, the synaptic density was negatively correlated with brain controllability (whole-brain: $r=-0.76$, $p=0.018$), particularly in frontal($r=-0.78$, $p=0.012$), occipital($r=-0.74$, $p=0.021$), and parietal($r=-0.73$, $p=0.024$) regions. These results suggest that increasing synaptic density may temporarily reduce network controllability in the absence of external stimulation. Finally, we explored the developmental synchronization between the maternal and fetal brain. Using longitudinal maternal neuroimaging from preconception to postpartum, we found that maternal and fetal brain controllability were significantly anti-correlated ($r=-0.68$, $p=9.39e-4$), with extremes occurring at similar times before birth (mother's maximum at 36.63 weeks; infant's minimum at 35.24 weeks). These findings suggest coordinated but opposing changes of maternal and fetal brain networks across gestation.

Together, our results provide a comprehensive, multimodal view of how controllability emerges and develops during the perinatal period, potentially influenced by intrinsic biology, environmental exposure, and maternal-fetal synchrony.

KEYNOTE PRESENTATION

Expanding the frontiers of neuroimaging in toddlers with wearable OPM-MEG

Margot Taylor, *University of Toronto*

Functional brain imaging in infants, toddlers and young children is an enormous challenge using conventional neuroimaging methods, and this has greatly limited the number of studies in very young children. New optically pumped magnetometer (OPM) magnetoencephalography (MEG) technology is revolutionising this field, allowing high spatial and temporal resolution scans to be completed in young children. I will present data focussed on children 1-5 years of age (n>200), including young children with autism. We use child-friendly protocols: video-based resting states, moving visual circles (which elicit gamma band activity) and emotional faces. We find significant changes with age in periodic, aperiodic and evoked signals that vary across the brain and relate to emerging behaviours. OPMs are transforming neuroimaging research in toddlers and young children and this technology will greatly advance our understanding of brain-behaviour relations over these critical, early years of life.

SESSION 2: COGNITIVE DEVELOPMENT

Chairs: Rhodri Cusack, *Trinity College, The University of Dublin*
Áine Dineen, *Trinity College*

INVITED SPEAKER

Early executive functions – what have we learned in the lab, from parents, and by measuring brain activity?

Karla Holmboe, *School of Psychological Science, University of Bristol*

Recent years have seen an increase in research into executive functions (EFs) during infancy and toddlerhood ('Early EFs'). Whereas the structure of EFs during the preschool years (approx. 3-5 years) appears to involve one or two core domains, EFs in infancy and toddlerhood appear to be more fragmented, with low and often non-significant correlations between different tasks and across ages. Nevertheless, there is now evidence that EF skills develop dramatically over the first 2-3 years of life, as does the neural substrate underlying this development.

In this talk, I will present data from my longitudinal research programme on Early EF skills, focusing primarily on inhibitory control (the ability to stop a dominant or tempting response when needed), but also touching on other EFs, such as working memory and cognitive flexibility. Much of my research has involved developing EF tasks that are engaging and easy to understand even for very young children, have a consistent design across age, and that we can combine with suitable neuroimaging methods to explore the emerging neural substrates of EFs. I will present lab-based data from some of these tasks as well as longitudinal functional near-infrared spectroscopy data showing substantial changes in the neural substrate of inhibitory control across the first 3½ years of life. I will also discuss a parallel line of longitudinal research involving parent-reported Early EF skills and their associated outcomes at preschool age. Lab-based and parent-report findings show convergence in some aspects of early EF development but diverge substantially in other respects. Finally, I will briefly mention longitudinal work we are currently carrying out and our plans for the future.

CONTRIBUTED TALKS

O2.1 Intrinsic timescales in the infant brain shorten from 6 to 18 months and relate to the alpha brain rhythm

Anna Truzzi[1], Josué Rico-Picó[2], M Rosario Rueda[3], Rhodri Cusack[4]

[1]Queen's University Belfast, [2]Teachers College; Columbia University, [3]University of Granada, [4]Trinity College Dublin

Summary: The infant brain up to 6 months of age shows longer brain intrinsic timescales compared to adults. These timescales shorten by 9–16 months and are related to brain rhythms. Investigating the neural mechanisms behind time–integration will help us to understand how babies learn complex patterns from the continuous stream of sensory inputs.

Details: The human brain integrates information over time at distinct intrinsic timescales (ITS), and in adults the individual patterns of ITS relate to cognitive scores (Liégeois et al., 2019), severity of ASD symptoms (Watanabe et al., 2019), and the state of consciousness (Golesorkhi et al., 2021). Our recent research in sleeping neonates employing fMRI found that intrinsic timescales also already have a specific structure at birth, but it is different from adults (Truzzi & Cusack, 2023). Neonates showed longer overall timescales in all brain areas compared to adults. There was also a trend for shortening of ITS with postnatal age. However, it remains unclear: i) how the brain timescales develop; ii) how they relate to brain rhythms; and iii) whether longer timescales in neonates could have been caused by slower hemodynamic responses or sleep state. To address these limitations, we replicated and extended our previous findings by investigating the longitudinal development in awake infants at 6-, 9-, and 16-months using EEG during movie watching and comparing them to adults in the same condition. We replicated the finding that ITS decreases with age, from 6 to 16 months. Additionally, ITS were still longer than adults at 6 months of age but had similar values at 9 and 16 months. Contrary, the spatial pattern across electrodes differed between infants and adults. In extending our earlier finding to EEG in awake infants, we have ruled out a hemodynamic or sleep-state explanations. Further, we found a relation between ITS and alpha band features. We found a relation between the intrinsic brain timescales and self-predictability in the alpha band. The alpha rhythm is the dominant oscillation in the brain and the most explored in developmental EEG studies and its development has been related to the integration of perceptual information (Freschl et al., 2022). At 6 months, timescales became negatively correlated with the amplitude of the alpha burst, whereas the lagged coherence in the alpha band was positively correlated to the intrinsic timescales at every age. Altogether, these signal that infant ITS becomes shorter with a shift in brain topology compared to adults. Since the sensory streams extract the meaningful patterns of information on different timescales, understanding the brain mechanisms driving time integration in the infant brain will allow us to devise well-controlled experiments to understanding how infants learn from a forever changing and extremely complex stream of information.

O2.2 Features learned from an infant's perspective are more aligned with the infant brain

Cliona O Doherty[1], Áine Dineen[1], Anna Truzzi[2], Graham King[1], Enna-Louise D'arcy[1], Chiara Caldinelli[1], Tamrin Holloway[1], Eleanor Molloy[3], Rhodri Cusack[1]

[1]Trinity College Dublin, [2]Queen's University Belfast, [3]The Coombe Hospital; Trinity College Dublin

Summary: Here we explore deep neural network (DNN) models of high-level vision during development. Infant and adult fMRI responses were compared to a DNN trained on infant headcam data, versus another trained on a web-based dataset. We find that models trained on infant views learn features that are significantly more aligned with 2-month-old visual cortex.

Details: Deep neural networks (DNNs) are effective computational models of high-level vision in adults, learning meaningful feature representations that align with fMRI responses in ventral visual cortex (VVC) (1, 2). Recent work has shown that headcam recordings from young infants can be used for model training (3, 4), but applying these models to brain development has not yet been possible due to difficulties in collecting sufficient awake fMRI data in young cohorts. Here, we acquired a dataset of 2-month-old infants (n=101, mean CGA=2.46 mo) and adults (n=17) as they viewed images of 12 animate and inanimate categories in the scanner. Representational similarity analysis was used to examine whether DNNs trained on infant visual experience can better predict neural responses in the developing brain. The images used during scanning were presented to two vision transformers: one trained on web-based data (CLIP) and another on egocentric headcam data from a single child (CVCL) (3, 5). Representational dissimilarity matrices (RDMs) were constructed using the models' feature embeddings and compared to neural response patterns from ventrotemporal cortex. We found that category representations in VVC were surprisingly mature at 2-months of age. While adults were generally more similar to all models, both age groups were correlated to the DNN embeddings. However, the features learned by a model trained on infant views were significantly more predictive of 2-month-old infants' VVC than a typically trained model. In adults, the inverse was true: features from CLIP trained on a standard dataset were more aligned with adult visual responses. In a searchlight analysis, clusters of significant voxels in infant VVC were recovered for only the model trained on infant views, despite both models selectively predicting voxels in adult VVC. This demonstrates that the statistical structure of early visual experience is important for modelling the representational structure of the infant brain. As the field of awake infant fMRI continues to grow, tools from computational cognitive neuroscience will become more applicable for studies of development. Our findings suggest that models trained on developmentally relevant data are key to fully capturing the early emergence of high-level vision.

O2.3 Simultaneous EEG-fMRI investigation of sound sequence processing in neonates

Parvaneh Adibpour[1], Slava Karolis[1], Ines Tomazinho[2], Dario Gallo[2], Cidalia Dacosta[2], Kamilah St Clair[2], Wendy Norman[2], Kathleen Colford[2], Fraser Aitken[2], Claire Kabdebon[3], Jonathan O'Muircheartaigh[1], Tomoki Arichi[2]

[1]Kings College London, [2]Guys and St Thomas' NHS Foundation Trust, [3]Institute of Language, Communication and the Brain; CNRS

Summary: Detecting regularities and deviations in environmental stimuli is key to learning, attention, and adaptive behavior. Emerging research suggests that these abilities may be atypical in individuals with neurodevelopmental conditions [1]. We combined EEG and fMRI to gain deeper insight into the neural underpinnings of these abilities in neonates.

Details: We acquired simultaneous EEG-fMRI data during natural sleep from 25 neonates using an auditory oddball paradigm. After rejecting motion-corrupted data, the study group included 18 neonates (birth age=39.8 [37.6-40.9] gestational weeks, scan age=41.3 [40-44.1] weeks, 8 female). Twenty-one blocks of sounds sequences composed of four speech syllables were presented over 20 min. Each block consisted of either six repetitions of the same sound sequence (standard) or occasional violation of regularities with half of the sequences involving a deviant or a missing sound (fig 1.a).

EEG data was acquired using a 32-channel MR-conditional Brain Products system. MR gradient and pulse artefacts were removed from recorded data using Analyzer II software. Recordings were filtered (0.5-15 Hz), cleaned for motion artifacts using the APICE preprocessing pipeline [2], re-referenced with respect to average-reference, and then segmented into epochs relative to the onset of the last sound in the sequence. Auditory evoked responses were obtained by averaging trials corresponding to each experimental condition. Average activity over frontocentral channels was compared between conditions using a paired t-test.

fMRI data were acquired with a Philips Achieva 3T MRI scanner and a 32-channel head coil, using an echo-planar imaging sequence with TR=2001 ms, resolution 2.08x2.08x2.9mm3. Preprocessing and GLM analysis were performed in FSL [3], using a neonatal optimized basis function set [4] to define subject-level activation maps. Z-statistical maps from each subject were aligned to the subject's T1-weighted image and warped to a 40-week template [5] using ANTs [6], and group average effects were identified using nonparametric permutation testing [7].

EEG auditory evoked responses showed a decrease in amplitude from the 1st to the 3rd sound, indicating habituation to repetition (fig 1.b). For the last (4th) sound, a mismatch response to deviance (deviant vs standard) was elicited (fig 1.c). The mismatch response emerged at two distinct time windows (500 and 1200 ms) and had a frontocentral scalp distribution.

fMRI analyses identified functional activity in response to sound sequences, in a distributed network, encompassing thalamus, auditory and sensori-motor cortices (fig 2.d). Comparing deviant to repeated sounds localized clusters of activity within the posterior regions of the left primary auditory areas and in the superior temporal gyrus (fig 2.e). Interindividual variability in EEG mismatch responses were significantly related to elevated activation levels for deviant compared to repeated sounds in the anterior cingulate cortex (fig 2.f).

We demonstrate that the neonatal brain encodes the regularity and deviance in sound sequences through specific processing roots both in primary auditory and higher-order areas. In-scanner EEG habituation and mismatch responses were consistent with previous reports [8], indicating that neonates are sensitive to the statistics of sound sequences. These findings suggest the presence of a hierarchy for sensory processing in neonates and might have implications for understanding atypical patterns of divergence related to neurodevelopmental conditions.

SESSION 3: CLINICAL QUESTIONS

Chairs: Tomoki Arichi, *King's College London*
Marta Koromn, *National Institute of Mental Health*

INVITED SPEAKER

The gut-brain axis in early life

James Boardman, *Centre for Clinical Brain Sciences, University of Edinburgh*

Professor Boardman will discuss evidence for gut-brain interactions in infancy and childhood. He will describe analyses integrating microbiome data with structural and diffusion brain MRI, which suggest a role for the gut-brain axis in the development of encephalopathy of prematurity, a condition common in preterm infants and closely associated with neurodevelopmental impairment. The data focuses research attention on microbial manipulation as a potential route to neuroprotection in the NICU.

CONTRIBUTED TALKS

O3.1 Early postnatal cortical microstructural development and its association with early psychopathology risk

Yanbin Niu[1], M. Catalina Camacho[2], Kurt Schilling[3], Kathryn Humphreys[1]

[1]Vanderbilt University, [2]Washington University in St. Louis, [3]Vanderbilt University Medical Center

Summary: Cortical microstructure undergoes rapid, regionally specific development in early infancy, but its potential relevance for later mental health remains unclear. This study uses advanced diffusion MRI to map cortical microstructure in early postnatal life and examine its links to later psychopathology symptoms.

Details: Precision imaging techniques that accurately map the resting-state networks (RSNs) of individuals could lead to biomarker discovery for studying brain development. However, the estimation of individual-level RSNs in neonatal populations has been rather elusive due to the unique challenges involved with fMRI data at this early stage. Here, we use Bayesian modeling in combination with surface-based analysis to obtain clean estimates of RSNs for individual neonates using only 10 minutes of fMRI data. Leveraging the large dataset from the developing Human Connectome Project (dHCP), we built cross-sectional maturation curves for preterm and full-term neonates that show different developmental trajectories across brain regions.

Methods: Infant mental health is a major public health priority, yet the developmental origins of its vulnerabilities remain poorly understood. The human brain undergoes rapid and profound structural and functional changes in the first few months after birth, establishing foundations for cognitive, motor, and emotional development. At the microstructural level, this period is marked by critical processes such as synaptogenesis, dendritic arborization, myelination, and neuronal differentiation. Understanding these early transformations is essential for mapping normative trajectories and identifying deviations that may increase psychopathology risk. Advanced multi-shell diffusion MRI offers unique opportunities to assess microstructural maturation in vivo during early infancy.

This study aimed to (1) map cortical microstructural development during the early postnatal period, and (2) examine whether early microstructural features are prospectively associated with psychopathology symptoms at 18 months.

Diffusion MRI data were collected from 103 infants. After quality control, 76 datasets (age: 3.43–6.29 weeks) were included. Microstructural metrics—Neurite Density Index (NDI) and Orientation Dispersion Index (ODI)—were projected to the 44-week dHCP surface template. Cortical regions were parcellated using the multimodal Glasser atlas, and functional networks were defined using the Cole-Anticevic Brain-wide Network Partition. Parent-reported internalizing symptoms were assessed at 18 months. Covariates included sex and gestational age at birth.

Results revealed a hierarchical topographic organization, with higher NDI and ODI in primary sensorimotor regions (e.g., visual, auditory, motor) compared to less mature association regions (e.g., prefrontal cortex). While ODI did not show age-related changes, NDI increased significantly across regions (mean $\beta = 0.202$), with strongest growth in sensorimotor areas ($\beta = 0.381$). No significant associations were found between early NDI or ODI and later internalizing symptoms.

This study is among the first to characterize early cortical microstructure in vivo, revealing rapid sensorimotor maturation in the first weeks of life. Though we did not detect links to later symptoms, future work with larger samples is needed to clarify whether these null findings reflect limited power or true developmental patterns. .

O3.2 Does fetal sex modulate risk and resilience in brain development in congenital heart disease: A multi-site MRI study

Sian Wilson[1], Seungyoon Jeong[2], Henry Feldman[2], P. Ellen Grant[1], Caitlin K. Rollins[1], Kiho Im[2]

[1]Harvard Medical School, [2]Boston Children's Hospital

Summary: Severe forms of congenital heart disease (CHD) occur more frequently in males than in females, suggesting sex-linked mechanisms may play a role in CHD pathophysiology. Abnormal brain development in utero contributes to adverse neurodevelopmental outcome in CHD, but the role of fetal sex in shaping brain development in CHD remains unknown.

Details:
Study Objective: Cortical expansion is impaired in the third trimester in fetuses with CHD, and the magnitude of this impairment is predictive of worse neurodevelopmental outcome. In this study, we examine two independent fetal MRI cohorts to test the hypothesis that sex modulates the impact of CHD on fetal cortical development.

Methods: 504 3T T2-weighted fetal brain MRIs (20 – 39 weeks Gestational Age (GA)) were acquired from two sites, London and Boston. Our Boston cohort includes 135 fetuses diagnosed with CHD, and 157 Controls, while the London cohort includes 212 controls acquired

as part of the Developing Human Connectome Project (dHCP). All MRIs were processed with the same pipeline, including motion correction, slice-to-volume reconstruction, segmentation, cortical plate surface reconstruction and registration. We parcellated the surface into 30 cortical regions per hemisphere, calculating sulcal depth, mean curvature and surface area in each parcel.

With the Boston cohort, we used the Control subjects for normative modelling, to fit growth curves for each surface feature in each region, charting their maturation with gestational age (GA). We then calculated z-scores for each subject, representing the deviation from the expected mean for a given surface metric. We fit a general linear model to compare z-scores between (i) Control Male vs. Control Female; (ii) CHD Male vs. CHD Female; (iii) Control Male vs. CHD Male; and (iv) Control Female vs. CHD Female, while accounting for birthweight and GA. To each set of cortical region-specific results, we used the false-discovery-rate to correct for multiple comparisons.

To check whether the control result in our Boston cohort generalized to another cohort, we deployed the same analysis pipeline on the dHCP data, which we split into a 'Control' group and a 'Test' group. The 'Test' group matched the CHD group in the Boston cohort in terms of sex, GA and number. We then repeated the same normative modelling using the dHCP Control group and calculated the Z-scores on the 'Test' group. We fit a general linear model to compare z-scores between (i) Control Male vs. Control Female; (ii) Test Male vs. Test Female; (iii) Control Male vs. Test Male; and (iv) Control Male vs. Test Male, while accounting for birthweight and GA.

Results: Female fetuses with CHD exhibit significantly reduced cortical expansion in 28 regions compared to female controls, even after accounting for CHD severity, brain size, and body size. In contrast, males with CHD showed no differences compared to controls, suggesting that fetal sex may modulate the impact of CHD on brain development. No sex differences were found between controls in the Boston cohort. In the dHCP cohort we also found no sex differences, enhancing confidence in the methodology and suggesting this sex difference is unique to CHD.

Conclusions: Although male sex is associated with more severe CHD diagnoses, we identify female sex as a risk factor for impaired cortical growth in CHD. In control subjects from both cohorts we found no sex differences in fetal cortical development, reinforcing the specificity of this effect to CHD. To test the generalizability of these findings, we are analyzing MRIs from a third site that includes 400 fetuses with CHD. This in utero study allows us to isolate early sex-linked physiological mechanisms such as genetic and hormonal influences, before postnatal social and environment factors have a greater influence on neurodevelopment.

O3.3 Dose-dependent effects of prenatal opioid exposure on infant neurodevelopmental trajectories

Janelle Liu[1], Kai Xia[2], Wesley Thompson[3], Rina D. Eiden[4], Karen Grewen[2], Wei Gao[1]

[1]Cedars-Sinai Medical Center, [2]University of North Carolina Chapel Hill, [3]Laureate Institute for Brain Research, [4]The Pennsylvania State University

Summary: Prenatal opioid exposure (PODE) disrupts neurodevelopment, but the impact of PODE dosage and timing on infant brain connectivity is poorly understood. Since exposures during different sensitive periods have differential impacts on neurobehavioral outcomes, addressing this gap is essential for predicting outcomes and informing early intervention.

Details: Infants with prenatal opioid exposure (PODE) experience deficits in cognitive, motor, and language development that can cascade to deficits in behavioral and emotional regulation. Although PODE is related to aberrant brain connectivity at birth, no studies have examined its impact on the longitudinal development of functional connectivity. Animal models show that PODE dosage and timing critically shape outcomes, but human fMRI studies typically rely on binary exposure classifications, limiting the ability to detect these nuanced effects. Here, we use resting-state fMRI to map growth trajectories of functional network development across the first year in PODE infants and examine how trimester-specific dosage shapes these trajectories.

Infants with PODE (n=27) were scanned during natural sleep at four timepoints: 2 weeks, 3 months, 6 months, and 12 months. Maternal opioid use during pregnancy was quantified using the Timeline Follow Back; cumulative dosage per trimester was quantified as morphine milligram equivalents. Birthweight and maternal education were included as covariates of no interest in all analyses. We used a heatmap analysis to identify trimester-specific dosage effects on neonatal functional connectivity and cross-sectional effects of first trimester dosage on functional connectivity at each timepoint. Longitudinal growth trajectories of connectivity were modeled using multivariate sparse functional principal components analysis. Linear regression tested whether first trimester dosage altered functional connectivity growth in eight canonical brain networks (visual, sensorimotor, dorsal attention, ventral attention, limbic, frontoparietal, default mode, and subcortical networks).

Distinct dose-dependent effects on neonatal brain connectivity were observed across trimester (Figure 1). Higher first trimester dosage was associated with widespread alterations across the brain, with the highest concentration of effects on frontoparietal network connectivity. Second trimester dosage had the greatest impact on default mode network connectivity, whereas third trimester dosage had the largest effect on visual network connectivity. Cross-sectional results showed dynamic shifts in dosage-related impacts: first trimester dosage most strongly impacted frontoparietal network connectivity at birth, subcortical network connectivity at 3 months, sensorimotor network connectivity at 6 months, and visual network connectivity at 12 months (Figure 2). Longitudinal analyses revealed that first trimester dosage significantly altered dorsal attention network growth (Figure 3A), with trending effects on frontoparietal network development (Figure 3B).

This is the first study to show how trimester-specific, dosage-dependent effects of PODE shape brain development, revealing early mechanisms that may underlie cognitive/language impairments in PODE infants as well as vision deficits and attention dysregulation in PODE youth. These findings point to critical windows in the first postnatal year for targeted intervention before the onset of observable symptoms to improve long-term outcomes for affected children.

SESSION 4: SOCIAL, EMOTIONAL, AND LANGUAGE DEVELOPMENT

Chairs: Lindsey Powell, *University of California*
Juliette Champaud, *University College London*

INVITED SPEAKER

Understanding early development through the parent-child interactome

Victoria Leong, *Nanyang Technological University*

During early sensitive periods, healthy neurodevelopment depends on warm, contingent communication and social engagement between infants and caregivers. The timing and pattern of these interactions is crucial. Optimally, caregivers provide rich multisensory experiences in responsive and predictable temporal sequences to modulate their infants' attention and emotion. This creates stable synchronous states, such as joint attention and shared positive affect, which potentiate communication and social knowledge transmission between adult and child. This multisensory interface can be described as the parent-child interactome, which provides a systems level description of the parent and child's joint neurophysiological and sensorimotor state space, created through interaction. Here, examples are provided from both human and animal optogenetic models of how neurophysiological coupling in the parent-offspring interactome is associated with stable attractor states that support successful information transmission. Moving from theory to real-world application, dyadic sociometrics is introduced as a technique for real-time multi-sensor AI-based analysis of the parent-child interactome (patent pending). This scalable technology is being deployed as a precise, culture-fair, deep phenotyping tool for early developmental assessment. In the first year of life, the parent-child interactome predicts emerging language, socioemotional and cognitive skills with up to 96% accuracy across different cultural contexts. The future potential for interactome-based techniques to advance current understanding of neurodevelopment and sensitive periods, and to be used in early risk identification and personalised therapeutics is discussed.

CONTRIBUTED TALKS

O4.1 Associations between frontolimbic white matter organization and inhibition to novelty in infancy

Alexander Dufford[1]

[1]*Oregon Health & Science University*

Summary: Inhibition to novelty refers to a child's tendency to react with fear, withdrawal, and distress when encountering new situations. However, few studies have examined the early white matter correlates of inhibition to novelty. Elucidating these early neural correlates can inform our neurobiological understanding of this anxiety disorder risk factor.

Details:

Objective: Evidence from connectivity studies in older children suggests that frontolimbic connectivity is associated with inhibition to novelty.1,2 However, few studies have examined the relation between frontolimbic white matter organization and inhibition to novelty in infancy. Based upon previous studies of behavioral inhibition,1,2 we focused on two frontolimbic white matter tracts: the uncinate fasciculus and cingulum bundle. The present study focused the analysis on diffusion-based metrics of white matter organization: fractional anisotropy (FA) and radial diffusivity (RD). Typical neurodevelopmental patterns have found that FA increases across infancy/toddlerhood, while RD decreases.3 The objective was to determine the association between these metrics and inhibition to novelty as measured by the ITSEA.4 We hypothesized that both the uncinate fasciculus and the cingulum bundle FA would be negatively associated with inhibition to novelty and positively associated with RD for both tracts.

Methods: The analysis focused on the 6-shell diffusion-weighted imaging (DWI) data from the Baby Connectome Project. Data was downloaded from the DSI Studio Fiber Data Hub. Before download, DWI data had been preprocessed with TOPUP and eddy. Participants were removed due to poor data quality (neighboring DWI correlation below 0.50). Deterministic tractography for the cingulum bundle and uncinate fasciculus was conducted using DSI Studio. Each fiber tract generated by the tractography was visually inspected. Average FA and RD values were calculated for each tract for both the left and right hemispheres. Outlier values were removed using a Hampel filter (2 times the median absolute deviation). The final analytic sample consisted of 112 participants, 48% female, with a mean age of 14.6 (SD=7.2). Inhibition to novelty was measured at a mean age of X using the ITSEA. Multiple linear regressions were used to test associations between FA/RD values and inhibition to novelty scores. Regressions included participant age at scan, sex, and age at ITSEA as covariates. Bonferroni correction was used to control for multiple comparisons.

Results: Greater right cingulum bundle FA was associated with lower inhibition to novelty scores (b=-4.36, 95% CI [-7.17, -1.56], t(85)=-3.09, p=0.003 (uncorrected); B = -0.36, 95% CI [-0.60, -0.13]). As expected, greater right cingulum bundle RD was associated with higher inhibition to novelty scores (b=3.90, 95% CI [1.87, 5.92], t(78) = 3.83, p<.001 (uncorrected); B=0.43, 95% CI [0.21, 0.65]). Bonferroni corrected p values for were p=.01 for the right cingulum bundle FA (R2 of 0.17) and p=.01 for right cingulum bundle RD (R2 of 0.25). Associations for the left cingulum bundle (FA and RD) and bilateral uncinate fasciculus (FA and RD) were not significant after Bonferroni correction (ps>.05).

Conclusion: We found partial support for our hypothesis, in that diffusion metrics of the cingulum bundle were associated with inhibition to novelty in infancy. We did not find support for an association between white matter organization of the uncinate fasciculus and inhibition to novelty in infancy. The cingulum bundle's white matter organization (reduced FA5,6) has been implicated in anxiety disorders, but few studies have examined brain-behavior associations earlier than childhood. These findings are significant, as they can focus our attention on future investigations of the cingulum bundle and its role in early anxiety risk. .

O4.2 Electrophysiological maturation predicts speech processing in infancy: Evidence from neural tracking of naturalistic speech

Katharina Menn[1], Melis Çetinçelik[2], Tineke Snijders[1], Anika van der Klis[3], Caroline Junge[3]

[1]*Tilburg University,* [2]*Max Planck Institute for Psycholinguistics,* [3]*Utrecht University*

Summary: Infants' brains continue to mature after birth, but how this affects learning remains unclear. This study provides evidence for a direct link between neural maturation and language acquisition, showing that more mature brain activity supports better neural processing of speech, shedding light on the neural basis of early language development.

Details: The infant brain is not fully matured at birth. During the first years of life, the brain undergoes rapid electrophysiological development, shifting from dominant low-frequency activity to greater high-frequency activity (Schaworonkow & Voytek, 2021; Le Van Quyen et al., 2006). Crucially, these electrophysiological properties of the infant brain shape information processing, such as speech perception. It has therefore been hypothesized that neural maturation directly influences early language development (Menn et al., 2023). However, direct empirical evidence for this relationship remains scarce. Here, we test this hypothesis by examining whether individual differences in neural maturation associate with neural speech processing in infancy.

We analyzed EEG data from a sample of 79 Dutch-learning 10-month-old infants, each tested twice on the same protocol within approximately one week, yielding n = 141 artifact-free datasets. During each session, EEG was recorded during two tasks: (1) a visual task during which infants watched toys on a screen, used to assess neural maturation, and (2) a speech task during which they listened to Dutch nursery rhymes, used to measure speech processing.

Neural maturation was quantified using frequency analyses of EEG. We measured the individual's peak frequency in the infant alpha range from 4–9 Hz (Corcoran, et al., 2018), and the aperiodic (1/f) slope of the EEG power spectrum, which captures the relative balance between high- and low-frequency activity (Donoghue et al., 2020). A steeper slope reflects more low-frequency activity while a flatter slope reflects increased high-frequency activity, indicative of neural maturation. Speech processing was assessed using speech-brain coherence, which captures the synchronization between neural activity and the speech envelope—a proposed mechanism underlying speech processing (Meyer, 2018; Giraud & Poeppel, 2018). Coherence was measured at three linguistically relevant rates: prosodic (1–3 Hz), syllabic (3–5 Hz), and phonemic (5–15 Hz). Higher coherence indicates stronger speech tracking and thus more robust speech processing.

Analyses revealed a significant relationship between aperiodic slope and neural tracking at all three rates: Infants with a flatter aperiodic slope, indicative of a more mature brain, showed stronger neural tracking (prosodic rate: $t = -3.49$, $p = .0006$; syllabic rate: $t = -4.36$, $p < .0001$; phonological rate: $t = -3.69$, $p = .0003$). In contrast, individual alpha frequency was not significantly related to speech-brain coherence at any rate (all $p > .8$).

These findings suggest that individual differences in electrophysiological maturation already associate with early speech processing, supporting a direct link of EEG maturation in shaping infants' speech processing, and potentially language acquisition.

O4.3 Investigating newborns' representations of language prosody with NIRS-EEG

Jessica Gemignani[1], Judit Gervain[2]

[1]*University of Padova, 2 University of Padua*

Summary: In this work we used concurrent NIRS and EEG to investigate whether newborns' prefer human speech over primate vocalizations, and how, if yes, such preference is supported at the neuro-functional level by their prenatal experience with the prosodic features of their native language.

Details:
Objectives: Functional near-infrared spectroscopy (fNIRS) and electroencephalography (EEG) are two of the most popular neuroimaging methods in the developmental neurosciences. In this work, we use them to investigate neuro-functional mechanisms of processing of prosody at birth; in fact, evidence suggests that at birth infants have a specific sensitivity to the prosody of the input signal (Partanen et al., 2013, Abboub et al., 2016, Benavides and Gervain, 2017). Interestingly, they don't seem to show a preference for speech over primate vocalizations (Vouloumanos and Werker, 2010). In this project, we investigated the neuro-functional patterns underlying the processing of the native language and primate vocalizations, at birth, with concurrent NIRS and EEG, and whether they change when the prosodic contours of the input material is violated.

Methods: 56 full-term (GA: 37-42 weeks) newborns were tested with concurrent NIRS-EEG at the maternity ward of the hospital of Padua, while being presented with two auditory conditions: (i) spoken sentences in Italian ("Speech"); (ii) baboon vocalizations ("Vocalizations"), using a montage including 16 NIRS channels, distributed bilaterally on the temporal and temporo-parietal areas, and 6 EEG electrodes (F3-Fz-F4-C3-Cz-C4), similarly to Cabrera & Gervain (2020). For each condition, 5 blocks were presented (mean duration of 65 s; inter-block interval 20-30s), each containing 25 repetitions of the same sentence or vocalization, 20 of them presented with a standard prosodic contour, while 5 of them presented with a time-reversed prosodic contour; fNIRS data was pre-processed with a validated commonly used pipeline (Gemignani & Gervain, 2021). EEG data was pre-processed with bandpass frequency filtering (1-30 Hz for ERPs, 1-100 Hz for time-frequency analysis), motion artifact correction, and rejection of trials affected by residual motion artifacts (details in Gemignani & Gervain, 2024). Following data quality check and rejection of bad quality trials, 34 newborns were retained for the analysis of NIRS data and 25 for the analysis of EEG data (NIRS-EEG: 22 newborns). Statistical analyses were carried out on block-averaged hemodynamic responses, from NIRS, and event-related potentials, from EEG, using cluster-based permutation tests. Further, time-frequency analysis of the EEG data is ongoing.

Results: The statistical analysis of NIRS data revealed a cluster of channels, located in the right temporoparietal area, where speech elicited significantly larger responses compared to vocalizations (Figure 1a) The analysis of ERPs revealed that newborns present significantly different responses when hearing deviant contours, compared to the standard contours, during the Speech condition and not during the Vocalizations condition (Figure 1b).

Conclusions and significance: Taken together, both NIRS and EEG suggest that, at birth, human speech occupies a central role: thanks to the prenatal experience accumulated throughout the last trimester of gestation (Gervain, 2018), newborns can readily discriminate incongruent prosodic presentations in their native language, but not in other non-speech sounds like primate vocalizations. Overall, this work brings insight on how the described neurofunctional architecture in place at birth is specific to human speech, and more broadly on the prenatal prosodic bootstrapping hypothesis, both at the hemodynamic and neurophysiological level.

FIT'NG Symposium Abstracts

S1-1 Imaging Neurodevelopment at unconventional field strengths: Revolutionising insights into early human brain development

Chiara Casella [1], Niall Bourke [1], Paul Cawley [1], Jessica Ellen Ringshaw [2], Manon Benders [3], Jucha Willers Moore [1]

[1] King's College London, [2] University of Cape Town & King's College London, [3] Wilhelmina Children's Hospital; UMC Utrecht

Summary: This symposium will explore how imaging at unconventional field strengths (i.e. ultra-high-field and ultra-low-field MRI) is reshaping the study of early brain development. Speakers will present cutting-edge research from both high-resource and global health contexts, spanning antenatal influences, preterm birth, and clinical translation. With contributions from researchers using 7T, and 64mT systems, the session highlights methodological innovation, cross-field harmonisation, and the potential of these technologies to enhance equity, diagnosis, and understanding of neurodevelopment across diverse populations.

Details: Recent advances in magnetic resonance imaging (MRI) are transforming our ability to investigate early brain development. The emergence of ultra-high-field (UHF) and ultra-low-field (ULF) MRI offers unique, complementary opportunities to examine neurodevelopment in greater detail and in underrepresented contexts.

ULF MRI enables imaging in low- and middle-income countries (LMICs), where early-life risk factors—such as malnutrition and infection—are disproportionately high. While these populations remain underrepresented in neuroimaging research, ULF systems offer a rare opportunity to address this inequity.

Conversely, UHF MRI provides unparalleled sensitivity to subtle anatomical and metabolic features in the developing brain. This is especially valuable for visualising small, clinically relevant structures such as the hippocampus and neonatal vasculature. Its enhanced resolution supports advanced biophysical modelling and spectroscopy, offering insight into trajectories and pathologies linked to preterm birth and perinatal injury.

By integrating insights from both ULF and UHF imaging, this symposium will showcase how unconventional field strengths are reshaping early developmental neuroscience. Through global and clinically focused research, we will discuss how these technologies inform early diagnosis, risk stratification, and targeted intervention.

How the Symposium Addresses the FIT'NG 2025 Selection Priorities

This symposium supports FIT'NG 2025 priorities by focusing on perinatal and early childhood neurodevelopment through innovative MRI approaches. It presents empirical findings from high-impact programmes in South Africa, the Netherlands, and the UK.

The session promotes methodological and geographical diversity by integrating global health, clinical innovation, and developmental neuroscience. Studies span both UHF and ULF imaging, with longitudinal data, translational relevance, and technical innovation.

Speakers represent institutions across Africa, Europe, and the UK, with a balance of career stages and disciplines—early career researchers (J.R., J.W.M.), senior academics (M.B.), and clinicians (P.C.).

Together, the talks will foster interdisciplinary exchange across technical development, clinical implementation, and research into long-term neurodevelopmental outcomes.

Contributions:

Paul Cawley: *Ultra-low-field MRI of the neonatal brain: An unconventional field strength with conventional applications?*
Paul will present developments in ULF imaging, including neonatal-specific protocols and normative data. He will discuss the challenges and opportunities of implementing ULF MRI in both high-resource and low-resource settings, framing it as a transformative tool for scalable, accessible neonatal imaging.

Jessica Ringshaw: *The impact of antenatal maternal anaemia on child brain development in South Africa: neuroimaging findings from high (3T) and ultra-low-field (64mT) MRI*
Jessica presents findings from South African longitudinal cohorts on how antenatal maternal anaemia affects early brain development. Her work highlights the importance of accessible imaging for improving screening, prevention, and policy in LMICs.

Manon Benders: *Mapping metabolic maturation in the neonatal brain with UHF MRI to predict outcomes following extremely preterm birth*
Manon will share pioneering 7T MRI data from the EMMA study, quantifying metabolic, vascular, and myelin development in extremely preterm neonates. She will highlight novel sequences (ihMT, MRSI), their safety in neonates, and their potential to predict outcomes and characterise atypical maturation.

Jucha Willers Moore: *Illuminating fine-grain functional development of the human brain using UHF MRI*
Jucha will present the first 7T fMRI studies in neonates, revealing spatially specific BOLD responses, haemodynamics, and depth-dependent cortical circuitry. She will discuss how UHF imaging enhances the study of vasculature and neurometabolites, providing new insights into early functional development.

S1-2 Understanding sensory development with task functional neuroimaging in the perinatal period

Julia Moser[1], Dimitrios Metaxas[2], M. Catalina Camacho[3], Isabella Mariani Wigley[4], Claire Njoo-Deplante[5]

[1] University of Minnesota, [2] University of Tübingen, Tübingen, Germany, [3] Washington University in St. Louis, [4] University of Turku, [5] INSERM; Université Paris-Sud, Université Paris-Saclay

Summary: This symposium presents task paradigms that can be used from the fetal period on to toddlerhood, to inform the development of sensory processing. Development of early sensory processing capabilities is not only important for language learning but alterations in basic sensory processing abilities are also associated with neurodevelopmental disorders. Despite spending the majority of their time asleep, fetuses and newborns respond to and learn from the sensory input of their environment, a developing process that can not be assessed by resting state brain imaging measures alone. All contributors to this symposium study different domains of early stimulus processing abilities with different neuroimaging methods. Integrating those findings across domains, methods and ages will eventually allow us to define normative trajectories of sensory development as well as identify infants at risk.

Details:

Background and Significance: The perinatal period is a period of rapid brain functional development. Findings from resting state fMRI provided important insights about how functional brain networks evolve while findings from resting state EEG and MEG studies demonstrated how neural signals evolve in terms of their regularity, predominant frequency and complexity. While being important contributors to our understanding of the developing brain, resting state measures are unable to assess how babies perceive and learn about the world around them as they do not probe the functioning of the developing functional circuits. Particularly in studies with older infants and toddlers, awake task paradigms therefore gained in popularity. In the perinatal period, sleep is the predominant state, complicating the usability of many of these paradigms. However, work of the contributors to this symposium and multiple others in the field, demonstrated that despite spending the majority of their time asleep, fetuses and newborns respond to and learn from the sensory input of their environment and neuroimaging can be used to investigate the development of these processes. Within this symposium we will present task paradigms that can be used from the fetal period on to toddlerhood, across multiple neuroimaging modalities, to investigate the development of sensory processing. Development of early sensory processing capabilities together with the ability to predict stimuli from the environment is not only important for language learning but alterations in basic sensory processing abilities are also associated with neurodevelopmental disorders. This includes stimulus content as well as the social and emotional evaluation of stimuli. All contributors to this symposium study different domains of early stimulus processing abilities with different neuroimaging methods. Integrating those findings across domains, methods and ages is an important step and will eventually allow us to define normative trajectories of sensory development as well as identify infants at risk. Furthermore, presenters in this symposium showcase the relevance of this work in relation to parental psychopathology and infant behavioral outcomes.

FIT'NG selection criteria: This symposium combines results from neuroimaging research in fetuses, neonates, infants and toddlers across multiple neuroimaging modalities (EEG, fMRI, fetal MEG, fNIRS and DOT), all contributing to the common question of understanding the development of sensory processing starting in the perinatal period. This aligns well with the research represented in the FIT'NG community and the idea of combining and choosing neuroimaging modalities based on their suitability for the question at hand and the developmental time point of interest. This allows using the strength of each method and to combine insights from research across development. The contributors to this symposium come from various geographical locations (France, Germany, Finland and the USA) and career stages (master student to assistant professor), representing the diverse nature of the FIT'NG community.

Titles and contributions:

Dimitrios Metaxas will share preliminary findings from a new fetal MEG study titled "*Investigating multisensory integration in third trimester fetuses using fMEG"* investigating multisensory integration in the last trimester of pregnancy. He will demonstrate how fetal MEG recordings can be combined with auditory and visual stimuli to study the development of evoked responses in utero.

Maria Catalina Camacho will show results from an auditory oddball fMRI study titled "*Auditory oddball habituation and risk for anxiety in neonates*". She will share findings investigating neonatal oddball responses, identify the age specific hemodynamic response shape, habituation of these responses and their relationship to maternal anxiety symptomatology and risk for neonatal anxiety.

In her talk "*Mapping the Key Components of Caregiving: Early Brain Responses to Gentle Caress and Speech*", **Isabella Mariani Wigley** will demonstrate both the feasibility and the value of task-based paradigms in probing the developing social brain, and underscore their importance in longitudinal research aimed at identifying early markers of socio-emotional development. In her talk she will present findings from a series of studies within the FinnBrain Cohort Study (0-2 years), utilizing fMRI, fNIRS, and DOT.

Claire Njoo will follow with a presentation on "*Neural encoding of phonetic features at birth and in 3 month-old infants using EEG*" showcasing phoneme perception studied with EEG, disentangling how the brain decodes elementary units of speech. Her talk will showcase important insights into speech perception and language learning gained from neuroimaging in preverbal infants.

The symposium will be moderated by **Julia Moser**, who has expertise in fetal and neonatal MEG and infant fMRI work, using both task and rest.

FIT'NG Flash Talk Abstracts

FLASH TALK SESSION 1
SUNDAY SEPTEMBER 7, 2025

P1-H-39 Combining functional ultrasound and high-density diffuse optical tomography for whole brain connectivity imaging in the neonate (WIP)

Flora Faure [1], Julie Uchitel [2], Kelly Pammenter [3], Andrea Edwards [4], Katharine Lee [1], Samuel Powell [5], Greg Smith [6], Robert Cooper [7], Topun Austin [8], Charlie Demene [2]

[1] University of Cambridge, [2] Institute Physics for Medicine Paris; INSERM, [3] NeoLAB; Rosie Hospital; Cambridge University Hospitals NHS Foundation Trust, [4] Cambridge University Hospitals NHS Foundation Trust, [5] Gowerlabs Ltd, 6 Gowerlabs Ltd., [7] University College London, [8] Professor

Summary: No whole brain functional connectivity imaging modality is currently available for neonatal brain monitoring at the bedside. This work, by combining functional ultrasound and high-density diffuse optical tomography imaging, will enable whole brain high spatial resolution images of neonatal functional connectivity.

Details: Functional connectivity (FC) imaging in newborns is considered a potential biomarker for early diagnosis of neurodevelopmental disorders. However, its clinical implementation using available imaging tools has been hampered by low-resolution cortical measurements (e.g. EEG, fNIRS) or challenges in neonatal use (e.g. fMRI). Here we combine two cutting-edge functional imaging technologies, functional ultrasound (fUS) and high density diffuse optical tomography (HD-DOT), for deep tissue and high spatial resolution neonatal functional mapping at the cot-side.

We acquired fUS and HD-DOT data on 12 healthy term neonates (postnatal day, d =1.8±1.0 days, gestational age, GA= 39.6±1.4 weeks) during sleep using a custom neonatal headcap (Fig A). The fUS probe was driven using custom ultrafast imaging sequences (3 tilted plane wave compounded at 600 Hz, before SVD filtering and power Doppler averaging) for imaging a contrast proportional to cerebral blood volume (CBV). The HD-DOT system enabled acquisition of light absorbance at 735 and 850 nm for 1728 (source-detector) multi-distance channels, enabling calculation of cortical total haemoglobin (HbT) concentration. The 2 systems were synchronised via a custom triggering system. We used photogrammetry to co-locate the optodes and fUS probe with the head (Fig B-C).

Despite imaging different contrasts (CBV vs HbT) and having different temporal resolutions, confocal fUS and HD-DOT channels showed very comparable temporal evolution in the resting state frequency band (0.01-0.1Hz). Quantitatively, we calculated the correlation between the CBV fUS signal cortical ROI (Fig D) and good quality (low variance, high optical intensity) HbT channels (Fig E). This showed higher correlations for the frontal channels around the ultrasound ROI (Fig F) compared to parietal channels (0.43±0.23 vs 0.15±0.25, $p<0.001$). The next step is to undertake HD-DOT image reconstruction in order to 1) refine the spatial extent of the correlation with the confocal fUS signal (Fig G) and 2) evaluate FC using multiple fUS ROIs and DOT cortical parcellation.

These first results shows that confocal fUS and HD-DOT measurement give very similar measurements of brain activity, through concurrent changes in CBV and HbT, respectively. This is the first important step in developing a system to map long-range thalamo-cortical and cortico-cortical connectivity in the developing brain in order to identify those at high risk of later neurodevelopmental problems.

P1-B-4 Cortical morphology in very preterm born neonates with intraventricular hemorrhage

Lingkai Tang [1], Lilian M. N. Kebaya [2], Emily S. Nicoles [1], Emma Duerden [1]

[1] Western University, [2] University of Toronto

Summary: Neonates born very preterm are particularly vulnerable to intraventricular hemorrhage. Early brain development involves intricate changes in cortical structure, however, the specific effects of IVH on cortical morphology remain unclear, necessitating further investigation into how injury during this critical period may influence brain ontogeny.

Details:
Objective: To examine the associations between hemispheric severity of IVH and localized anatomical features, including, grey matter volume, cortical thickness (CT) and surface area (SA) in very preterm born neonates.

Methods: 34 very preterm born neonates (male: 19) were recruited for the study with mean gestational age (GA) of 26.84 (standard deviation [SD] = 3.24) weeks. Anatomical T1-weighted MRI scans were acquired at mean term equivalent age (TEA) of 37.79 (SD = 1.73) weeks, with a 1.5 T GE scanner and 0.39 × 0.39 × 0.5 mm of voxel size. IVH was graded bilaterally using Papile's method (grade 0 – 4 from no injury to severe injury). The anatomical scans were automatically segmented into 33 cortical regions using infant FreeSurfer and multiple neonatal atlases. For each region, grey matter volume, cortical thickness and surface area were estimated. Multivariate linear models were adopted for each hemisphere and each type of anatomical feature, with sex, GA, TEA and IVH grade as predictors and features of all regions as responses. Significance level was set to 0.05, adjusted for multiple comparisons.

Results: Twelve neonates had no IVH, while 10 had mild-moderate IVH, and 12 had moderate-severe IVH. Overall, cortical volumes and thickness showed significant differences between the severity of IVH. Cortical volumes were significantly larger in bilateral insula, right ventrolateral prefrontal cortex, right orbitofrontal cortex, left inferior parietal lobules and right inferior temporal cortices. Additionally, CT in the insula, temporal, cingulate cortices and the inferior parietal lobule correlated with IVH severity, while only a few regions of SA showed similar associations. No effects of biological sex were evident.

Conclusion: In very preterm neonates with IVH, the severity of injury is more closely associated with alterations in CT than with SA. Given that SA develops earlier in ontogeny, while CT emerges later, our findings suggest that the impacts of IVH may preferentially affect later stages of brain development. This underscores the importance of monitoring CT as a critical marker of cortical anatomical changes following IVH.

P1-D-18 The role of the Neonatal Hypothalamus in early sleep development

Katharina Pittner[1], Martin Bauer[1], Nora Moog[2], Jerod Rasmussen[3], Bibiana Horn[4], Damien Fair[5], Christine Heim[1], Sonja Entringer[6], Claudia Buss[1]

[1] Charité - Universitätsmedizin Berlin, [2] Max-Planck-Institute of Human Development, [3] University of California, Irvine, [4] Hasso-Plattner-Institute for Digital Engineering, [5] University of Minnesota, [6] Institute of Medical Psychology, Charité-Universitätsmedizin Berlin

Summary: Sleep is crucial for infant development yet the brain mechanisms underlying early sleep regulation remain underexplored. We investigated whether neonatal hypothalamus volume predicts sleep development over the first two years of life.

Details:

Introduction: Sleep is crucial for health and well-being throughout the lifespan but in infancy in particular. Infants spend more time asleep than at any other stage in life. Sleep during infancy is necessary to support healthy neurodevelopment, yet the brain mechanisms underlying early sleep regulation remain underexplored. The hypothalamus plays a key role in sleep homeostasis, particularly in establishing the sleep-wake cycle. Animal studies show that hypothalamic lesions cause severe sleep disruptions, but human research—especially in infants—is scarce.

Studying the hypothalamus in infancy has been challenging due to its small size and it is not included in common infant MRI segmentation pipelines such as BIBSNET. However, a newly developed and validated segmentation approach, segATLAS (Rasmussen et al., 2024), enables reliable hypothalamus segmentation in neonates.

Existing studies on hypothalamic volume and sleep in adults report mixed findings. In Parkinson's disease, smaller hypothalamic volumes have been linked to lower melatonin levels, whereas insomnia patients show larger hypothalamic volumes than healthy controls. However, the cross-sectional nature of these studies leaves open the question of whether these volume differences are causes or compensatory changes.

To our knowledge, this is the first study to examine the association between neonatal hypothalamus volume and sleep development over the first two years of life.

Methods: Neonatal hypothalamic volume was segmented using the segATLAS pipeline, which registers FreeSurfer-compatible MNI hypothalamic subfields onto the Baby Connectome Project atlas and then maps them to native infant space. Night sleep duration was assessed through maternal report at 3, 6, 9, 12, 18, and 24 months.

After quality control, data from 88 healthy infants (45 girls, gestational age = 39.53 ± 1.55 weeks, scan age = 29.51 ± 11.03 days) were available, with a total of 360 sleep reports. We used linear mixed-effects models to estimate the association between hypothalamus volume and night sleep duration, including a random intercept and slope and fixed effects for age, hypothalamus volume (residualized for gestational age, scan age, and sex), and their interaction.

Results: The interaction between age and hypothalamus volume was significant ($\beta = 0.10$, $t(270) = 2.28$, $p = 0.02$), indicating that infants with larger hypothalamic volumes exhibited a steeper increase in night sleep duration over time. There was no main effect of hypothalamic volume on night sleep duration. A significant age effect was observed, with night sleep duration increasing over the first two years.

Discussion: These findings suggest that neonatal hypothalamus volume plays a role in the maturation of circadian sleep rhythms, with larger volumes associated with greater night sleep consolidation over time. Future work will examine hypothalamic white matter integrity and functional connectivity to further elucidate its role in early sleep regulation.

P1-E-33 The association of prenatal maternal depression and neonatal white matter microstructure: The moderating role of maternal exposure to childhood maltreatment

Fiona O' Donovan[1], Martin Bauer[1], Katharina Pittner[1], Nora Moog[2], Jerod Rasmussen[3], Alice Graham[4], Damien Fair[5], Christine Heim[1], Sonja Entringer[1], Pathik Wadhwa[3], Hyagriv Simhan[6], Thomas O'connor[7], Martin Styner[8], Claudia Buss[1]

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Summary: Previous research indicates that prenatal maternal depression manifests differently in the body depending on if the pregnant woman has a history of childhood maltreatment. This study investigates if the association of prenatal maternal depression and neonatal white matter differs depending on a history of childhood maltreatment.

Details: Maternal depression during pregnancy has been associated with differences in the white matter microstructure of offspring with heterogeneous findings. The changes are likely mediated via biological signals. A reason for the varying results could be the moderating role of maternal exposure to childhood maltreatment (CM). Recent research has shown that the physiological state of pregnant women with higher depressive symptomatology differs depending on history of exposure to CM. The objective of this study was to extend these findings to the women's offspring, by examining whether the association of maternal depression during pregnancy and neonatal white matter microstructure is moderated by maternal exposure to CM.

The study population was comprised of 167 mother-infant dyads recruited from three study sites. Depression was quantified using the Centre for Epidemiologic Studies Depression Scale (CESD) throughout pregnancy. History of maternal exposure to CM was assessed using the Childhood Trauma Questionnaire (CTQ) at the first study visit. Soon after birth, diffusion weighted imaging was performed in the neonates (mean scan age: 28.23 days) and was processed using dmriprep. A study specific atlas was generated and the bilateral cingulum, fornices, uncinate fasciculi and the genu of the corpus callosum were extracted. Fractional anisotropy, axial diffusivity (AD) and radial diffusivity (RD) measures were computed for each tract for every subject. ComBat was used to harmonise the white matter microstructure measures to account for different scanners at the different study sites. A multivariate analysis was performed to quantify the association of the white matter microstructure measures with the interaction of maternal depression during pregnancy and maternal CM exposure.

Following multiple comparison correction, there was a statistically significant association between the white matter microstructure measures and the interaction of maternal depression and CM exposure in the right parahippocampal cingulum (p= 0.04893) and in the left and right uncinate fasciculus (p= 0.036729 for both) after adjusting for key covariates including gestational age at birth, scan age, sex, motion during scan, maternal use of anxiety/depression medication, and socioeconomic status. Further investigation of the individual white matter microstructure measures determined that both AD and RD were significantly associated with the interaction between maternal depression and CM exposure in all significant tracts (AD: p=0006286, p=0.0009285, p=0.001248 respectively. RD: p=0.009903, p=0.04007, p=0.0159 respectively). In the group that had experienced CM there was a positive association between maternal CESD score and neonatal AD and RD measures, whereas there was a negative association between the maternal CESD score and neonatal AD and RD measures in the group that had experienced no or a low level of CM. No associations were found with the left parahippocampal cingulum, bilateral dorsal cingulum, bilateral fornices, or the genu of the corpus callosum.

Thus, our findings suggest maternal depression during pregnancy has a diverging association with neonatal white matter diffusivity measures depending on the presence or absence of a history of CM. Depression as a consequence of CM may have a differential pathophysiology to depression independent of CM, which may exert differential effects on offspring white matter microstructure.

FLASH TALK SESSION 2
MONDAY SEPTEMBER 8, 2025

P2-E-89 The roles of prenatal disadvantage and postnatal enrichment on structural development of the cortex from birth to age three

Lisa Gorham[1], Aidan Latham[1], Joshua Jackson[1], Max Herzberg[1], Ursula Tooley[1], Tara Smyser[1], Dimitrios Alexopoulos[1], David Loseille[1], Barbara Warner[1], Joan Luby[1], Deanna Barch[1], Cynthia Rogers[1], Kara Garcia[2], Christopher Smyser[1]

[1]Washington University in St. Louis, [2]Indiana University School of Medicine

Summary: In this study, we are using a longitudinal cohort of infants to study how poverty, as well as enriching life experiences, affect cortical expansion in the first three years of life. This work may allow us to identify potential interventions to support healthy brain development.

Details:

Objective: Between birth and age three years cortical surface area increases greatly, having implications for subsequent cognitive and socio-emotional development. Different brain regions mature at varying rates, which may reflect different temporal windows of sensitivity to exposures like poverty or enriching experiences. However, it remains unclear if these exposures influence patterns of cortical expansion.

Methods: We analyzed MRI data from a cohort of full-term infants oversampled for poverty using the anatomically constrained multimodal surface matching (aMSM) pipeline, which optimizes point correspondence between sequential cortical surface reconstructions to create smooth maps of cortical expansion for each child. 83 children underwent structural MRIs at birth and age 2 years; 64 at birth and age 3; and 38 at ages 2 and 3, giving us a total of 185 pairs of longitudinal scans across 111 unique children. Our two composite exposures of interest were prenatal social disadvantage (maternal education, neighborhood poverty, insurance status, healthy eating, and income to needs ratio) and postnatal enrichment "Thrive" (child sleep, positive parenting, neighborhood safety, child nutrition, and environmental stimulation). Using Bayesian hierarchical models with partial pooling, we assessed whether disadvantage and Thrive predicted both mean expansion and variability in expansion across the cortex using the Glasser parcellation, while controlling for age at first scan, time between scans, gestational age at birth, and sex.

Results: The effect of disadvantage on mean expansion varied across the cortex (Figure 1). Disadvantage was negatively associated with mean expansion in occipital and posterior association regions, indicating reduced expansion in individuals experiencing more disadvantage, but was positively associated with mean expansion in the insula and medial frontal lobe. Additionally, higher disadvantage was associated with greater variability in expansion between subjects (significant across all cortical regions). In contrast, higher Thrive was associated with increased mean expansion across the entire cortex but was unrelated to variability in cortical expansion.

Conclusions: This suggests that exposure to poverty and enriching life experiences may have an impact on the structural development of the cortex. As the brain's structure has implications for cognition and mental health, these results highlight the importance of early life experiences.

P2-K-53 Mapping the functional organization of the neonatal basal ganglia and thalamus

Samantha Blake[1], Ashley Nielsen[1], Joan Luby[1], Deanna Barch[2], Barbara Warner[1], Cynthia Rogers[1], Chad Sylvester[2], Christopher Smyser[1]

[1]Washington University in St. Louis, [2]Washington University

Summary: Resting-state fMRI has shown that subcortico-cortical functional connectivity aligns with neuroanatomically-defined circuitry, exhibiting localized representation of individual networks in the basal ganglia and thalamus in children and adults. Whether this organization is present at birth or requires postnatal experience is unknown.

Details: Here, we investigate neonatal subcortical functional organization by mapping the representation of individual functional networks. This study used at least 10 minutes of low-motion, whole-brain fMRI data that were collected during natural sleep from 261 healthy, full-term infants (PMA at scan: 38-45 weeks) as part of the Early Life Adversity and Biological Embedding (eLABE) study. First, subcortico-cortical functional connectivity (FC) was generated by correlating the timeseries from each voxel in the basal ganglia (BG) and thalamus (THAL) with the average timeseries from each cortical functional network defined by previously described adult network assignments (Fig. 1A), excluding cortical vertices within 20mm. Each subcortical voxel was assigned a single functional network using a "winner-take-all" approach based on FC and repeated with split halves. The winner-take-all approach revealed localized representation of individual functional networks in the BG and THAL (Fig. 1B, split half overlap 81% voxels) are largely in line with the functional organization seen in children and adults. Interestingly, early developing sensorimotor systems (e.g., somatomotor) were both strongly

correlated (FC>0.1; Fig. 1A) and overrepresented in the THAL (70%; Fig. 1B), yet representations of some late developing association networks (e.g., salience, default mode, frontoparietal) were also present in both the BG and THAL at birth. These findings provide insight into the emergence of subcortico-cortical functional organization and the relative roles of prenatal developmental programming and early postnatal experience on these brain circuits. Neonatal subcortico-cortical FC shares many similarities with that of children and adults, potentially indicating that prenatal developmental processes (e.g., neural migration, spontaneous activity) drive this organization. However, important differences in neonatal subcortical functional organization remain, including overrepresentation of sensorimotor network, which may reflect current experiences of the neonate (e.g., sensory/motor experiences) and/or the need for continued development to refine the representation of information from multiple functional networks. This characterization of the state of subcortico-cortical functional organization in healthy, full-terms at birth may provide important context for investigations of prenatal exposures or premature delivery that disrupt prenatal developmental processes.

P2-C-64 Early Brain Development of Functional Networks and Impact of Preterm Birth

Qianwen Chang[1], Sunniva Fenn-Moltu[1], Tomoki Arichi[1], Grainne Mcalonan[1], Dafnis Batalle[1]
[1]*King's College London*

Summary: Early brain development is a critical period when neural networks are formed, establishing the foundation for cognitive functions. We examined the typical development of functional networks in neonates and the impact of preterm birth using the fMRI data from dHCP. We also explored whether network features are linked to neurodevelopmental outcomes.

Details:

Background: Early brain development is a critical period for the formation of neural networks, establishing the foundation for higher cognitive functions. Understanding this process is important, as atypical functional connectivity during the perinatal period and following preterm birth has been linked to a higher likelihood of subsequent neurodevelopmental conditions. This study aims to understand early functional connectivity development and the impact of preterm birth.

Method: fMRI data acquired from 394 neonates (325 term-born, 69 preterm-born) at term-equivalent age (postmenstrual age at scan ≥ 37 weeks) from the developing Human Connectome Project (dHCP) were used in this study. A whole-brain atlas was constructed using cortical ROIs from the 7-network Schaefer atlas (400 parcels), subcortical ROIs from the dHCP template, and cerebellar ROIs from the SUIT atlas. The atlas was transformed to the neonatal 40-week dHCP template. After band-pass filtering (0.01-0.1 Hz), functional connectivity was computed as the pairwise Pearson correlation of average timeseries between ROIs, with only positive correlations retained. Proportional thresholding was applied at different network densities (5% to 50%, at 1% steps). Network features, including mean functional connectivity strength (FCS), network integration (measured by normalised global efficiency), and network segregation (measured by normalised local efficiency), were calculated at each density and averaged across all network densities. First, effects of PMA at scan and birth status (term/preterm-born) on network features were examined using linear regression, controlling for sex and head motion outliers (and PMA at scan for birth status). Second, associations between network features at birth and neurodevelopmental outcomes (Balyley III, Q-CHAT, CBCL) at 18 months were assessed using partial correlation, controlling for sex, PMA at scan, and corrected age at assessment.

Results: Normalised global efficiency ($r = 0.280$, $p < 0.001$), and normalised local efficiency ($r = 0.239$, $p < 0.001$) were positively associated with PMA at scan (Fig. 1). Preterm-born neonates showed significantly lower mean FCS ($r = 0.21$, $p < 0.001$), normalised global efficiency ($r = 0.129$, $p = 0.011$), and normalised local efficiency ($r = 0.148$, $p = 0.003$) compared to term-born neonates. Normalised global efficiency ($r = -0.124$, $p = 0.032$, uncorrected) and normalised global efficiency ($r = -0.131$, $p = 0.023$, uncorrected) were negatively correlated with CBCL sleep score accross the whole sample (including term and preterm neonates) (Fig. 2).

Discussion: We characterised the typical development of neonatal functional networks, showing that network integration and segregation increase with age. Our findings suggest that preterm birth lowered mean functional connectivity strength, network integration and segregation. We found that larger normalized global and local efficiency were associated with better sleep across the whole sample. Sleep disruption commonly accompanies neurodivergence. However, 18 months is still a very early stage of development and whether these early network features predict neurodevelopmental characteristics in later childhood or even adolescence and adulthood is an outstanding question.

P2-K-115 Development of Manual Skills and Lateralized Brain Activity During Infancy: A Longitudinal fNIRS Study

Claudio Ferre[1], Evan Yarnall[1], Xiwen Su[1], Hyunjoon Kim[1], Marie Kelly[1]
[1]*Boston University*

Summary: This study examines how infant hand use and corresponding brain activity develop together, and how early brain injury disrupts this process. Our goal is to understand how early movement experiences shape the brain, to better support infant's motor development.

Details: Manual skills emerge over the first two years of life with rapid progressions in skill level, and fluctuations between unimanual and bimanual actions. Asymmetric perinatal brain injury disrupts this trajectory, often resulting in unilateral cerebral palsy (UCP)—the most common pediatric motor disability. Although behavioral studies have characterized early manual skill development in both neurotypical and clinical populations, less is known about how brain regions associated with control of goal-directed actions evolve in parallel with skillful movements. The objective of our study was to characterize development of infant manual skills in relation to developing cortical activity.

Neurotypical infants (NT) and infants diagnosed with UCP (total=20 infants) were observed longitudinally from 6 to 24 months of age (at 3-month intervals). Manual skills were assessed in a semi-naturalistic play session using a validated assessment and included presentation of ~25 infant-friendly objects/toys. Play sessions were digitally recorded and coded frame-by-frame using Datavyu. For each toy/object trial, active hand (left vs. right vs. bimanual), frequency of use, and duration of bouts were assessed for 1) reach-to-grasp, 2) unimanual manipulation, and 3) bimanual manipulation. Concurrently, functional near-infrared spectroscopy (fNIRS) (NIRSport2, NIRx) captured hemodynamic responses during performance of manual skills. fNIRS signal was synched to digital video recordings. Measurements were collected with an optode array (8 sources;12 detectors) centered bilaterally over somatosensory

cortex. For all univariate analyses, significance was tested with a non-parametric permutation (5000 permutations) test based on Welch's t-statistic suitable for unequal variance and sample sizes. Longitudinal data of hand-use patterns were analyzed using a multilevel model with fixed and random effects.

From 6 to 24 months, we observed a shift in the proportion of manual skills that were unimanual compared to bimanual, with a greater proportion of bimanual actions at older ages ($p<.01$ for time x skill parameter). We also identified a development progression from symmetric bimanual actions at younger ages to asymmetric bimanual actions at older ages ($p<.01$). We quantified hemodynamic responses at the fNIRS channel level for individual sessions, with each session comprised of on average over 100+ unique bouts of object manipulation. On average, we observed a robust contralateral difference in peak activation of the left hemisphere with greater amplitude modulation occurring during right hand manipulation as compared to left hand manipulation ($p<.01$). We observed a similar trend for greater contralateral activation in the right hemisphere during left-handed manipulations, although this difference was not significant ($p=.06$). Greater lateralized activation was observed during asymmetric bimanual actions as compared to symmetric bimanual manipulations ($p<.05$). Notably, infants with UCP exhibited atypical asymmetrical activation as early as 6 months of age. By measuring real-time brain activity in dynamic, multi-sensory contexts, this study highlights how emerging manual skills shape experience-dependent development of the sensorimotor system. Our findings suggest that early disruptions to motor experiences in UCP may canalize atypical brain asymmetries, offering new insights into early intervention targets to promote optimal neurodevelopment.

FIT'NG Conference Poster Sessions

Poster Session 1
Sunday, September 7 15:05–16:30

Poster Session 2
Monday, September 8 15:20–16:45

Poster numbers are divided first by session, then by theme, and finally with a unique number.

Session – Theme – Board Number (Example: 1-A-1)

Both poster sessions will be held in Hyde Suite 1.

Themes

A Big data
B Clinical populations
C Cognitive development
D Developmental psychology
E Early life stress
F Emotional development
G Methods: Analytics/Statistics
H Methods: Data acquisition
I Methods: Data processing
J Methods: Tool sharing and data dissemination
K Other
L Prenatal programming
M Variation/Relation to symptoms

FIT'NG Conference Posters | Abstracts

POSTER SESSION 1
SUNDAY, SEPTEMBER 7 15:05 – 16:30

A – Big Data

P1-A-1 Structural and functional correlates of brain energy efficiency during perinatal development

Huili Sun [1], Dustin Scheinost [1]

[1] *Yale University*

Summary: Brain undergoes rapid structural and functional changes during the perinatal period, yet how these systems interact to support emerging cognition remains unclear. Using network control theory and multimodal imaging, we investigate how structural connectivity shapes energy use from fetal to neonatal stages, revealing their coordinated development

Details: The brain undergoes rapid structural and functional changes during the perinatal period. Previous studies have characterized their developmental trajectories individually. However, the interaction between structural and functional development and their trajectories is less well-characterized. Network control theory provides a powerful framework for quantifying the theoretical energy required to transition between brain states based on structural connectivity. In this study, we leveraged this framework to examine the relationship between resting-state functional energy fluctuations and structural control energy, aiming to elucidate the co-development of brain structure and function from in utero to postnatal life.

We analyzed diffusion and resting-state functional MRI data from 147 fetuses and 610 neonates under the dHCP protocol. Structural and functional connectomes were constructed using standard preprocessing pipelines and an infant-adjusted AAL atlas, resulting in individual 90×90 connectomes. For each subject, structural control energy was estimated using network control theory to model he cost of activating whole-brain resting-state-like activity. Functional energy was quantified by the amplitude of low-frequency fluctuations (ALFF) from resting-state fMRI. Whole-brain control energy maps were highly consistent between fetuses and neonates (r=0.48, p=2.18e-6), with high-energy regions localized to the frontal, parietal, and precuneus areas. A similar pattern was found in ALFF distributions (r=0.34, p=0.0011), with peak activity in the amygdala and temporal lobes across both groups, suggesting a continuous developmental trajectory of brain structure and function. We next assessed the regional correspondence between control energy and ALFF. In fetuses, no significant global correlation was observed (r=0.15, p=0.072), though small clusters—primarily in the right prefrontal cortex—showed localized associations (FDR-corrected). In contrast, neonates demonstrated stronger and more widespread structure-function coupling (term: r=0.13, p=0.0049; preterm: r=0.31, p=2.10e-5), especially in the right motor and temporal cortices (FDR-corrected).

Together, these findings reveal a developmental transition in structure-function coordination, highlighting the emergence of more integrated structure-function coupling after birth. This suggests that real-world sensory and environmental experiences may play a critical role in shaping functional dynamics supported by the structural connectome in early life.

P1-A-2 Predicting anti-seizure medication on discharge, epilepsy diagnosis and developmental outcomes with neonatal EEG

Lingkai Tang [1], Daniela Yepes [2], Kevin Kordbacheh [2], Emily Guarasci [2], Maryam Nouri [2], Emma Duerden [1]

[1] *Western University,* [2] *London Health Science Centre*

Summary: Newborns can have seizures after birth and can later develop epilepsy or unfavorable neurodevelopmental outcomes. Also, the decision-making process of prescribing antiseizure medication upon discharge can be complex due to various influencing factors. We propose that predictive models trained with early EEG data, can be a potential solution.

Details: Objective: Four predictive tasks were performed to examine whether neonatal EEG, combined with machine learning methods, can predict the prescription of ASM on discharge and epilepsy at two later follow-ups, and developmental outcomes, for patients having seizures right after birth.

Methods: In total, 119 newborns participated. Due to missing data, not all participants completed all four predictive tasks (Fig. 1). Developmental outcomes were assessed at the 2nd follow-up and all unfavorable outcomes were integrated into one category. EEG was acquired within days after birth. The recordings were downsampled to 250 Hz and filtered to 0.5 to 70 Hz. A 20-minute segmentation of the preprocessed data were firstly transferred to amplitude-integrated EEG then used to a predictive deep learning model. The model was a combination of convolutional layers and transformer layers to capture both geometrical and temporal information of the EEG data (Fig. 2). The model was trained separately for the 4 tasks and validated with 5-fold validation Model performance was evaluated by accuracy, area under receiver operating characteristic curve (AUC), f1-score and Matthews correlation coefficient (MCC). The latter two metrics were better for unbalanced classes. Since the sample size might be limited for training such a model, we used data augmentation by upsampling minority class and adding Gaussian noise. Also, EEG recordings of some participants were longer than 20 minutes, therefore, we tested using random segmentations for training to show that the timing of EEG scan might not be an issue with our method.

Results: The predictive model achieved above-chance performance for all 4 tasks. With data augmentation, the model performance was largely improved (Fig. 3). We also showed that using random segmentations, there was no significant difference on model performance (Fig. 4).

Conclusion: Our findings suggest that neonatal EEG data has potential to predict the prescription of ASM on discharge, later development of epilepsy and developmental outcomes. Future work includes acquiring more samples and model explanation for clearer clinical interpretation and decision making.

B – Clinical Populations

P1-B-3 Early modulation of tactile sensory processing in preterm infants: A window into future neurodevelopmental outcomes

Anne-Lise Marais [1], Victoria Dumont [1], Marie Anquetil [1], Anne-Sophie Trentesaux [1], Nadege Roche-Labarbe [1]

[1] *University of Caen Normandy*

Summary: Preterm babies are at high risk of NDD, but early signs are subtle and hard to detect. This study reveals how tactile processing is actively regulated in the preterm brain and shaped by time spent outside the womb. Understanding these early bricks of early atypical cognition may help detect vulnerable infants sooner and improve support from birth.

Details: Background: Prematurity increases the risk of Neurodevelopmental Disorders (NDD), yet early vulnerability markers remain scarce, limiting early detection and intervention. Sensory prediction (SP), a key cognitive process, regulates sensory processing through repetition suppression (RS) of irrelevant stimuli or amplification of relevant ones. NDDs, particularly autism and attention disorders, are often linked to sensory—especially tactile—deficits. Altered tactile SP and RS may thus be early mechanisms of cognitive vulnerability. This study aimed to provide evidence of tactile SP and RS in preterm neonates and to explore how prematurity level impacts them.

Methods: At 35 weeks corrected gestational age (GA), we used EEG to measure event-related potentials (ERP) in 84 preterm infants (born 24–34 weeks GA) during a tactile oddball-omission paradigm. We presented 290 vibrations (200ms) on the forearm, with the 40 initial and 40 final stimuli being identical (all standards) to assess RS. In between were presented frequent standards with rare deviants and omissions in pseudo-random order to assess prediction error. We analyzed four regions of interest (ROI): somatosensory and frontal, contra- and ipsilateral.

Results: Results show that the brain of preterm neonates actively regulates somatosensory processing: repeated standard stimuli are associated with a significantly reduced amplitude of the late negative component (N3) of the ERP in the somatosensory and frontal contralateral ROIs, whereas deviant stimuli elicit a significantly larger N3 in the somatosensory contralateral ROI. These effects are positively correlated with the proportion of extra-uterine experience, i.e. negatively correlated with GA at birth. Spontaneous activity is visible during omissions, which may reflect pure predictive signal.

Discussion: Prematurity and early extra-uterine experiences significantly shape sensory modulation. Preterm neonates form tactile predictions but their regulatory patterns depend on time spent in or out of the womb. These modulations may reflect adaptive responses to NICU stress but could hinder later sensory and cognitive development. Ongoing follow-up at 2 years assesses links between neonatal tactile processing and neurodevelopmental outcomes, potentially enabling early screening and intervention for at-risk infants.

P1-B-4 Cortical morphology in very preterm born neonates with intraventricular hemorrhage

Lingkai Tang [1], Lilian M. N. Kebaya [2], Emily S. Nicoles [1], Emma Duerden [1]

[1] Western University, [2] University of Toronto

Summary: Neonates born very preterm are particularly vulnerable to intraventricular hemorrhage. Early brain development involves intricate changes in cortical structure, however, the specific effects of IVH on cortical morphology remain unclear, necessitating further investigation into how injury during this critical period may influence brain ontogeny.

Details: Objective: To examine the associations between hemispheric severity of IVH and localized anatomical features, including, grey matter volume, cortical thickness (CT) and surface area (SA) in very preterm born neonates.

Methods: 34 very preterm born neonates (male: 19) were recruited for the study with mean gestational age (GA) of 26.84 (standard deviation [SD] = 3.24) weeks. Anatomical T1-weighted MRI scans were acquired at mean term equivalent age (TEA) of 37.79 (SD = 1.73) weeks, with a 1.5 T GE scanner and 0.39 × 0.39 × 0.5 mm of voxel size. IVH was graded bilaterally using Papile's method (grade 0 – 4 from no injury to severe injury). The anatomical scans were automatically segmented into 33 cortical regions using infant FreeSurfer and multiple neonatal atlases. For each region, grey matter volume, cortical thickness and surface area were estimated. Multivariate linear models were adopted for each hemisphere and each type of anatomical feature, with sex, GA, TEA and IVH grade as predictors and features of all regions as responses. Significance level was set to 0.05, adjusted for multiple comparisons.

Results: Twelve neonates had no IVH, while 10 had mild-moderate IVH, and 12 had moderate-severe IVH. Overall, cortical volumes and thickness showed significant differences between the severity of IVH. Cortical volumes were significantly larger in bilateral insula, right ventrolateral prefrontal cortex, right orbitofrontal cortex, left inferior parietal lobules and right inferior temporal cortices. Additionally, CT in the insula, temporal, cingulate cortices and the inferior parietal lobule correlated with IVH severity, while only a few regions of SA showed similar associations. No effects of biological sex were evident.

Conclusion: In very preterm neonates with IVH, the severity of injury is more closely associated with alterations in CT than with SA. Given that SA develops earlier in ontogeny, while CT emerges later, our findings suggest that the impacts of IVH may preferentially affect later stages of brain development. This underscores the importance of monitoring CT as a critical marker of cortical anatomical changes following IVH.

P1-B-5 Early development of functional brain networks is modulated by Family Nurture Intervention: A multicenter replication study

Pauliina Yrjölä [1], Michael Myers [2], Martha Welch [2], Anton Tokariev [3], Sampsa Vanhatalo [4]

[1] University of Helsinki; CEA Paris-Saclay, [2] Columbia University Medical Center, [3] Early Brain Activity, Systems, and Health Group; University of Helsinki, [4] BABA Center, University of Helsinki

Summary: Family Nurture Intervention has previously been shown to improve functional brain networks of preterm infants and to reduce their prematurity-related compromise. In this work we set out to undertake a replication of our previous findings and to extend the investigation the development of these networks from early preterm to term age.

Details: Objective: Preterm infants spend the third trimester, a critical period of brain development, in the neonatal intensive care unit (NICU), rendering neurocritical care a great challenge of neonatal medicine. Our recent work demonstrated the positive effect of Family Nurture Intervention (FNI), a bedside facilitation of mother-infant emotional connection, on reducing the prematurity-related adversities on cortical networks. In this work, we set out to undertake a replication study of our previous findings and to extend the investigation the development of these networks from early preterm to term age.

Methods: Repeated EEG recordings (124 channels) between 33-45 weeks of conceptional age were obtained from 115 preterm infants receiving either standard care (SC, N=68) or Family Nurture Intervention (FNI, N=47) at Morgan Stanley Children's Hospital, New York (internal site) and University of Texas Health, San Antonio (external site). EEG recordings (19 channels) of healthy term-born controls (HC, N=67) were collected at Helsinki University Central Hospital at term age (41 weeks). 3-minute epochs of active (AS) and quiet sleep (QS) were selected, preprocessed, and source-reconstructed into cortical signals, and functional connectivity was estimated by phase correlations. First, we computed networks showing group difference at term age (Wilcoxon rank-sum test). Next, we compared connectivity strength of the preterm groups (FNI and SC) relative to HCs (Wilcoxon rank-sum test). Finally, we compared the developmental changes in these networks between the preterm groups (cocor).

Results: The previously found FNI-related decrease of functional connectivity was replicated within the same site, but not at an external site. In the within-site cohort, the connectivity levels of FNI infants were comparable to HCs, while the SC group showed significantly higher levels of connectivity ($p < 0.05$). The developmental analysis revealed a significant divergence ($p < 0.05$) of the development of functional networks between the FNI and SC groups during the preterm period: FNI infants showed decreased connectivity with age while SC infants showed variable development (increase, decrease or no change).

Conclusion: Our findings suggest that FNI leads to replicable brain-wide changes in cortical activity networks of preterm infants. Moreover, the intervention may restore prematurity-related effects by rendering the networks comparable to the control infants born at term age.

C – Cognitive Development

P1-C-6 The neural basis of late talking in very preterm infants

Jennifer Vannest [1], Mekibib Altaye [2], Junqi Wang [2], Lili He [2], Maria Barnes-Davis [2], Amy Pratt [1], Nehal Parikh [2], Lisa Hunter [2]

[1] *University of Cincinnati,* [2] *Cincinnati Children's Hospital Medical Cente*

Summary: Children who are late in meeting expressive language milestones are identified as "late talkers", these delays are common in children born prematurely. We used functional and structural imaging to examine whether there were connectivity changes in infancy that predicted late talking at age 2 in children born prematurely.

Details: Children not meeting expressive language milestones at 18-24 months are described as "late talking" (Rescorla at al., 1997). Preterm birth is a risk factor for late talking and communication difficulties: 25-40% of children born very preterm (VPT, ≤32 wks completed gestation) have communication deficits at school age (Nguyen et al., 2018). We explored if differences in structural and functional connectivity could be detected at term-equivalent age (TEA) in VPT children who, at 2 years corrected age (CA) were late talkers compared to children with typical language development.

Methods:191 infants born at 23-32 weeks gestational age participated in MRI at TEA. Imaging data was collected during natural sleep including a T2-weighted structural image, diffusion-weighted imaging (TR/TE 6972/88 ms, 2×2×2 mm, b-values 800 sec/mm2 and 2000 sec/mm2) and resting functional MRI (EPI TR/TE 1187/23 ms, 2.5×2.5×2.5 mm, 400 frames, with field map).

At 24-30 months CA, caregivers completed the Communicative Development Inventories, (CDI, Fenson, 2007) as part of an assessment of speech/language/hearing. 38 children were identified as late talkers, based on CDI Words Produced. 34 additional children (not late talkers) had other communication deficits detected on other testing, the remaining 119 had typical communication skills.

Neuroimaging data were processed using developing Human Connectome Project (dHCP) pipelines (Makropoulos et al, 2018, Bastiani et al., 2019; Fitzgibbon et al., 2020). 22 regions of interest (ROIs) were selected from the dHCP neonatal atlas (Makropoulos et al., 2016), including frontal, temporal, and parietal cortices, subcortical and cerebellar regions implicated in communication processes. To derive structural connectomes from DWI, we computed mean FA values for fiber tracts connecting the selected ROIs creating a 22x22 matrix. For resting fMRI, Pearson correlations between each pair of ROIs were computed, generating a 22x22 functional connectome.

Pairwise functional and structural connections were then input to a penalized regression approach using Least Absolute Shrinkage and Selection Operator (LASSO), to identify a stable, generalizable set of connections predictive of late talking compared to typical language development. To ensure robustness of selected variables and assess variability in model performance, we generated 500 bootstrap samples, resampling with replacement from the original dataset. For each bootstrap iteration, a logistic regression model with LASSO regularization was fit using 5-fold cross-validation. This process identified variables that were consistently selected, allowing us to assess stability and importance. Variables that appeared in 80% of the bootstrapping iterations were retained.

Results: Late talkers had significantly decreased structural connectivity in infancy between the left lateral anterior temporal region and right cerebellum, right superior temporal region and right cerebellum, left medial inferior temporal region and left caudate. Functional connectivity was reduced in late talkers between anterior and inferior regions in the right temporal lobe, and the left lateral anterior temporal region and left cerebellum. These results suggest that the underlying neural basis of late talking at age 2 in VPT children is detectable in infancy; social/environmental and medical factors will be explored in additional analyses.

P1-C-7 Are faces too salient to benefit from attentional facilitation in infancy? (WIP)

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Summary: While we know that faces naturally capture infants' attention, the role of early attentional processes in shaping visual perception remains unclear. This study investigates how different auditory cues are capable of facilitating infants' attention towards highly salient stimuli such as faces, versus less salient visual categories such as birds.

Details: Faces hold a unique status in human perception, naturally capturing infants' attention (Gliga et al. 2009; Reynolds and Roth 2018). However, the role of early attentional processes in shaping visual perception remains unclear. Using a frequency-tagging approach combined with electroencephalography (Quek and de Heering 2024), the present study investigates whether infants' attentional dynamics toward distinct visual categories, including highly salient stimuli such as faces, can be modulated. To this end, 6- to 9-month-old infants will view rapid streams of images flickering at the frequency of 6 Hz (6 images/second), with faces and birds interlaced at 1.2 Hz (1 out of 5 images) and 1.5 Hz (1 out of 4 images), respectively. Crucially, either human voices or bird vocalizations will be presented non-periodically throughout each trial to test if different auditory cues facilitate infants' attention towards highly salient stimuli (faces) versus less salient stimuli (birds). Given that infants' face categorization is less robust than in adults (Leleu et al., 2020), we hypothesize that the face-selective response will be facilitated by human voices. Alternatively, this response may remain unaffected, reflecting a ceiling effect due to the natural saliency of faces, as observed in adults (Quek and de Heering 2024). Overall, this work will shed light on the role of attentional dynamics early in life and provide broader insights into the visual processing of faces and of less salient categories such as birds.

P1-C-8 AROI-based functional connectivity predictive modeling of neonatal brain connectivity for early language and cognitive outcomes

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Summary: Early prediction of developmental outcomes is key for timely intervention. ROI-based functional connectivity modeling offers anatomically interpretable insights. This study aims to identify neonatal brain features predictive of later cognitive and language performance.

Details: Early identification of neurodevelopmental outcomes is critical for initiating timely interventions and improving long-term trajectories in infants at risk for developmental delays. In this study, we leveraged fMRI data of 402 neonates (278 term-born, 124 preterm-born) from the developing Human Connectome Project (dHCP) to examine whether resting-state functional connectivity can predict Bayley-III developmental scores at 18 months. Functional connectomes were constructed using a 208-node cortical atlas (Schaefer atlas) and eight subcortical nodes, with data preprocessed using a neonatal-optimized pipeline.

We developed a Region-of-Interest CPM (R_CPM) approach that involved a two-stage process: (1) In each of 400 iterations, 10% of subjects were used to identify ROIs by selecting the top 1000 edges most strongly correlated with behavioral scores (controlling for scan age, birth age and motion). Nodes appearing most frequently across these edges were ranked, and the top 20% were selected. Nodes consistently ranked in the top 20% across iterations were defined as reference ROIs. (2) The remaining 90% of subjects were used to build predictive models using only the functional connectivity (edges) involving the reference ROI. Model performance was assessed using leave-one-out cross-validation. Statistical significance was $p<0.05$.

R_CPM identified several reference ROIs whose connectivity patterns reliably predicted language and cognitive outcomes. Specifically, the following positive connections can predict cognitive Bayles III score: (a) reference ROI Left Fusiform Gyrus with right occipital lobe, right Parietal lobe and right temporal lobe; (b) reference ROIs Left_Lingual_Gyrus ,Left_Calcarine_Gyrus and Left_Cuneus connect with with parietal lobe, motor cortex and left occipital lobe; (c) reference ROIs Right_Lingual_Gyrus with parietal lobe, prefrontal lobe and left temporal lobe; (d) reference ROI Right_Superior_Occipital_Gyrus with motor cortex, parietal lobe, temporal loba and limbic lobe; (e) reference ROI Left_Superior_Temporal_Gyrus and Left_Rolandic_Operculum with occipital lobe, right parietal lobe and insula; (f) reference ROI Left_Precentral_Gyrus with occipital lobe, limbic lobe and parietal lobe. The following positive connections can predict language Bayles III score: (a) reference ROI Left_Calcarine_Gyrus with motor cortex parietal loba and insula; (b) reference ROI Left_Calcarine_Gyrus with motor cortex, parietal and temporal lobe, and right limbic lobe; (c) reference ROI Left_Superior_Temporal_Gyrus with occipital lobe, right limbic and temporal lobe, and insula; (d) reference ROIs Left_Superior_Temporal_Gyrus and Left_Rolandic_Operculum with occipital lobe and right limbic lobe; (e) reference ROIs Right_Lingual_Gyrus and Right_Calcarine_Gyrus with parietal and left occipital lobes.

These results highlight the potential of ROI-guided predictive modeling to uncover neonatal region-specific features associated with later developmental performance. We found that functional connectivity measured was able to predict language and cognitive scores at age 18 months. A next step would be to apply this approach to patient groups for prediction of functional impairment and potential use for individualized intervention.

P1-C-9 Perceptual sensitivity is associated with infants' neural processing of social tactile information

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Summary: The neural correlates of perceptual sensitivity, or one's ability to detect slight, low-threshold stimuli within their environment, has not yet been studied in infancy. Understanding how perceptual sensitivity relates to the processing of social tactile cues early in development may provide potential biomarkers for sensory processing disorders.

Details: Perceptual sensitivity refers to one's ability to perceive slight, low-threshold stimuli within their environment. This is a particularly important trait for young infants as perceiving, attending to, and responding to nuanced social cues ultimately aids in their ability to form and maintain social bonds. One salient form of social communication in infancy is through touch, which is used to communicate emotions and convey affiliation. Understanding the neural correlates of infants' perceptual sensitivity within the tactile sensory domain will elucidate neural mechanisms that aid in attentional awareness to social cues. We hypothesized that infants who behaviorally displayed greater levels of perceptual sensitivity would show increased neural response to social touch compared to non-social touch in areas of the brain related to social tactile processing (e.g., the somatosensory cortex, amygdala, and insula). We recruited 22 healthy infants, ranging in age from zero- to four-months old, and had their primary caregiver complete the Infant Behavior Questionnaire- Revised. The perceptual sensitivity subscale score was computed for each infant. Infants were rocked to sleep and underwent functional magnetic resonance imaging (fMRI). During the fMRI, infants were gently stroked with a paintbrush on their left leg to simulate social (paintbrush on skin) and non-social (a piece of medical grade plastic is placed between the paintbrush and the skin) touch. General linear models assessed the relationship between infant's perceptual sensitivity and their preferential neural response to social touch. We found that greater levels of infant perceptual sensitivity were associated with greater neural response to social touch in the right supplementary motor area, left precentral gyrus, left postcentral gyrus, and left middle frontal gyrus. However, perceptual sensitivity was negatively correlated with activation in the right parahippocampal gyrus, right insula, right superior temporal gyrus, left amygdala, left hippocampus, right orbitofrontal gyrus, and left rectus gyrus. In adults, the areas associated with greater neural activation are related to the processing of informational properties of touch (e.g., texture, temperature, etc...), whereas the areas associated with reduced neural activity are related to the processing of the socially and emotionally rewarding properties of touch. This suggests that infants with greater perceptual sensitivity may be suppressing the emotional response associated with social tactile processing as to not overwhelm the system. These results may be indicative of a biomarker associated with atypical sensory processing that should further be explored.

P1-C-10 The role of structural connectivity at birth in defining category representations at 2-months-old

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Summary: In this study, we use functional and diffusion MRI to test if category responses in 2-month-old infants are predicted by structural connectivity at birth. We predict that the localisation of category responses in high-level visual cortex may be driven by innate wiring within the visual system.

Details: In this study, we use functional and diffusion MRI to test if category responses in 2-month-old infants are predicted by

structural connectivity at birth. We predict that the localisation of category responses in high-level visual cortex may be driven by innate wiring within the visual system. We seek to understand the role of innate structural connectivity as a potential tool to guide the development of category representations in the visual ventral cortex (VVC). Recent findings indicate that the infant VVC contains rich category representation at two months old. Given the constraints on infant vision up until this point, this is earlier than would be expected if its development were experience-guided. Instead, these findings suggest that innate structure plays a role in early category recognition. A proposed mechanism is the 'biased connectivity' hypothesis; applying this to the VVC would imply that innate patterns of structural connectivity guide the development of neural category specification in infants. This connectivity-guided development hypothesis is supported by the findings that functional connectivity is present in category-specific areas as early as 27 days of age. Structural connectivity was measured using probabilistic tractography on neonatal diffusion MRI data from the developing human connectome project (n=445). This dataset was then combined with awake functional MRI data from a separate cohort of 2-month-olds (n=98) viewing 12 distinct object categories in the scanner. For each object category, we built an Elastic Net regression model to determine the extent to which voxelwise response patterns of functional activity in the two-month VVC could be predicted by structural connectivity at birth. Our models successfully predicted functional activity in the two-month VVC from neonate structural connectivity, outperforming a baseline model and explaining up to 40% of the variance in functional responses. Each category model displayed a unique spatial profile of structural connectivity associated with function. Functional activity was best predicted by connectivity with regions in the Early Visual Cortex (EVC) and other visual areas, such as V6. Our findings suggest that the unique functional patterns in response to various categories could be driven by distinct wiring, present at birth. While the extent to which structural connectivity is guiding the development of category-specificity is still unclear, our findings indicate an association existing in the first two months of life.

P1-C-11 Neural oscillatory dynamics of building novel visual object representations in infancy

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Summary: We aim to better understand the role of neural oscillatory dynamics in the formation visual category representations after short- and long-term learning experiences, from infancy into adulthood.

Details: Despite growing interest, the neural rhythms of building basic visual representations in infancy remain poorly understood. The adult visual system is dominated by oscillations in the 3–8 Hz theta and 8–14 Hz alpha ranges. While the theta rhythm is proposed to order and bind perceptual information into novel representations, the alpha rhythm is associated with the processing of familiar visual information. Emerging evidence suggests that theta and alpha are also present in the infant brain, but we are just beginning to understand their functionality.

Here, we present the evidence from two EEG studies examining the oscillatory dynamics of building basic representation is the infant brain. We achieve this by leveraging time-frequency analysis and frequency-resolved representational similarity analyses to comparing the processing of familiar and novel visual information in infants, children, and adults.

The first study investigates the functional properties of theta and alpha rhythms across development by comparing oscillatory responses to novel versus recently learned familiar stimuli. High-density EEG was recorded in a large sample (N = 187) spanning five age groups—6-month-olds, 12-month-olds, 4-year-olds, 6-year-olds, and adults. Specifically, participants were familiarized to a set of 12 images, after which these familiar images were presented alongside novel images in a random sequence. Preliminary results indicate that theta connectivity increases globally when infants view novel compared to familiar images, suggesting a crucial role of theta in the formation of novel representations. Data from all age groups will be presented at the conference.

The second study investigates how cultural familiarity shapes category representations and their neural oscillatory underpinnings in infancy. Employing a cross-cultural approach, we examined infants aged 5 and 11 months from Germany and Japan as they viewed 36 images from five categories, reflecting either typical German or Japanese cultural contexts. We applied Representational Similarity Analysis to their EEG to determine category decoding accuracy and its temporal dynamics. First results reveal a clear difference in category decoding accuracy between culturally familiar and unfamiliar items for 11-month-olds, with potential differences emerging as early as 5 months. Ongoing analyses using frequency-resolved RSA will illuminate how culture-specific experience shapes the oscillatory dynamics visual category processing in the first year of life.

Taken together, these studies shed light on the neural oscillatory dynamics in the formation of visual category representations after short- and long-term learning experiences, from infancy into adulthood.

P1-C-12 Does structural neural connectivity mediate the relationship between early bilingual exposure and language outcomes in young children? A DTI study (WIP)

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Summary: Neuroanatomy of white matter tracts supporting key language regions in bilingual children is under-researched due to early individual differences and difficulties acquiring MRI data in children. This study provides critical insights on how bilingualism shapes the structure of the main tracts underlying language development in diverse 4-6-year-olds.

Details: Extensive research finds that specific features of children's early language environments (e.g., adult words, conversational turns, etc.) strongly relate to their later language and cognitive, as well as academic outcomes (Hart & Risley, 1995; Weisleder & Fernald, 2013). There are also studies finding associations between children's language environments and functional activation in temporal and prefrontal cortical regions, thus, relating early language exposure to functional activation supporting children's language development (Garcia-Sierra et al., 2016; Romeo et al., 2018a). However, there is limited evidence on functional and structural connectivity in young bilingual children who are exposed to two and/or more languages early on. Given the evidence on the critical role of early language environments in shaping the neuroanatomy of key white matter tracts (e.g., superior longitudinal fasciculus (SLF)/arcuate fasciculus (AF)) in monolingual children (Romeo et al., 2018b; Skeide et al., 2016), it is important to examine how early bilingual environments affect the

microstructure of white matter tracts connecting the main language-related cortical regions.

This study aims to examine how early bilingual experiences, independent of socioeconomic status (SES), relate to the microstructure of the SLF/AF. Specifically, we predict that (1) SLF/AF might act as critical neuroanatomical mechanisms (mediation analysis) by which children's bilingual environments shape their language and EF skills. Furthermore, we hypothesize that (2) there might be specific regions of both SLF and AF that show microstructural differences (sub-tract analysis) in how they relate to early language development in bilingual children. Lastly, given the evidence on bilinguals' bilateral hemispheric recruitment of neuronal resources in language-based tasks as opposed to left-lateralized brain activation in monolinguals (Hull & Vaid, 2007), we will also conduct (3) exploratory analysis examining whether the structural architecture of SLF/AF in bilinguals is left-lateralized or hemispherically balanced (laterality analysis).

Participants are n=47 4-6-year-old children from diverse SES, racial/ethnic, and linguistic backgrounds with usable DTI and LENA data of home audio recordings. From the total sample (n=47), 25 children were categorized as bilingual based on their caregivers' responses to the LSBQ (Luk & Bialystok, 2013). Their LENA data were annotated for whether it contained only English, only non-English language(s), both English and non-English languages, or no speech. Thus, we derived a continuous measure of bilingualism such that 0 indicated equal amounts of English and non-English (balanced bilingual), and 1 indicated either fully English or fully non-English (monolingual). The DTI data will be preprocessed using the robust QSIPrep 0.12.1 pipeline (Cieslak et al., 2021). Hypotheses #1 and #2 will be tested using the Automated Fiber-Tract Quantification (AFQ; Yeatman et al., 2012; 2018). Lateralization (hypothesis #3) will be examined by creating an average fractional anisotropy index across both whole SLF and AF, and, subsequently, estimating the leftward asymmetry of activation in SLF/AF correspondingly.

This is the first known study to examine how early bilingualism shapes the neuroanatomy of language-supporting white matter tracts in SES-, racial/ethnically-, and linguistically diverse children as young as 4-6 years old.

P1-C-13 - Neonatal tactile prediction is associated with sleep quality at age two in children born preterm (WIP)

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Summary: Children born preterm are at higher risk of neurodevelopmental and sleep disorders. To better understand these trajectories, this study explores whether neonatal sensory prediction, an early marker of brain development, is associated with sleep quality at age two.

Details: Children born preterm are at heightened risk for atypical developmental trajectories, including neurodevelopmental disorders (NDDs). Sleep disorders (SDs) are also frequently observed in both children born preterm and those diagnosed with NDDs. Sleep plays a critical role in development,supporting synaptic pruning, brain plasticity, memory consolidation, emotional regulation… Consequently, early sleep disturbances may have lasting effects on neurodevelopment, potentially both resulting from and contributing to atypical brain function.

This longitudinal study (in progress) aims to determine whether a neonatal brain marker—tactile sensory prediction (SP)—predicts later sleep disturbances. SP refers to the brain's ability to anticipate sensory stimuli and modulate its response to repetitive and non-relevant inputs, a mechanism known as repetition suppression (RS). We assessed SP and RS using a tactile oddball-omission stimulation protocol at 35 weeks corrected gestational age in preterm newborns, measuring brain responses using electroencephalography (EEG). At age two, sleep quality is assessed using a combination of one-week actigraphy data, a sleep diary, and a parental screening questionnaire (SDSC-Y). Principal component analysis is used to derive composite sleep quality indices for subsequent regression analyses.

To date, two-year follow-up data have been collected for 33 children out of the 90 newborns initially included in the Neonatal measures. Preliminary results suggest an association between neonatal SP and RS amplitudes and sleep quality at age two. This study aims to improve our understanding of the early mechanisms underlying NDDs and SDs, and to inform new strategies for early prevention and intervention.

P1-C-14 Flexible autonomic nervous system dynamics underlie attentional control in infancy

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Summary: We apply a non-linear analytical method to quantify autonomic underpinnings of attentional control in infancy. Understanding how physiological processes contribute to development of attentional abilities can clarify the underlying mechanisms and potentially inform future research into individual differences in typical and atypical cognition.

Details: The autonomic nervous system, although relatively understudied compared to the central nervous system, is thought to play a key role in supporting attentional control, a cornerstone of cognitive control in early development. To address the non-trivial challenges autonomic signals present to traditional modeling, we leverage recurrence quantification analysis (RQA), an established nonlinear approach for quantifying autonomic influences on heart-rate activity (Figure 1). Using RQA, we examine trait level (long timescale) and state level (moment-by-moment timescale) autonomic dynamics in relation to infants' attentional engagement with objects in a cross-cultural sample from Singapore and Brazil (N = 77 (NSingapore = 32, NBrazil = 45), Age = 13.79 ± 4.14 months). Across both state and trait levels, lower physiological recurrence is consistently associated with greater attentional engagement (Figure 2). At the trait level, we observe significant individual differences reflected in cultural variation (higher recurrence in Brazilian infants; $B = 0.40$, $p < 0.01$) and age-related increases in recurrence ($p < 0.05$) (Figure 3). At the state level, recurrence sensitively differentiates subtle differences across engagement phases ($p < 0.001$), distinguishes periods of attentional engagement from disengagement ($p's < 0.001$), and captures dynamics surrounding transitions between engagement phases ($p < 0.01$). Importantly, this study highlights both unique and shared contributions of state and trait-level autonomic processes to attentional control. We suggest that decreases in physiological recurrence (at both trait and state levels) indicate enhanced autonomic flexibility arising from stronger parasympathetic contribution, which is crucial for early attentional control.

P1-C-15 Characterising cortical depth-dependent BOLD responses in the neonatal primary visual cortex using ultra-high field fMRI

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Summary: Despite its importance across the lifespan, the development of the visual system is protracted in early infancy. Using 7T fMRI, we aim to explore how differences in depth-dependent cortical activation can provide new insight into the developing neurobiology of the neonatal visual system.

Details: Introduction: The visual system undergoes prolonged development during early life, continuing into early childhood 1,2. However, this contrasts with maturation of the underlying anatomical organisation of the primary visual cortex (V1), which is established prenatally 3. Functional maturation of V1 in this period is poorly understood, with early functional MRI (fMRI) visual studies during early infancy describing both positive and/or negative blood-oxygenation-level-dependent (BOLD) responses 4,5,6. This uncertainty can be resolved with 7 Tesla (T) MRI, which offers marked increases in functional contrast and signal-to-noise ratio, even enabling study of cortical-depth-dependent BOLD responses in V1 to provide insight into its functional and neurovascular maturation. We hypothesised that neonatal V1 BOLD responses across cortical depths will differ from adults due to ongoing development of cortical function, physiology and vasculature.

Methods: NHS research ethics approval and written consent were attained for data collection. Data were acquired from five healthy term-age neonates (38.14 weeks post-menstrual age (PMA) at scan, range: 35.29-41.00 PMA, four male) during natural sleep and four adults with eyes closed (median: 27 years old, range: 22-27 years, one male) using a 7T system. BOLD-weighted fMRI data were acquired (parameters: Table 1) with 26.6 s blocks of an 8Hz flickering visual stimulation (Figure 1). Data were pre-processed with age-optimised pipelines, and whole cortical thickness ROIs were manually defined inferior to the calcarine sulcus. ROIs were split into three equi-volume depths using LAYNII 7 and then used to extract depth-specific timeseries.

Results: fMRI data were successfully acquired in all participants. Large clusters of positive BOLD activation were identified around the calcarine sulcus in V1 across all neonates and adults (Figure 2). In adults, the trial-averaged BOLD response was positive across all cortical depths, peaking at 6% at 6 s, followed by a small post-stimulus undershoot. In the neonate, the BOLD response was delayed and temporally dispersed, peaking at 2% around 14 s until returning to baseline around 22 s post-stimulus (Figure 3).

Discussion: We demonstrate robust positive BOLD activation in V1 across all three cortical depths in response to visual stimulation in term neonates, indicating the presence of functional hyperaemia. This contrasts with earlier studies at lower field strengths (1.5 and 3T) which reported negative and/or positive BOLD responses. Our findings likely represent the increased sensitivity to BOLD in the cortical microvasculature at 7T8. Compared to adults, the neonatal depth-dependent BOLD response was lower in amplitude, delayed, and more temporally dispersed, perhaps due to substantive differences in cerebral physiology, vascular architecture and neurovascular coupling9,10. Ultra-high field fMRI allows detailed characterisation of positive depth-specific BOLD response profiles in the developing brain, advancing our understanding of the establishment of layer-specific functional circuitry

[1]Kiorpes et al. J Neurosci. 2016; [2]Lewis & Maurer. Dev Psychobiol. 2005; [3]Farley et al. J Neurosci. 2007; [4]Lee et al. Developmental Medicine & Child Neurology. 2012; [5]Born et al. Pediatric Research. 1998; [6]Viessmann & Polimeni. Curr Opin Behav Sci. 2021; [7]Huber et al. NeuroImage. 2021; [8]Yacoub et al. Magn Reson Med. 2001; [9]Harris et al. Dev Cogn Neurosci. 2011; [10]Kozberg & Hillman. Prog Brain Res. 2016

P1-C-17 Neurodevelopmental foundations of pretend play

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Details: Play is a fundamental part of childhood, supporting cognitive development and learning (Hoffmann 2012). Pretend play, in particular, allows children to explore social roles and simulate various situations safely through imagination (Pellis 2014). Although the behavioral importance of play is well established, its underlying neural mechanisms remain poorly understood. Given the known role of the default mode network (DMN) in supporting creativity in adults (Beaty 2016, Lee 2021), we hypothesized that the development of play behavior is closely linked to the maturation and reorganization of the DMN and its interactions with other brain networks.

To test this, we analyzed data from the Baby Connectome Project (Howell, 2019), focusing on infancy (6 months to 3 years). This dataset included behavioral assessments of play from the Infant-Toddler Social and Emotional Assessment. We measured within- and between-network functional connectivity between the DMN and networks defined in the 7-network Yeo atlas (Preregistered: https://osf.io/nm72b). As an exploratory analysis, we also examined data from childhood (ages 4 to 10), using neuroimaging data collected in our lab and parent-rated play behavior from the Literacy and Numeracy questionnaire. We replicated our findings using child-specific 7-network Yeo atlas (Tooley, 2021).

In infancy, play scores increased with age ($R^2 = 0.113$, $P < 0.001$) and within-network connectivity of the DMN increased ($R^2 = 0.065$, $P_{FDR} < 0.001$). After controlling for age, sex, and head motion, stronger DMN connectivity was significantly associated with higher play scores ($R^2 = 0.012$, $P_{FDR} = 0.043$). In childhood, play scores decreased with age ($R^2 = 0.056$, $P = 0.038$), and connectivity between the DMN and the ventral attention network declined ($R^2 = 0.372$, $P_{FDR} = 0.014$). Children with higher, or less mature, DMN–ventral attention connectivity showed higher levels of play ($R^2 = 0.051$, $P_{FDR} = 0.014$), suggesting that increasing segregation between these networks may limit spontaneous imaginative play.

Overall, the findings point to a developmental pattern in which changes in network architecture co-occur with changes in play behavior. In infancy, greater within-network integration in the DMN coincides with increases in pretend play, while in childhood, increased network segregation was observed alongside reduced pretend play. As societal and educational contexts increasingly emphasize academic outcomes, it is crucial to consider the potential neural costs of fostering repetitive training and limiting free play in infancy and early childhood.

D – Developmental Psychology

P1-D-18 The role of the Neonatal Hypothalamus in early sleep development

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Summary: Sleep is crucial for infant development yet the brain mechanisms underlying early sleep regulation remain underexplored. We investigated whether neonatal hypothalamus volume predicts sleep development over the first two years of life.

Details: Introduction: Sleep is crucial for health and well-being throughout the lifespan but in infancy in particular. Infants spend more time asleep than at any other stage in life. Sleep during infancy is necessary to support healthy neurodevelopment, yet the brain mechanisms underlying early sleep regulation remain underexplored. The hypothalamus plays a key role in sleep homeostasis, particularly in establishing the sleep-wake cycle. Animal studies show that hypothalamic lesions cause severe sleep disruptions, but human research—especially in infants—is scarce.

Studying the hypothalamus in infancy has been challenging due to its small size and it is not included in common infant MRI segmentation pipelines such as BIBSNET. However, a newly developed and validated segmentation approach, segATLAS (Rasmussen et al., 2024), enables reliable hypothalamus segmentation in neonates.

Existing studies on hypothalamic volume and sleep in adults report mixed findings. In Parkinson's disease, smaller hypothalamic volumes have been linked to lower melatonin levels, whereas insomnia patients show larger hypothalamic volumes than healthy controls. However, the cross-sectional nature of these studies leaves open the question of whether these volume differences are causes or compensatory changes.

To our knowledge, this is the first study to examine the association between neonatal hypothalamus volume and sleep development over the first two years of life.

Methods: Neonatal hypothalamic volume was segmented using the segATLAS pipeline, which registers FreeSurfer-compatible MNI hypothalamic subfields onto the Baby Connectome Project atlas and then maps them to native infant space. Night sleep duration was assessed through maternal report at 3, 6, 9, 12, 18, and 24 months.

After quality control, data from 88 healthy infants (45 girls, gestational age = 39.53 ± 1.55 weeks, scan age = 29.51 ± 11.03 days) were available, with a total of 360 sleep reports. We used linear mixed-effects models to estimate the association between hypothalamus volume and night sleep duration, including a random intercept and slope and fixed effects for age, hypothalamus volume (residualized for gestational age, scan age, and sex), and their interaction.

Results: The interaction between age and hypothalamus volume was significant ($\beta = 0.10$, $t(270) = 2.28$, $p = 0.02$), indicating that infants with larger hypothalamic volumes exhibited a steeper increase in night sleep duration over time. There was no main effect of hypothalamic volume on night sleep duration. A significant age effect was observed, with night sleep duration increasing over the first two years.

Discussion: These findings suggest that neonatal hypothalamus volume plays a role in the maturation of circadian sleep rhythms, with larger volumes associated with greater night sleep consolidation over time. Future work will examine hypothalamic white matter integrity and functional connectivity to further elucidate its role in early sleep regulation.

P1-D-19 Measuring pre-speech and language development among infants with oral cleft: Feasibility of a study to enhance understanding of mechanisms that impact outcomes and guide clinical decisions

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Summary: Children with oral cleft experience significant issues with speech and language. The complex interplay of mechanisms impacting these outcomes are poorly understood. This feasibility study assessed changes in pre-speech, language, and neural structure/activation measures across the 16 months of life.

Details: Objective: The objective of the current study is to provide feasibility of a study design that evaluates pre-speech and language development across the first years of life, differences in infants with oral cleft, and relationship to neural structure.

Methods: Longitudinal observational study with visits at 2 months, 6-8 months, and 14-16 months of age. Baseline assessment included vocal acoustic recording, parental ratings of emergent language, functional near-infrared spectroscopy (fNIRS) auditory processing task, and structural magnetic resonance imaging (MRI). Return visits repeated all measures, except for the MRI. Pending 2 final visits, descriptive and inferential statistics for a) retention and success rates, b) change trajectories for each measure, and c) associations between each measure will be presented.

Results: Ten control infants (50% male) and 10 infants with oral cleft (70% male) were enrolled and tested at visits 1 (2.2 ±0.4 months). Nineteen returned for visit 2 (7.2 ±0.6 months) and 16 have returned for follow-up at visit 3 (15.1 ±0.6 months; with two more scheduled at the time of this submission). Success rates for data collection are currently moderate to high: 80-90% vocal recordings, 100% emergent language ratings, 63-73% fNIRS, and 60-80% MRI. Ratings of emergent language demonstrate expected growth curves; where infants with cleft have slower growth in expressive language. Vocal complexity also reflects changes, without significant group differences. Neural activation shows a subtle shift in left, anterior fronto-temporal activation with age during infant-directed speech. Currently, relationships between early and later vocal acoustics and emergent language ratings are low. However, more mature vocal acoustics are associated with increased left and decreased right fronto-temporal activation during infant-directed speech. Further, decreased white matter is associated with immature vocal acoustics at visit 1, but more mature acoustics at visit 2.

Conclusions: This feasibility project demonstrates feasibility of obtaining data, the importance of collecting various measures of pre-speech/language development, and potential associations to neural activation and structure. Results from the larger study will enhance understanding of this developmental period in the general population and provide essential information to improve clinical decision-making for patients with oral cleft.

P1-D-20 Neurophysiological habituation and sensory reactivity differences across behavioral habituation patterns in autistic children

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Summary: Reduced neurophysiological habituation was linked to differences in responses to sensory stimuli, which may underlie reduced behavioral habituation in autism. Yet, how these neurophysiological and sensory features differ across behavioral habituation classifications remains unclear, limiting our understanding of processing differences in autism.

Details: The current study examines how neurophysiological habituation and sensory reactivity patterns differ as a function of behavioral habituation classifications in autistic children.

70 autistic children aged 3-6 years participated, and usable data were obtained from 38 children (Mean age=4.14, SD=.87). Neurophysiological habituation (P50 and N100 components) was derived from a 100-trial Paired-Click paradigm using an EGI 124-electrode system. Sensory Processing Assessment for Young Children (SPA; Baranek et al., 1999) was used to assess behavioral habituation through response patterns to a repeated phone ring, as well as sensory reactivity features (hypo-, hyper-reactivity, and sensory seeking). Behavioral habituation responses were categorized into three patterns: 1.Habituating (decrease in response); 2.Nonresponding (no response); 3.Hyper-responding (responds to most trails, no decrease in response). General linear models (GLM) were used to examine the differences in both the P50 and N100 amplitudes and sensory reactivity features between the three habituation classifications.

The GLM revealed a significant main effect of behavioral habituation classifications ($F(2,61)=3.83$, $p=.027$), with higher hypo-reactivity scores in Nonresponding children ($M=2.92$) than in Habituating children ($M=2.21$;$t(63)=-2.74$, $p=.008$). Another significant main effect for behavioral habituation patterns was found ($F(2,61)=3.59$, $p=.033$), with higher sensory seeking scores in Hyper-responding children ($M=2.91$) than in Habituating children ($M=2.26$; $t(63)=-2.21$, $p=.031$). For neurophysiological habituation, there was a marginal effect ($F(1,31)=4.13$, $p=.051$), with smaller N100 amplitude in the left hemisphere for Nonresponding ($M=5.17$) compared to Habituating children ($M=-.54$; $t(32)=-2.03$, $p=.051$). No significant differences were found with the P50 component (ps > .39).

Autistic children classified as Nonresponding (i.e.,showed no behavioral habituation) also showed increased hypo-reactivity and a trend toward reduced neurophysiological habituation, possibly due to reduced sensory registration from decreased sensory gating. In contrast, Hyper-responding children did not differ in neurophysiological habituation from children in the other habituation groups but showed increased sensory seeking compared to Habituating children. This suggests that behavioral hyper-responsivity may reflect sensory craving, though the underlying neurophysiological mechanism remains unclear. Notably, only Nonresponding children showed a trend towards reduced neurophysiological habituation, suggesting that additional factors may shape the relationship between behavior and physiology. It is possible that these children either failed to register the stimuli or registered too much due to low sensory filtering, leading to overstimulation and difficulty prioritizing responses—suggesting that the same external, observable behavior may reflect different underlying neurophysiological processes.

These findings underscore the need to examine neurophysiological processes underlying similar clinically observable behaviors in autism that have critical impact on developmental and clinical outcomes. Understanding these mechanisms is key, as atypical habituation can interfere with learning and daily participation, hence, has a cascading impact on development. Further, greater awareness of differences in neurophysiological processing may also help clinicians better understand and support autistic children's needs.

P1-D-21 Can early neural responses to objects in infants' ventral visual stream predict language development?

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Summary: This study investigates the link between early visual object processing and subsequent vocabulary development. We hypothesise that distinct object representations in the ventral visual pathway during infancy will aid in the production of object labels at 2 years old.

Details: Preverbally, infants rely on vision to build an understanding of objects in their environment. The ventral stream of vision is crucial for object recognition, forming mental representations that may support subsequent word learning. However, the degree to which preverbal visual representations underpin word development remains unclear. This longitudinal study investigated the relationship between neural responses to objects in the ventral stream of 2-month-old (n=101) and 9-month-old (n=44) infants and their vocabulary production at 2 years. We predicted that infants with more distinct neural responses to objects during infancy would show earlier production of these object labels. Awake functional MRI measured infants' neural responses to various categories of objects during the first year of life. Language development was assessed at 24-31 months old (mean age = 26 months) using the MacArthur Bates Communicative Development Inventory. Representational similarity analysis examined the structure of visual representations in infancy, which could then be compared to CDI measures of language production. To further quantify the semantic structure in infant visual representations, we explored whether correspondence to a language based artificial neural network predicted later word learning.

There was a small, non-significant trend that suggested objects whose labels were produced at 2 years had more distinct visual representations at 2 and 9 months. Our hypothesis that categorical responses to objects relate to later word learning was therefore not supported. However, infants with similar visual representations to features extracted from a DNN trained on lexical input exhibited stronger later word development. Evidence suggests a structured development of visual representations in the initial year of life. While the limitations limit definitive conclusions regarding later word learning, the potential of computational models to provide insights into this relationship is noteworthy. Future work should be directed towards a more rigorous examination of the interplay between early visual organization and subsequent lexical development.

P1-D-22 Foetal auditory perception: Heart rate responses to music during late gestation

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Summary: The present study measures foetal heart rate to see if late-term foetuses have the ability to discriminate musical timbres and harmonies. The results will add to the existing knowledge of foetal auditory processing capacities and will help us to understand how foetuses perceive the world around them.

Details: Music is a human universal and is commonly known for its beneficial effect on well-being and development. Prenatal music perception has, however, only been partially investigated. Previous studies have shown that some basic musical processes are already present during the third trimester of pregnancy, but more complex mechanisms, such as timbre and harmony perception have not yet been investigated during gestation. Newborns already show timbre and harmony processing, and, given the prenatal origin of many neonatal competences, these musical abilities might also start during gestation. The present study investigates if foetuses between 35-37 weeks of gestation can discriminate between musical timbres and harmonies.

Experiment 1 uses a clarinet, a trumpet, and a violin timbre while Experiment 2 uses various major and minor chords. Both experiments are divided into several sound and silence blocks. Foetal heart rate (FHR) will be measured with a cardiotocograph and 2D-ultrasound will be used to perform foetal check-ups to confirm typical development of the foetus, to ensure the correct placement of the probes, and to monitor foetal movements during the experiments.

It is hypothesised that we will see an initial decrease in the FHR after stimulus presentation as part of an orienting response, followed by a slowly decreasing heart rate acceleration, as has been shown in previous FHR studies. This response will decrease during individual sound blocks, showing habituation to the repeatedly presented stimulus. If foetuses are able to discriminate musical timbres and harmonies, it is expected to see an increase in the FHR response when a new stimulus is being introduced.

FHR will be analysed in two separate two-way repeated analyses of variances to compare foetal responses to the different timbres and to major and minor chords.

The results will add to the existing knowledge of foetal auditory processing capacities, in particular to timbre and harmony perception. The findings from this study will strengthen our understanding of how foetuses perceive the world around them. Understanding the natural environment of foetuses and knowing which auditory abilities are present during gestation will help to inform policies of auditory stimulation in artificial environments, like neonatal intensive care units. This will help to build optimised environments to allow typical development of hospitalised preterm infants and newborns.

P1-D-24 The cortical scene processing network emerges in infancy, prior to independent navigation experience

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Summary: How do category-selective brain areas develop in the human cortex? Here we used fMRI in awake 2-9-month-old infants to show that scene-selective regions develop within a few months of visual exposure, and prior to active experience using scene information to navigate independently, placing powerful constraints on potential developmental mechanisms.

Details: Using vision to recognize and navigate the local visual environment, or "scene", is fundamental for healthy, independent human living. By adulthood, human cortex contains at least three regions that respond selectively to visual scene information, but it remains unknown when or how these regions develop. One hypothesis is that scene selectivity emerges gradually in regions that initially prefer low-level visual features associated with scene processing (e.g., peripheral visual input, high spatial frequencies), with development driven by exposure to the visual statistics of natural scenes. An alternative hypothesis is that scene selectivity is already present early on in infancy, with later development driven by active experience (e.g., using visual scene information to navigate). To address these possibilities, we collected low-motion functional magnetic resonance imaging data from awake 2–9-month-old infants, most of whom had never independently navigated (e.g., by crawling). Infants watched videos of real-world scenes with ego-motion, as well as faces, objects, and block-scrambled versions of the scene videos. We found stronger responses to scenes than control conditions in the location of each of the three adult scene regions. Scene-selective responses could not be explained by low-level visual properties of the stimuli, and were found even when analyses were limited to pre-crawling infants only, or younger infants less than 5.3 months old. Scene-selective regions therefore emerge prior to active navigation experience, and after only limited exposure to visual scene statistics.

P1-D-25 Investigating brain specialization for song and speech at birth

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Summary: In this work we used NIRS to investigate whether, at birth, human speech, non-linguistic melodies and songs are processed by similar neural pathways, or whether they elicit different functional patterns in relation to the different content they carry (linguistic, musical or both, respectively).

Details: Objectives. For humans, speech and music represent the most abstract, structured, and therefore cognitively complex, use of sounds. Processing both speech and music requires perceiving and integrating their distinctive, although in some respects similar,

acoustic dimensions (Albouy et al., 2020). Several studies in the literature have extensively explored similarities and differences in how the adult brain perceives music and speech (Peretz & Zatorre, 2005; Zatorre, 2013). By contrast, little is known about whether infants, and especially newborns, process these two types of auditory stimuli similarly. Existing studies suggest that the newborn brain is already lateralized for the prenatally heard language (e.g., Peña et al. 2003, Sato et al. 2011), activating the left auditory cortex, as well as for instrumental music, activating the right auditory cortex (Perani et al., 2010; Perani, 2012). However, there is little evidence about the neurocognitive mechanisms underlying the perception of song at birth. Processing song is particularly relevant, as it requires processing musical and linguistic information simultaneously. Importantly, song is a natural ecological stimulus for young infants, as caregivers often hum or sing spontaneously, even if they don't have formal musical education. In this work, we therefore explore how the newborn brain processes vocal sounds, i.e., speech, song and hummed melodies at birth.

Methods: 70 healthy full-term (GA: 37- 42w, 40 females) neonates were recruited and tested at the Maternity Ward of the Padua University Hospital in Padua. Of these, 40 Italian newborns were included in the final analyses. We used near-infrared spectroscopy (fNIRS) to measure the brain responses in the frontal, temporal, and parietal areas bilaterally while newborns listened to three auditory conditions: (i) speech utterances in Italian (Speech); (ii) sung songs in Italian (Song); and (iii) hummed song melody (Hummed). Spoken sentences carry linguistic information; sung sentences add a melodic component to speech, while hummed melody only carries the musical component, without linguistic information. After standard pre-processing of the fNIRS data (Gemignani & Gervain, 2021), statistical analyses were conducted using cluster-based permutation tests.

Results: The statistical analysis revealed a right-lateralized cluster of channels (Figure 1) displaying a main effect of Condition, both in HbO and HbR, carried by significantly larger responses for both Speech and Song compared to Hummed. Thus, we found that, already at birth, infants discriminate between these three acoustic dimensions, with different neural responses for songs, speech and hummed melody in right temporoparietal areas, known to be involved in processing both prosodic and melodic information. To disentangle which of the specific acoustic components characterize these three types of stimuli are responsible for the different brain activations, supplementary acoustic analyses of the stimuli are currently ongoing.

Overall, this work is bringing important insights in the understanding of whether music and language, and more specifically song and speech, rely on distinct or overlapping neural mechanisms, highlighting that both biological and experience-dependent factors underpinning their perception are already present at birth.

P1-D-26 Activity evoked in multiple demand network of two- and nine-month-olds by naturalistic stimuli

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Summary: This study investigates early functional engagement of the Multiple Demand (MD) network in two-month-old infants. Using naturalistic fMRI and controlling for visual complexity and attentional salience, we show that higher-order brain networks are engaged earlier than traditionally believed.

Details: The infant frontal cortex was traditionally thought to develop late in childhood, with higher cognitive networks such as the Multiple Demand (MD) network maturing alongside executive functions. However, recent studies suggest earlier MD activity. Schettini et al. (2024) observed MD engagement in children aged 4–12, while Ellis et al. (2021) found that the frontal nodes of the MD supported attention in a cohort of infants 3–20 months. These findings suggest that the MD network may be functional from a much earlier age than previously thought.

The present study aims to investigate MD activity in its earliest stages in two-month-old infants. Two-month-old infants (n = 134), nine-month-old infants (n = 65), and adults (n = 18) watched six 22.5-second movies in pseudo-random order during fMRI scanning. Infant data were processed using Nipype, and adult data with fMRIPrep. Data with >50% motion artifacts were excluded, yielding a final sample of 126 two-month-old infants, 49 nine-month-old infants, and 16 adults. Fitted time courses were extracted from MD regions of interest (ROIs) in the MD network using a general linear model (GLM). Infant responses were then predicted via a leave-one-infant-out GLM for both the two-month-old and the nine-month-old group. To assess whether frontal activity reflected low-level stimulus features, we included two control measures. Visual complexity was measured by frame-wise entropy, with higher values indicating greater unpredictability. Attentional salience was estimated using STRA-Net to generate dynamic eye-fixation maps, from which we computed the RMS difference between frames to capture shifts in predicted attentional focus over time.

Two-month-old infants displayed consistent brain activation overlapping with MD regions. Nine-month-olds showed widespread, strong inter-subject consistency. When comparing across age groups, differences could be observed between two-month-olds and the older age groups. Entropy correlated with activity in the visual cortex but not in MD areas. Similarly, the STRA-Net RMS saliency measure showed activity in the ventral visual cortex (VVC) for both two-month-olds and nine-month-olds, while the visual complexity measure was associated with activation in the early visual cortex (EVC). Notably, neither measure explained activity in the MD network.

These results suggest that the MD network is already engaged as early as two months, supporting higher-order processing that appears independent of stimulus visual complexity and saliency attention. This engagement in the MD network differs from that observed in nine-month-olds and adults. Overall, these findings suggest the MD network contributes to cognition earlier than previously thought, with distinct developmental dynamics across age.

P1-D-27 Maternal and infant oxytocin are linked to EEG, stress, and temperament in infants of depressed and non-depressed mothers

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Summary: This study examined maternal and infant oxytocin levels in relation to infant temperament, EEG asymmetry, and mother-infant attachment. We explored associations between neurohormones, maternal mood, and neurophysiological profiles to understand early socioemotional development.

Details: Stress and depression are thought to neurologically program fetal and infant regulatory tendencies (Gartstein & Skinner, 2018). Despite their importance, few human studies examine both prenatal and postnatal bio-hormonal environments, which may be critical for understanding socioemotional developmental trajectories. The neurohormone oxytocin (OT) has been implicated in infant socio-emotional development and mother–infant bonding behaviors (Jones & Mize, 2022; Ziegler & Crockford, 2017). This study investigated maternal and infant OT levels in relation to individual differences in infant temperament, EEG asymmetry, and early attachment. Sixty-four mothers provided prenatal urine samples during the third trimester (29–38 weeks gestation) and again at 4 months postpartum. They also completed measures of depressive symptoms, maternal–fetal attachment (prenatal and postnatal), and infant feeding. OT was measured in both mothers and infants at two time points, alongside assessments of mother–infant interactions, infant EEG, and cortisol responsivity to stress at 4 months. Our analyses evaluated neurohormonal and neurophysiological regulation patterns in families both with and without maternal mental health risk. Maternal OT levels were significantly associated across time points ($r = .62$, $p < .001$), indicating stability, while infant OT levels were highly variable and not significantly correlated across time. Prenatal maternal depression and stress were positively correlated ($r = .33$, $p = .01$), and depressive symptoms remained relatively stable into the postpartum period ($r = .31$ to $.65$, $p < .05$). Infant OT levels during the early postnatal period were not significantly associated with maternal depression, but they were positively associated with infant inhibitory control at 4 months ($r = .74$, $p = .015$). Higher infant OT was also linked to increased anterior EEG asymmetry at central sites ($r = .79$, $p = .034$), suggesting greater left-hemispheric activity and a possible developmental shift toward anterior cortical engagement. Infant OT levels were inversely correlated with post-stress cortisol levels ($r = –.37$, $p = .011$) and with vocal reactivity ($r = –.53$, $p = .020$), suggesting regulatory associations between OT, stress responsivity, and temperament. Contrary to expectations, prenatal maternal attachment scores were not significantly predicted by maternal or infant OT levels. However, postnatal regression analyses revealed that maternal depression and OT together predicted 18% of the variance in maternal–infant bonding scores, with depression emerging as the stronger predictor ($p < .05$), while OT also contributed modestly ($p = .15$). Examining prenatal and postnatal neurohormonal risk factors alongside infant temperament provides insight into the early emergence of socioemotional regulation. These findings highlight potential biological pathways through which maternal mental health and infant neurohormones may jointly shape early brain–behavior development. Ongoing analyses will further investigate associations between neurohormonal profiles and cortical markers of regulatory functioning in both normative and at-risk populations.

P1-D-28 Neonatal neural activation and maternal-neonatal neural connectivity are modulated by skin-to-skin and affectionate touch in the first days after birth

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Summary: How mother-newborn tactile communication in the early neonatal period shapes the scaffolding of the socioemotional brain is not known. This study characterises the neural underpinnings of mother-newborn interaction by measuring maternal and neonatal brain synchronisation in response to skin-to-skin and affectionate touch just days after birth.

Details: Introduction: Mothers are the first, natural social partners of their newborn babies, who are born wired for interpersonal connection. Neonatal communication is primarily through affectionate physical touch, including skin-to-skin care and gentle stroking, which are crucial for the developing mother-infant bond and neurodevelopment across the lifespan. Affectionate touch is transmitted by unmyelinated, slow-conducting C-tactile afferents optimally activated by gentle, slow stroking. Very little is known, however, about how newborn babies' brains respond to—or how mothers' and newborns' brains engage during—affectionate touch.

Objective: The Brain Activation in Mother and BabY (BAMBY) study aimed to assess mothers' and newborn babies' neural responses to affectionate touch in the days after birth. Specifically, the BAMBY study characterised newborn neural activation, here desynchronisation of newborn electroencephalography (EEG) power ($\mu V^2/Hz$), and mother and newborn neural connectivity (within-brain and cross-brain), here voltage-normalised weighted phase lag index (normed wPLI), in neonatal theta (2–4 Hz) and alpha (5–7 Hz) frequency bands across social (skin-to-skin) and nonsocial (mother in bed, newborn in cot) contexts and across socially encoded (static touch and slow stroking) and non-socially encoded (fast stroking) touch types in the first hours or days after birth.

Methods: Hyperscanning EEG (synchronised via trigger box) was recorded from 37 mother-newborn dyads (21 male) across social context and touch type in a 2x3 factorial design (Figure 1). Median maternal age was 33 (range: 19-43) years, birth weight was 3390 (range: 2460-4925) grams, gestation was 39+3 (range: 37+0 to 41+6) weeks, and age was 1 day (range: 0-7 days). EEG preprocessing and analyses were conducted in EEGLAB for MATLAB. Neonatal sleep state was manually coded. Exploratory generalised regression modelling was conducted to select significant predictors for linear mixed-effects (LME) modelling of neural activation and neural connectivity (participant number as random effect). Post-hoc comparisons were conducted with Bonferroni-corrected p-values following significant effects ($ps < .05$) and trends ($ps < .10$).

Results: The BAMBY study reports for the first time that the human newborn brain shows event-related desynchronisation (decrease in power) and increased functional connectivity (increase in normed wPLI) in social compared to nonsocial contexts and during socially encoded compared to non-socially encoded touch types (Figures 2-3). Additionally, the BAMBY study reports the first evidence of a mother-newborn inter-brain neural network measurable just after birth that is responsive to these social and touch cues (Figure 3).

Furthermore, these neural responses are dependent on newborn sleep state, showing specificity to neonatal active sleep and not neonatal quiet sleep.

Conclusions: The BAMBY study finds that maternal touch cues coordinate the oscillatory responses of the newborn brain and elicit maternal-neonatal brain-to-brain synchrony even in the earliest moments of postnatal life. This evidence suggests that maternal touch may tune the newborn's social and emotional brain through reorganisation of newborn functional neural networks. These findings highlight the rich complexity of mother-newborn interaction at the neural level in the days after birth and provide compelling support for maternal touch interventions in the neonatal period.

P1-D-29 Intracranial volume as a neurodevelopmental marker: An umbrella review (WIP)

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Summary: Intracranial volume (ICV) is commonly used in early neuroimaging studies as a proxy for early brain development. However, its validity as a neurodevelopmental marker has not been systematically assessed. We aim to evaluate whether ICV meaningfully reflects fetal and early postnatal neurodevelopmental trajectories and risk for psychiatric outcomes.

Details: Objective: Intracranial volume (ICV) is frequently used in fetal and infant neuroimaging as a proxy for maximal brain size and early neurodevelopment. However, the assumptions underpinning its use, particularly regarding its developmental origins, sensitivity to environmental influences, and link to psychiatric risk, have not been comprehensively evaluated. This mixed-methods umbrella review investigates whether ICV can reliably serve as a neurodevelopmental marker, focusing on fetal and early postnatal brain growth, prenatal environmental exposures, psychiatric vulnerability, and shared genetic influences.

Methods: We conducted a systematic umbrella review of systematic reviews, meta-analyses, and selected empirical studies from EMBASE, MEDLINE, and Cochrane. Eligible studies examined ICV or its proxies (e.g., head circumference) in human populations from the prenatal period through early childhood. We synthesized findings across four domains: (1) normative ICV development from fetal life to toddlerhood; (2) effects of prenatal environmental exposures (e.g., maternal substance and medication use, nutrition, psychosocial stressors, chemical exposures); (3) associations between ICV and neurodevelopmental or psychiatric outcomes (e.g., ASD, ADHD, schizophrenia); and (4) genetic underpinnings of ICV. Due to limited review evidence, empirical genetic studies were included to capture heritable aspects of ICV relevant to developmental risk.

Preliminary insights: Initial findings suggest ICV is sensitive to a range of prenatal exposures, especially tobacco, alcohol, stimulants, and stress. Several psychiatric conditions, notably ADHD and schizophrenia, show altered ICV patterns. Genetic studies indicate substantial heritability of ICV, with emerging but modest overlaps with psychiatric risk variants, underscoring its potential as a developmental biomarker.

Conclusions: Although data synthesis is ongoing, early findings suggest that ICV is not a neutral anatomical measure but a biologically dynamic marker that reflects early life exposures and genetic liability. By integrating developmental, environmental, and genetic perspectives, this work-in-progress aspires to inform future imaging studies on when, and for whom, ICV may serve as a relevant marker of early neurodevelopmental trajectories and vulnerability.

P1-D-30 Parent-infant neural synchrony is impacted by experience and selective attention

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Summary: The current research examined parent-infant joint attention (i.e., attending to the same thing at the same time) by indexing synchronized brain activity between infants (6-, 9-, and 12-month) and their parents. Our research questions concerned how parent-infant brain synchrony is impacted by object familiarity and selective attention.

Details: Joint attention between parents and infants is an important developmental milestone that emerges in the first year of life and impacts later social and emotional development. Brain-to-brain synchrony has been reported when individuals experience and attend to the same thing simultaneously. However, it remains poorly understood how dyadic synchrony is impacted by experience and selective attention in a developmental population. The current study assessed how a brief associative label training session impacted joint attention in a cross-sectional sample of parent-infant dyads at 6- (n = 15), 9- (n = 16), and 12-months (n = 18). Dyads read books in which novel objects were associated with a label on day one and returned on day two when EEG was recorded while dyads were concurrently presented with images of trained (i.e., from the book) and untrained objects (i.e., novel objects not in the book). Importantly, each overlapping object flickered at a specific rate (i.e., 5 Hz, 6 Hz) to evoke frequency tagged steady-state visual evoked potentials (ssVEP). Here we leveraged this frequency tagging technique to assess (a) sensory and attentional biases and (b) parent-infant neural synchrony. Signal-to-noise ratios (SNRs) were computed to quantify the neural response to each concurrently presented stimulus. Analyses demonstrated that infants showed greater SNR to the trained stimulus while parents had greater SNR to the untrained stimulus, suggesting that prior experience is differentially guiding attention mechanisms between parents and infants. Inter-site phase-locking across the parent and infant topographies was used to index dyadic neural synchrony. Analyses of parent-infant synchrony showed greater phase-locking for the untrained stimulus than the trained stimulus, suggesting synchrony was more impacted by the parent's neural activity than the infant's. We further examined the effect of selective attention by using the trialwise SNR values to identify which object was selectively prioritized over the concurrent, competing object. Greater dyadic neural synchrony was found when an object was the attended stimulus, relative to the non-attended stimulus. This effect was consistent across trained and untrained objects and whether the infant's SNR or the parent's SNR was used to identify the attended stimulus. Together, results showed that while on average, attentional prioritization may differ within the dyad, selective attention effects in neural synchrony offer an important index of joint attention between parents and infants.

E – Early Life Stress

P1-E-31 Nutritional status over the first two years of life is related to EEG theta and beta power

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Summary: Malnutrition has wide-ranging effects on child development, yet the underlying mechanisms are not yet well known. We examine the timing and strength of relations between nutritional status and neurodevelopment over the first two years of life in Bangladeshi children, with the aim of probing the biologically embedding of nutrition in this context.

Details: Early malnutrition can have a host of consequences on the developing brain (Georgieff et al., 2018). Further research is needed to better understand the timing of these associations and which metrics of malnutrition best predict brain function. This project investigates longitudinal relations between early malnutrition and electroencephalography (EEG) in Dhaka, Bangladesh, a city with high rates of child malnutrition (NIPORT & ICF, 2023).

Common nutritional indicators were collected from participants (N = 130) at nine timepoints between 3 and 24 months of age. Height-for-age (HAZ), weight-for-height (WHZ), and weight-for-age (WAZ) Z-scores were calculated (with higher scores indicating better nutritional status), and linear mixed models were fit. The number of timepoints at which children were stunted (HAZ < -2), wasted (WHZ < -2), or underweight (WAZ < -2) were calculated to reflect cumulative malnutrition. EEG data were collected with a 128-channel net at 6 and 24 months of age and processed with HAPPE 4.0 (Gabard-Durnam et al., 2018) to extract absolute theta and beta power in key regions (Figure 1). Pearson correlations were computed to examine relations between malnutrition and EEG features.

We found that rates of malnutrition increased over the first two years of life as indexed by declining HAZ, WAZ, and WHZ over time, as well as rising rates of stunting, wasting, and underweight as children got older (Figure 2). Examining key relations between malnutrition and EEG (Figure 3), better nutritional status at 3 months of age (indexed by random intercepts for WAZ and WHZ) was positively related to theta power in multiple regions at 6 months, suggesting that children who start out better nourished at 3 months have higher theta power 3 months later. Children with a greater cumulative burden of malnutrition (indexed by more episodes of wasting or underweight) had higher beta power at 24 months in select regions. Notably, these associations are in the opposite direction to what has been found in most prior literature: higher theta and lower beta in malnourished children, warranting further investigation.

Overall, measures of malnutrition at 3 months of age appear to be better predictors of 6-month EEG measures, while measures of cumulative malnutrition may be better predictors of 24-month EEG measures. This research could inform context-specific, accurate identification strategies and earlier interventions to better support malnourished Bangladeshi children.

P1-E-32 Relationship between prenatal environmental unpredictability, neonate functional connectivity, and socioemotional functioning at 1 year

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Summary: Pregnancy is a unique period of biological and socioemotional transition. This project investigates the relationship between environmental unpredictability, an understudied domain of prenatal stress, and infant neural functional connectivity. We also examine prospective associations with socioemotional functioning at 1 year old.

Details: Objective: Prenatal stress is linked to cognitive, socioemotional, and physical health outcomes across the lifespan. However, research has yet to examine the domain of unpredictability. This is a critical gap given that ecological changes are prevalent during pregnancy (Saxbe et al., 2018) and understanding the role of environmental unpredictability may provide specific targets for intervention. Here we use resting-state (rs)-fMRI to test the effects of prenatal environmental unpredictability on infant amygdala functional connectivity (FC) and socioemotional functioning at 1 year old.

Methods: Participants were N=81 mother-infant dyads. Prenatal environmental unpredictability was operationalized as the number of parental job changes, residential moves, and changes in household member composition (Belsky, 2012; Doan & Evans, 2020). The number of prenatal occurrences were counted for each domain. Raw scores for household changes and residential moves were re-coded into three bins: 0 changes (0), 1-2 changes (1), and 3 or more changes (2). Occupational transitions were re-coded as follows: 0 changes (0), 1-3 changes (1), and 4 or more changes (2). Binned domain scores were summed to derive Total Unpredictability.

Infants completed a rs-fMRI scan (Mage =30.85, SD = 15 days) and data was preprocessed using FSL (Jenkinson et al., 2012) and AFNI (Cox, 1996). Seed-based whole-brain correlation analyses were used to estimate FC. Amygdala seeds were defined using bilateral parcellations from a neonate-specific atlas (Shi et al., 2011). Seed-based FC maps were obtained for each seed by extracting the mean fMRI time series and correlating with the time series of every other voxel. Network masks were derived using a t-test (voxel-wise $p < .001$, cluster correction alpha <.05, $t > 0$). Voxel-wise correlation analyses were performed to test associations between prenatal environmental unpredictability variables and amygdala to whole-brain FC.

Pearson's correlations were used to test prospective associations between neonatal FC, unpredictability, and socioemotional functioning at 1 year old in a subsample of infants (N=45). Socioemotional functioning was measured using the Brief Infant-Toddler Social and Emotional Assessment (BITSEA, Briggs-Gowan & Carter, 2006).

Results: Parental occupation changes were positively associated with left amygdala to left precentral and postcentral FC (Fig 1A). Similarly, parental occupation changes were positively associated with connectivity between the right amygdala and right postcenteral and parietal areas (Fig 1B). Parental occupation changes were negatively associated with left amygdala–left occipital gyrus FC (Fig 2). Residential moves were negatively associated with connectivity between the right amygdala and a cluster including the right cuneus and superior occipital gyrus (Fig 3).

Correlation analysis found that right amgydala–right occipital connectivity was positively associated with BITSEA competency scores (r = .30, p = .048) (Fig 4).

Conclusion: We found evidence that parental occupation changes and residential moves are associated with neonate amygdala FC with somatosensory, association, and occipital regions. Our findings also suggest that altered amygdala FC may be related to later socioemotional functioning. This research contributes to the growing literature on early stress by examining the understudied role of prenatal environmental unpredictability.

P1-E-33 The association of prenatal maternal depression and neonatal white matter microstructure: The moderating role of maternal exposure to childhood maltreatment

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Summary: Previous research indicates that prenatal maternal depression manifests differently in the body depending on if the pregnant woman has a history of childhood maltreatment. This study investigates if the association of prenatal maternal depression and neonatal white matter differs depending on a history of childhood maltreatment.

Details: Maternal depression during pregnancy has been associated with differences in the white matter microstructure of offspring with heterogeneous findings. The changes are likely mediated via biological signals. A reason for the varying results could be the moderating role of maternal exposure to childhood maltreatment (CM). Recent research has shown that the physiological state of pregnant women with higher depressive symptomatology differs depending on history of exposure to CM. The objective of this study was to extend these findings to the women's offspring, by examining whether the association of maternal depression during pregnancy and neonatal white matter microstructure is moderated by maternal exposure to CM.

The study population was comprised of 167 mother-infant dyads recruited from three study sites. Depression was quantified using the Centre for Epidemiologic Studies Depression Scale (CESD) throughout pregnancy. History of maternal exposure to CM was assessed using the Childhood Trauma Questionnaire (CTQ) at the first study visit. Soon after birth, diffusion weighted imaging was performed in the neonates (mean scan age: 28.23 days) and was processed using dmriprep. A study specific atlas was generated and the bilateral cingulum, fornices, uncinate fasciculi and the genu of the corpus callosum were extracted. Fractional anisotropy, axial diffusivity (AD) and radial diffusivity (RD) measures were computed for each tract for every subject. ComBat was used to harmonise the white matter microstructure measures to account for different scanners at the different study sites. A multivariate analysis was performed to quantify the association of the white matter microstructure measures with the interaction of maternal depression during pregnancy and maternal CM exposure.

Following multiple comparison correction, there was a statistically significant association between the white matter microstructure measures and the interaction of maternal depression and CM exposure in the right parahippocampal cingulum (p= 0.04893) and in the left and right uncinate fasciculus (p= 0.036729 for both) after adjusting for key covariates including gestational age at birth, scan age, sex, motion during scan, maternal use of anxiety/depression medication, and socioeconomic status. Further investigation of the individual white matter microstructure measures determined that both AD and RD were significantly associated with the interaction between maternal depression and CM exposure in all significant tracts (AD: p=0006286, p=0.0009285, p=0.001248 respectively. RD: p=0.009903, p=0.04007, p=0.0159 respectively). In the group that had experienced CM there was a positive association between maternal CESD score and neonatal AD and RD measures, whereas there was a negative association between the maternal CESD score and neonatal AD and RD measures in the group that had experienced no or a low level of CM. No associations were found with the left parahippocampal cingulum, bilateral dorsal cingulum, bilateral fornices, or the genu of the corpus callosum.

Thus, our findings suggest maternal depression during pregnancy has a diverging association with neonatal white matter diffusivity measures depending on the presence or absence of a history of CM. Depression as a consequence of CM may have a differential pathophysiology to depression independent of CM, which may exert differential effects on offspring white matter microstructure.

P1-E-34 Identifying regional changes in macro- and microstructure in neonates with hypoxic ischaemic encephalopathy

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Summary: Newborns with hypoxic-ischaemic encephalopathy (HIE) may have typical brain MRI appearances, yet still experience a range of long-term difficulties. We aimed to quantify subtle brain changes in HIE by comparison to healthy infants, helping us to understand the variety and evolution of early signs of injury that may be imperceptible to the eye.

Details: Objective: Identification of deviations in brain macrostructure and microstructure in neonates with Hypoxic-Ischaemic Encephalopathy (HIE) but no overt MRI lesions, using normative models of structural and diffusion MRI metrics derived from healthy controls.

Methods: MRI data from 462 healthy neonates were obtained from the Developing Human Connectome Project. 21 neonates with a clinical diagnosis of HIE were scanned using identical protocols. Structural T2-weighted and diffusion-weighted images were processed using standard neonatal pipelines to extract tissue volumes and diffusion metrics—Apparent Diffusion Coefficient (ADC) and Fractional Anisotropy (FA)—across 96 regions of interest. Normative models were built using Gaussian Process Regression (GPR), incorporating postmenstrual age (PMA) and days since birth as covariates. Z-scores were used to compare HIE cases to the normative distribution; values with |Z| > 2.6 were defined as major deviations.

Results: Normative models demonstrated expected developmental trends: absolute tissue volumes increased with PMA, especially in grey matter, while FA increased, and ADC decreased in white matter and subcortical structures. Relative tissue volumes remained largely stable with increasing age (Figs. 1, 3). In HIE neonates, 62% (13/21) exhibited at least one major deviation in raw volumetric data, and 71% (15/21) showed deviations in scaled tissue volumes. Affected regions varied between individuals. For diffusion metrics, 41% (7/17) showed major ADC deviations and 65% (11/17) showed FA deviations, most commonly in the corpus callosum and temporal lobe. In all cases, ADC and FA deviations occurred in opposite directions, with elevated ADC and reduced FA being most frequent (Figs. 2, 4).

Conclusions: Normative modelling reveals individual and region-specific abnormalities in brain development following HIE, even in the absence of visible lesions. These findings highlight the heterogeneity of injury patterns and underscore the value of quantitative MRI and normative references in detecting subtle early changes. This approach offers a foundation for personalised assessment and may inform future studies linking early deviations to neurodevelopmental outcomes.

G – Methods: Analytics/Statistics

P1-G-35 Pushing the boundaries of background functional connectivity for infant fNIRS data: Evaluating alternative analytical approaches

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Summary: Background functional connectivity (BGFC) analyses offer insights into infant neurodevelopment but are limited by task design constraints. This study refines analytic approaches to assess the feasibility of BGFC for infant fNIRS data, expanding its applicability for studying early brain function in diverse experimental designs.

Details: There is increasing interest in task-based functional connectivity analyses to examine the emergence of functional networks during specific cognitive states starting early in development (e.g., infancy). However, studying functional connectivity in infants presents unique methodological challenges including both participant-driven factors (i.e., number of trials completed) and current task design approaches (i.e., randomizing trials). Task-based neuroimaging studies must be carefully designed to collect sufficient high-quality data, while remaining sensitive to infants' developing motor and cognitive abilities. This limits the feasibility of certain analysis techniques, particularly those requiring a high number of trials or strict adherence to contiguous trial structures.

This study aims to expand established analysis approaches for infant functional connectivity studies by reanalysing an existing fNIRS dataset with a recognised signature of task-based functional connectivity. We assess the feasibility of moving away from conventional analyses that require several contiguous trials per condition - a requirement that is often impractical in infant studies. Instead, we explore whether background functional connectivity (BGFC) analyses, which utilises the residual neural response (i.e., what remains after removing task-evoked responses), can offer a more flexible and scalable approach.

To do so, we evaluate three analytic strategies: (1) downsampling, which systematically reduces the number of trials included to assess how many are necessary for well-powered analyses; (2) shuffling, which randomly reorders trial-level residuals within conditions to test whether connectivity patterns are driven by trial sequence; and (3) toward single-trial analysis, which examines whether connectivity measures can be meaningfully extracted from individual trial residuals.

Our findings indicate that downsampling was informative about the number of trials needed for well-powered analyses and the timing of the functional connectivity effect. Removing trials from the start of the block was not viable, but this approach was viable when trials were removed from the end. The shuffling approach was not viable, suggesting that trial order may be important for capturing meaningful connectivity patterns. Single-trial residual analyses revealed that while connectivity can be examined toward the level of individual trials, averaging trial-level residuals before performing connectivity analyses produced more robust and interpretable results.

These findings provide new insights into the methodological feasibility of background functional connectivity analyses for infant fNIRS data. By demonstrating that downsampling and averaged single-trial connectivity approaches are viable, our study highlights ways to enhance the accessibility and flexibility of task-based functional connectivity studies in infancy. These results have important implications for task design, as they suggest that strict adherence to contiguous trial structures may not be necessary, allowing researchers to design more adaptable and infant-friendly paradigms. Ultimately, this work contributes to advancing the methodological toolkit for studying functional brain networks in early development.

P1-G-36 Conditional fetal atlas learning for real-time tissue segmentation

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Summary: Fetal brain Magnetic resonance imaging (MRI) is challenged by protocol variability and individual developmental differences. We present a deep learning framework that generates age-specific templates, to standardize spatial and intensity features, enabling real-time segmentation, and visualization of neurotypical developmental trajectories.

Details: Magnetic resonance imaging (MRI) of the fetal brain has emerged as an increasingly valuable tool for in-vivo assessment of brain development and maturation. However, assessing neurodevelopmental changes remains challenging, mainly due to inter-individual variability in brain development, different scanner and imaging protocols, and intensity inhomogeneities. Additionally, the uncertainty in determining gestational age further complicates the evaluation process, requiring profound expertise. To address these limitations, brain atlases provide a standardised reference system, enabling mapping between subjects, thus objective assessment and improved intra- and inter-subject comparability. Here, we propose a continuous conditional atlas learning framework, called CAL-GAN, that enables both structural representation of the fetal brain and fast segmentation of new cases. CAL-GAN uses a U-Net-based, direct registration approach to generate sharp, age-specific atlases, and incorporates a discriminator to refine anatomical realism. The models are trained on our curated fetal brain dataset from the General Hospital of Vienna, encompassing 308 neurotypical

subjects between 21 and 37 weeks of gestation. Our results demonstrate that the proposed method can generate age-specific atlases with sharp structural boundaries and realistic shape variance. In addition, the proposed approach allows robust, real-time segmentation of previously unknown subjects. Thereby, achieving a high overall Dice similarity coefficient of 85.5% across six selected tissue labels. Finally, we demonstrate how volumetric analysis of these atlases elucidates neurotypical growth trajectories, offering insights into fetal brain development. The proposed deep learning framework enables real-time, age-specific fetal brain templates with minimal preprocessing, allowing for individualized developmental assessment. It achieves segmentation accuracy comparable to conventional approaches while operating significantly faster. Additionally, the framework allows further extensions, such as applications to specific diseases and integration with other imaging modalities such as ultrasound, expanding its potential for research and clinical use.

P1-G-37 Baby brain gradients revealed by functional harmonics

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Summary: We aim to understand how the human brain is organized at birth. Using brain scans from over 700 newborns, we mapped large-scale patterns of brain activity to reveal early foundations of functional organization and how they may guide later development.

Details: Background: Understanding the functional organization of the human brain is a fundamental question in neuroscience. Recent studies have highlighted structural brain gradients as a novel approach to comprehend the organization of functionally specialized areas and canonical brain networks.

Methods: In this study, we mapped the gradients in the neonatal brain using functional connectome harmonics (functional harmonics). We analyzed fMRI data from 714 sleeping neonates to explore the sensory-to-multimodal main brain gradient and the main axes of embryological development.

Results: Our findings reveal that the neonatal brain exhibits an adult-like sensory-to-multimodal gradient while retaining key embryological development axes. Functional harmonics showed strong correlations with primary adult functional gradient patterns, gene expression gradients, cognitive functions, and developmental expansion. Additionally, two brain metrics: power (total information flow) and entropy (degree of disorder) derived from the dot product of individual time points in the fMRI data across time reveal that that power increases and entropy decreases with increasing postmenstrual age, with robust associations to age, sex, and preterm birth.

Discussion: The observed decrease in entropy suggests a shift toward greater neural stability and efficiency. In contrast, the increase in power may reflect enhanced global integration of neural signals, a greater capacity for information processing, or an overall strengthening of functional connectivity within the developing brain. Overall, our study reveals that functional harmonics may underlie cortical and subcortical brain gradient ontogeny in neonates. The associated fundamental principles suggest that brain gradients can be valuable for studies across the human lifespan, providing a deeper understanding of brain development and organization.

H – Methods: Data Acquisition

P1-H-38 Modeling early cortical development with human brain organoids: Time-dependent mean diffusivity as a proxy for fetal-stage water exchange biomarkers

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Summary: Imaging fetal (cortical) brain development in vivo is challenging for technical and ethical reasons. Brain cortical organoids offer an in vitro model, but non-invasive markers of maturation are needed. This study evaluates whether time-dependent diffusion MRI reveals microstructural features and water exchange relevant to fetal brain development.

Details: Cortical development shapes cognitive function and brain health, with abnormalities linked to neurological disorders [1,2]. Key transitions in associative neuron maturation begin in utero and extend through early childhood [3]. Studying the late fetal or preterm period—characterized by dendritic differentiation and neuronal aggregation—remains challenging in vivo due to ethical and technical constraints. Brain organoids derived from induced pluripotent stem cells iPSCs provide an in vitro model that replicates key aspects of fetal cortical development while avoiding ethical concerns [4]. We used diffusion MRI (dMRI) to assess microstructural maturation in cortical organoids derived from healthy donor hiPSCs (NeuroNA Human Cellular Neuroscience Platform), applying DTI/DKI metrics [5,6] and examining diffusion time-dependence to evaluate features relevant to fetal cortical maturation. Nine brain organoids (~2 mm) were cultured for 4.5 months and combined into three assembloids (~4 mm). Organoids were fixed in 4% paraformaldehyde for up to 2 hours (based on size and ~1 mm/h diffusion rate), with swirling for uniform fixation, then washed in PBS and stored. Assembloids were scanned at 9.4T Bruker MRI CryoProbe (CIBM, Lausanne) and stabilized in agar within syringe holders. dMRI was acquired with a PGSE EPI sequence using b-values [1, 2, 3.5, 5, 7] ms/μm², directions [12, 16, 24, 30, 40], and Δ = [15, 26, 38] ms with δ = 4.5 ms; four b=0 images per Δ. Other parameters: TE/TR = 54 ms/2.4 s, 0.2-mm resolution, 0.4-mm slice spacing; 50 min scan per Δ. Data were denoised (Patch2Self), corrected for artifacts (Gibbs ringing, FSL topup/eddy) [8], and fitted for DTI (b=1 ms/μm²) and DKI per Δ using DIPY. Mean diffusivity (MD) time-dependence was analyzed with the CEXI model [9], simulating exchange between intra- (spheres) and extracellular compartments using synthetic b=1 ms/μm² data. All organoids reached 4.5 months of development (Figure 1A). dMRI yielded high-quality signals across all samples (Figures 1B–C). Inner and outer cortical-like regions were segmented manually based on visual contrast. DKI was applied across diffusion times (Δ), revealing distinct microstructural signatures (Figure 2).

FA was low (<0.15) and decreased with Δ, suggesting high permeability and limited alignment. Slightly elevated FA in the outer ring may reflect early development of elongated pyramidal or glial processes. MD was consistently higher in outer regions, likely reflecting the accumulation of oligodendrocyte precursors and immature neurons during cortical plate formation [11], and increased with Δ in both zones (Figure 3B). This MD increase, unlike the typical Δ-dependent decrease in mature white matter [10], suggested dynamic transmembrane water exchange. To probe this mechanism, CEXI simulations were performed. With impermeable membranes, MD remained stable or declined (Figure 4A). Allowing permeability produced increasing MD with Δ, modulated by cell size and permeability (Figures 4B–C). MK decreased with Δ, consistent with blurred compartmental boundaries due to exchange. Time-dependent dMRI revealed a permeability-driven MD increase, consistent with water exchange between compartments. This exchange-sensitive MD profile aligns with early-stage cortical physiology and may represent a non-invasive proxy of fetal neurodevelopment. Organoids, while not fetal imaging surrogates, help in identifying relevant dMRI biomarkers to cortical development.

P1-H-39 Combining functional ultrasound and high-density diffuse optical tomography for whole brain connectivity imaging in the neonate (WIP)

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Summary: No whole brain functional connectivity imaging modality is currently available for neonatal brain monitoring at the bedside. This work, by combining functional ultrasound and high-density diffuse optical tomography imaging, will enable whole brain high spatial resolution images of neonatal functional connectivity.

Details: Functional connectivity (FC) imaging in newborns is considered a potential biomarker for early diagnosis of neurodevelopmental disorders. However, its clinical implementation using available imaging tools has been hampered by low-resolution cortical measurements (e.g. EEG, fNIRS) or challenges in neonatal use (e.g. fMRI). Here we combine two cutting-edge functional imaging technologies, functional ultrasound (fUS) and high density diffuse optical tomography (HD-DOT), for deep tissue and high spatial resolution neonatal functional mapping at the cot-side.

We acquired fUS and HD-DOT data on 12 healthy term neonates (postnatal day, d =1.8±1.0 days, gestational age, GA= 39.6±1.4 weeks) during sleep using a custom neonatal headcap (Fig A). The fUS probe was driven using custom ultrafast imaging sequences (3 tilted plane wave compounded at 600 Hz, before SVD filtering and power Doppler averaging) for imaging a contrast proportional to cerebral blood volume (CBV). The HD-DOT system enabled acquisition of light absorbance at 735 and 850 nm for 1728 (source-detector) multi-distance channels, enabling calculation of cortical total haemoglobin (HbT) concentration. The 2 systems were synchronised via a custom triggering system. We used photogrammetry to co-locate the optodes and fUS probe with the head (Fig B-C).

Despite imaging different contrasts (CBV vs HbT) and having different temporal resolutions, confocal fUS and HD-DOT channels showed very comparable temporal evolution in the resting state frequency band (0.01-0.1Hz). Quantitatively, we calculated the correlation between the CBV fUS signal cortical ROI (Fig D) and good quality (low variance, high optical intensity) HbT channels (Fig E). This showed higher correlations for the frontal channels around the ultrasound ROI (Fig F) compared to parietal channels (0.43±0.23 vs 0.15±0.25, $p<0.001$). The next step is to undertake HD-DOT image reconstruction in order to 1) refine the spatial extent of the correlation with the confocal fUS signal (Fig G) and 2) evaluate FC using multiple fUS ROIs and DOT cortical parcellation.

These first results shows that confocal fUS and HD-DOT measurement give very similar measurements of brain activity, through concurrent changes in CBV and HbT, respectively. This is the first important step in developing a system to map long-range thalamo-cortical and cortico-cortical connectivity in the developing brain in order to identify those at high risk of later neurodevelopmental problems.

P1-H-40 Feasibility of using OPM-MEG to assess early movements among infants with low and high risk for neuromotor impairment (WIP)

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Summary: Early spontaneous movements are powerful predictors of later neuromotor outcomes, yet their neural basis remains unclear. This application of novel OPM-MEG demonstrates the feasibility of capturing neural activity during these essential movement patterns in awake, supine infants at both low and high risk for neuromotor impairments.

Details: Optically pumped magnetometer magnetoencephalography (OPM-MEG) offers a unique, non-invasive, and infant-friendly method to assess neural activity underlying movement in a naturalistic setting, with typically behaving infants, while retaining high temporal and spatial resolution. Here, we demonstrate the feasibility of acquiring high-quality OPM-MEG data in infants aged 3-5 months, both with and without risk of neuromotor impairments, highlighting the potential future clinical applications of OPM-MEG.

Infants were scheduled for scanning during daytime hours when they were alert and active. Upon arrival, infants were fitted with OPM helmets and given time to acclimate before acquisition. Infants were moved into the magnetically shielded room and positioned supine on a metal-free table (Figure 1). Throughout the session, a research assistant remained in the room, and a video camera recorded the session for behavioral scoring and data alignment. A scan was considered successful if at least 5 minutes of unsaturated data were collected. Sensors were placed over bilateral sensorimotor areas to capture the neural activity associated with movements. Sensor-level analysis will be conducted to quantify beta-band activity in low- and high-risk infants, which has previously been demonstrated to be important for motor activity in the sensorimotor cortex.

This is a two-group cohort design including infants aged 3-5 months at high risk for neuromotor impairment (n=4) and those at low-risk in the same age range with no known risk factors (n=6). Infants were considered high-risk if they had at least one of the following risk factors: low birth weight, premature birth, multiple gestations, maternal infections or complications, and/or postnatal injury. This sample includes 10 infants with an average age of 4.4 months (SD = 0.79), 4 females and 6 males. Race and ethnicity include

Hispanic/Latino/a/x/e = 10% and White = 90%. To date, 9 out of 10 visits yielded usable OPM-MEG and motor behavior data, supporting the feasibility of this novel approach. Data quality and group differences in beta-band activity will be further analyzed and presented in the final phase of the study.

This pioneering work lays the foundation for a potentially transformative approach to understanding early brain function and movement in infants. By exploring real-time neural data, we open the door to earlier, more precise identification of neuromotor risks using an innovative approach to monitor and refine evidence-based rehabilitation interventions, ultimately enhancing care for children.

P1-H-41 Visual gamma oscillations in early childhood measured by optically pumped magnetometer-based MEG

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Summary: We investigated gamma oscillations, which reflect a key physiological mechanism underlying brain function: the delicate balance between excitatory and inhibitory neuronal activity. Using a new child-friendly brain imaging system (OPM-MEG), we measured age-related visual gamma activity in 1–5-year-old children.

Details: Introduction: Neural oscillations in the gamma band are integral to human brain function. They relate closely to the balance between excitatory (glutamatergic) and inhibitory (GABAergic) signalling and have been implicated in the mechanisms underlying neurodevelopmental conditions such as autism. Characterisation of gamma oscillations from early childhood therefore has profound implications for understanding the developing brain, yet instrumental limitations have prevented such investigation. Here, we use a new neuroimaging system, optically pumped magnetometer-based MEG (OPM-MEG) to detect gamma oscillations in toddlers and preschool-aged children from 1 year.

Methods: OPM-MEG data were collected in 93 children, aged 1–5 years (including longitudinal data, total 125 sessions) during a visual stimulus of inwardly drifting maximum contrast circles presented over 60 trials. The OPM-MEG system included up to 128-channels of magnetic field detection in a wearable child-friendly helmet. Data were pre-processed, epoched around the circle trials, and trial counts were matched such that age was not significantly related to trial count ($p>0.1$, Spearman's). Beamforming was used to relate sensor signals to brain regions. Time-frequency and functional connectivity analyses were performed.

Results: The findings indicate that OPM-MEG is sensitive to significant changes in the gamma band following the onset of the visual stimulus in all age groups. The peak frequency of the response was between 33–36 Hz in all age group averages and showed no significant relation with individuals' age. While the peak response was in the low gamma band, we found a significant linear relationship with age in the high gamma frequencies (70–74Hz), such that older participants had greater amplitude ($p<0.05$, FDR), in agreement with previous MEG literature in older children. Whole-brain functional connectivity via amplitude envelope correlation revealed gamma networks that significantly decreased with age ($p<0.001$, NBS), with the most connected nodes in occipital and inferior temporoparietal cortex with frontal connections.

Conclusion: Our results are the first to demonstrate the sensitivity of an OPM system to visual gamma signals from as young as 1 year of age. We show that the gamma response to the visual stimuli in 1–5 year-olds is maximal in the low gamma range, with relative amplitude increasing with age in the high-gamma range. Functional connectivity across the gamma band decreased with age, which may suggest age-related refinement and specialisation of networks processing visual stimuli across this early childhood period.

P1-H-42 Characterisation of depth-dependent sensorimotor processing in the developing human cortex at 7T

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Summary: Processing of sensory information requires coordinated activity across multiple brain regions. However, circuitry underpinning this processing is still developing in neonates. To provide detailed characterization of this maturation in the neonatal sensorimotor system, we studied functional responses and connectivity using high-resolution 7T fMRI.

Details: Introduction: Sensorimotor information is processed hierarchically in the human brain, across multiple connected cortical areas1. In the last trimester of gestation, studies suggest that the circuitry underpinning sensorimotor processing is still emerging, with macroscale network-level changes in hierarchical processing from 34 weeks post-menstrual age (PMA) and ongoing development beyond term age2,3. Ultra-high field (7T) functional MRI (fMRI) can provide additional insight beyond that of traditional field strengths by localising activity to distinct cortical depths and characterising their respective functional connectivity profiles4,5. Using high spatial resolution 7T fMRI6, we characterised how establishment of the sensorimotor processing network relates to the development of intracortical circuitry.

Methods: UK NHS ethics approval and parental consent were attained. Data were acquired from 8 healthy neonates (median: 37.57 weeks PMA, range: 35.71–45 weeks PMA, 7 female) during natural sleep and 2 adults (median: 25.5 years, 2 female) using a Siemens 7T system7,8 using a GRE-EPI BOLD-weighted fMRI sequence (parameters: Table 1) over 11min5s. A robotic device provided passive sensorimotor stimulation (extension/flexion) to the right wrist (on/off blocks of 26.6s)9. Data were pre-processed using age-specific optimised pipelines10. The hand area in primary somatosensory (S1) and primary motor (M1) cortices were manually defined in both hemispheres. Depth-specific BOLD responses and functional connectivity profiles were then defined in ipsilateral and contralateral M1 and S1 hand areas using LAYNII and FSL tools.

Results: Significant positive activation clusters localised to contralateral (left) S1 and M1 in response to sensorimotor stimulation were seen in all neonates and adults (Figure 1A). Cortical depth-dependent differences in BOLD response amplitude and temporal features were evident across cortical regions and age groups (Figure 1C,D,E). In adults, negative BOLD responses were seen in ipsilateral M1 and S1 whereas positive BOLD responses were seen in neonates (Figure 2) with altered functional connectivity between all M1 and S1 regions in neonates. Functional connectivity maps for superficial or deep contralateral S1 seeds showed distinct depth-specific differences with significantly greater functional connectivity between superficial S1 and M1 than deep S1 and M1 in the contralateral hemisphere in neonates (Figure 3).

Discussion and Conclusion: Sensorimotor stimulation induces positive BOLD responses across cortical depths in both M1 and S1 in neonates from 35 weeks PMA. We demonstrate that depth-specific functional connectivity is already present at this age, likely underpinning early hierarchical sensorimotor processing. The amplitude of BOLD responses across hemispheres is markedly different in neonates perhaps due to immature inhibitory processing. Understanding these differences during early development is critical, as cortical circuitry disruption and altered sensory processing are a key characteristic of many neurodevelopmental disorders11.

References: 1. Iwamura et al. Curr Opin Neurobiol, 1998; 2. Allievi et al. Cereb Cortex, 2016; 3. Whitehead et al. Cereb Cortex, 2019; 4. Huber et al. Neuron, 2017; 5. Olman et al. PLOS ONE, 2012; 6. Viessmann & Polimeni, Curr Opin Behav Sci, 2021; 7. Malik et al. MRM, 2021; 8. Bridgen et al. Front Rad, 2024; 9. Allievi et al. Ann Biomed Eng, 2013; 10. Willers Moore et al. ISMRM, 2024; 11. Passarello et al. Brain Sci, 2022

P1-H-43 The prenatal concept of number: Evidence of visual processing of stimuli before birth

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Summary: Why do babies born early go on to have developmental difficulties and delays despite NICU unit care plans? It is clear that we cannot take newborn behaviour as evidence of innate capacities. More work must explore the development before birth, and how the sensory environment may influence these, to better inform NICU plans for preterm babies.

Details: Much debate has surrounded the ontogeny of human understanding of the physical world, be this a capacity present at birth or, alternatively, learned through development and experience of the world, either passively or as a conscious construction of knowledge by the infant. This debate is well illustrated through the investigation of infants' understanding of number. Many assume that establishing the presence of a number system in very young infants provides evidence for genetic underpinnings.

As with many visually assessed cognitive capacities though, the study of the development of numerical processing does not extend to prenatal research, primarily due to the technical complexities of delivering visual stimuli and measuring behavioural responses by foetuses. We consequently aimed to address the question of whether processing of number sets can be detected before birth using visual stimuli and methodology more akin to postnatal studies with controls developed in the infancy literature.. In the first sample, 88 foetuses were tested at 34 weeks gestation. Using a custom-made light source, sets of two and three dots were presented on alternate trials (order counterbalanced across the sample) for 45 seconds (fig. 1). Stimuli were held stationary for the trial to the periphery of the foetal face and light levels continually increased and decreased to control for variance in amount of luminance between conditions. This was then repeated for a second block, for a total of three minutes. Using 4D ultrasound, foetal head movements related to the visual stimuli were measured (fig. 2). Foetuses were excluded where good-quality imaging could not be obtained. In the final sample, 43 fetuses turned significantly longer towards than away from the 2-dots display, Wilcoxon rank, $z = 2.309$, $p = 0.021$ (fig. 3). However, they showed no difference in preference for turning towards compared with away from three dots. Results are consistent with those reported in neonatal research indicating differential attention to number sets. In a second sample of 71 foetuses, behavioural coding is currently underway to compare foetal looking in the same paradigm to 1- compared to 2- dot number sets. This work provides evidence for the utility of applying postnatal visual experimental techniques to a prenatal sample when coupled with ultrasound behavioural measures. Further, this work indicates an emerging concept of number before birth and before postnatal experience. In this presentation, we explore the potential contributions of both genetics and prenatal experience on development.

P1-H-44 Respiration-based coding of infant sleep states and their relationship to the developing functional connectome

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Summary: This study explored how different sleep states—active sleep (similar to REM sleep) and quiet sleep (similar to non-REM sleep)—influenced thalamic functional connectivity in infants.

Details: Introduction: Functional magnetic resonance imaging (fMRI) has revealed critical insights into the early development of the infant brain. However, the impact of sleep states on fMRI signals remains unclear. Active and quiet sleep exhibit distinct physiological patterns, including differences in respiration and neural activity. Prior electroencephalogram and functional near-infrared spectroscopy (fNIRS) studies suggest that these states affect functional connectivity; however, no fMRI studies have examined this in infants. In particular, the thalamus plays a crucial role in regulating sleep and wakefulness. This study aimed to investigate changes in thalamic functional connectivity in infants scanned during active and quiet sleep**.**

Method: Healthy, full-term infants (mean postmenstrual age: 45.9 weeks) were recruited for an fMRI study using a three tesla MRI scanner during natural sleep. A pressure pad sensor placed on the abdomen recorded respiration signals synchronized with fMRI. Sleep states were classified based on respiration variability—irregular breathing indicated active sleep, while rhythmic breathing signified quiet sleep—using validated criteria. Eleven infants met quality standards for both respiration and imaging. Standard resting-state preprocessing methods were performed. The average time course from a thalamus region of interest was correlated with the time course of every other voxel in the gray matter. These seed correlations were transformed to z-values using Fisher's transformation. We used linear mixed-effects models, controlling for age and sex, to compare thalamic seed connectivity maps from active and quiet sleep. Results were corrected for multiple comparisons using cluster-based correction.

Results: Comparisons between quiet and active sleep revealed significantly ($p<0.05$, corrected for multiple comparisons) reduced connectivity between the thalamus and somatomotor cortex in quiet sleep compared to active sleep.

Conclusions: We compared thalamic seed connectivity between infants in active compared to quiet sleep using a novel paradigm to assess infant sleep state. Changes in thalamic-cortical pathways were observed between quiet and awake sleep states. These changes mimic those seen in adults when comparing REM and non-REM sleep. Overall, using respiration data collected from a pressure pad during scanning is a viable way to code sleep state in fMRI data. Additionally, these sleep state differences may be important considerations for studies investigating the thalamus.

Fig. 1. Thalamic connectivity differences between awake and quiet sleep in infants. Infants in quiet sleep demonstrated significantly ($p<0.05$, corrected for multiple comparisons) reduced connectivity between the thalamus and somatosensory cortex compared to active sleep.

P1-H-45 Resting GABA concentration does not correlate with high frequency oscillations and BOLD functional connectivity in full-term neonates

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Summary: Functional imaging is widely used to study neonatal brain development, but the physiological basis of these signals is not characterised. In this multimodal study, we test whether BOLD functional connectivity and EEG high frequency oscillations at term birth reflect underlying cortical neurometabolite levels measured with MRS.

Details: Functional imaging of BOLD (fMRI) and electrophysiological (EEG) activity are widely used to study brain development. In adults, characteristics of functional responses depend on the cortical excitation/inhibition balance, with GABA levels in the visual cortex found to positively correlate with high frequency beta and gamma neuronal oscillatory activity and negatively correlate with BOLD % signal change in response to a visual stimulus [1,2]. Across early development, GABA-mediated activity switches from depolarisation to hyperpolarisation [3], with the timing likely differing across brain regions due to the rostral-caudal axis of maturation [4]. We test the hypothesis that GABA does not exert the same regulation on functional metrics in occipital and frontal cortices at term birth, by combining MRS to quantify GABA levels, EEG to measure high frequency neural oscillations and fMRI to measure BOLD functional connectivity (FC).

EEG, MRS and fMRI data were collected from 20 healthy full-term neonates (37.29 - 43.29 weeks postmenstrual age (PMA), 1-27 postnatal days at scan, 6 female) during natural sleep. Studies were performed with National Ethics Committee approval and parental consent.

BOLD fMRI and MRS data were acquired with a 3T Philips system. For MRS, MEGA-PRESS [5] (TE 68ms/TR 2000ms/320 averages) and PRESS (TE 30ms/TE 2000ms/126 averages) [6] were acquired from 27ml occipital and frontal cingulate voxels (Fig. 1A). Tissue corrected GABA levels were quantified from the MRS data with Osprey (Fig. 1C) [7]. GRE-EPI BOLD fMRI data (6 min 51s, 2 mm isotropic resolution, TR/TE 2930/43ms) underwent standard preprocessing using FSL and alignment to a 40-week PMA template [8]. Subject-level BOLD timeseries were extracted from the frontal cingulate region [8] and the visual resting state network estimated using ICA using dual regression (Fig. 1A) [9].

10-20 mins of 25-32 channel EEG data were acquired outside the scanner within 1 hour of the MRI scan using a Brain Products system. Data were bandpass filtered (0.1-70Hz) and ICA-denoised using MATLAB (2021a) and EEGLAB. Power spectral densities were estimated and averaged across occipital and frontal electrodes (Fig. 1B, D). Measures of absolute and relative frequency power, peak frequency and peak amplitude within alpha (8-13Hz), beta (13-30Hz) and gamma (30-70Hz) bands were extracted using FOOF analysis [10].

Linear partial correlation coefficients were calculated (regressing out PMA and gestational age), for both occipital and frontal lobes, between MRS and EEG, MRS and fMRI, and EEG and fMRI measures (Fig. 2). There were no significant relationships between occipital or frontal MRS GABA+, EEG high frequency content and fMRI FC.

Results indicate that the regulatory role of GABAergic activity on neural oscillations and FC may not yet be established in both the occipital and frontal lobes of the neonatal brain. This study highlights the need for further research into how the relationship between neurochemistry and synchronous neuronal activity evolves and depends on the spatiotemporal gradient of early brain development.

1. Lally et al. NeuroImage, 2014; 2. Muthukumaraswamy et al. PNAS, 2009; 3. Rivera et al. Nature, 1999; 4. Stiles & Jernigan, Neuropsychol Rev. 2010; 5. Mescher, et. NMR Biomed, 1998; 6. Bottomley PA. Ann N Y Acad Sci. 1987; 7. Harris et al. JMRI, 2015; 8. Schuh et al. BioRxiv, 2018; 9. Nickerson et al. Front Neurosci, 2017; 10. Donoghue et al. Nat Neurosci, 2020

I – Methods: Data Processing

P1-I-46 FetGEs: A deep learning approach for fetal MRI ganglionic eminence segmentation

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Summary: The Ganglionic Eminence (GE) plays a crucial role in fetal brain development, with anomalies potentially leading to postnatal neurological consequences. Fetal MRI studies aim to characterize its evolution, but manual segmentation poses challenges. We developed a GE segmentation tool to improve efficiency and consistency in analyzing GE evolution.

Details: The Ganglionic Eminence (GE) is a transient structure of the fetal brain, which evolves in the ventral telencephalon from the fifth-week post-conception and plays a pivotal role in neural migration during development. Early detection of GE anomalies is crucial for identifying migration deficiencies that may lead to postnatal neurological or psychiatric disorders. Currently, no robust automatic GE segmentation approaches exist to enable its early analysis. Segmentation challenges arise from the transient nature of this structure, resulting in an increase of isolated components and a decrease in their volumes with age. Additional complexity is introduced by the inaccuracy of determining the gestational age, potential motion artifacts due to fetal and maternal movement, and intensity fluctuations in images for the same structure. In this work, we propose an automated GE segmentation method for fetal Magnetic Resonance Imaging (MRI) data by extending 3D UNets and introducing a novel registration-driven generative data augmentation technique to increase the number of MRI from 138 to more than 2,400 fetal scans with manually defined labels by an expert neuroradiologist (Figure). Our solution spans 19 to 38 weeks of gestation, achieving a mean Dice score of 0.76 ± 0.05 in the 2nd trimester and 0.74 ± 0.05 in the 3rd trimester. Volume Similarity scores achieved 0.91 ± 0.09 and 0.87 ± 0.13, while Hausdorff Distances were 1.81 ± 2.58 mm and 5.72 ± 6.08 mm for the 2nd and 3rd trimesters, respectively. Overall, the GE volume decreases throughout pregnancy (R2 = 0.77, ranged 31-668

mm3), highlighting an inverse relationship to the whole brain volume which continues to grow (R2 =0.93). The volumetric dynamics of predicted GE segmentations correlate with known anatomical development patterns, indicating the model's ability to learn GE dynamics over time.

P1-I-47 Development of an automated segmentation model for pediatric brains with atypical neuroanatomy and exploration of volumetric differences in infants with ventriculomegaly

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Summary: Inaccurate segmentation is a major limitation of neuroimaging research in pediatric populations with atypical neuroanatomy such as ventriculomegaly. Segmentation pipelines are not trained to address brain anomalies, resulting in mislabeling of structures and poor analytic validity limiting neurodevelopmental research in clinical populations.

Details: Objective(s): A deep learning model is being developed to accurately segment pediatric brains with atypical anatomy. We additionally explored differences in cortical and subcortical volumes in infants with varying presentations of ventriculomegaly compared to typically developing infants.

Methods: Anomalous structural T2 images (n=7) collected from 2 separate ongoing Masonic Institute for the Developing Brain (MIDB) studies were submitted to the MIDB's Atypical Brain Working Group for segmentation correction. Participants ranged in age from 1-27 months (9.71± 8.52) with diagnoses of ventriculomegaly (n=6) and/or agenesis of the corpus collosum (n=2). Normative segmentation data (n=220) were acquired from the Baby Open Brains (BOBs) Repository. Anomalous T2 images underwent initial automated segmentation with the Baby and Infant Brain Segmentation Neural Network (BIBSNet), a deep learning segmentation model trained on normative data from the BOBs Repository. BIBSNet segmentations of anomalous T2s were manually corrected with ITK-SNAP by neuroimaging and neurosurgery researchers in the MIDB's Atypical Brain Working Group. Manually corrected anomalous segmentations were divided into model training (n=3) and held out test (n=4) datasets. A deep learning segmentation model was trained using real and synthetic images incorporating anomalous (n=3) and normative data (n=220). Two segmentation models were then applied to the held out anomalous test dataset (n=4): 1) the trained anomalous inclusion model and 2) the established normative only model (BIBSNet). Dice similarity coefficients (DSCs) were generated for 29 labelled brain structures to assess level of fit between manually corrected and resulting automated segmentations for each model. Averaged DSCs across all 29 structures and for the lateral ventricles for each model were compared with Wilcoxon Signed Rank test. Volumes of cortical and subcortical structures/regions of interest were estimated for 150 age-matched Baby Connectome Project participants (0.4 to 16.7 months) and 4 participants with varying presentations of ventriculomegaly (n = 1 with incidental unilateral hydrocephalus, n = 1 with bilateral ventriculomegaly, n = 1 with moderate hydrocephalus, n = 1 with severe hydrocephalus; 1.1-16.0 months corrected age).

Results: The anomalous inclusion model demonstrated a higher average DSC across all 29 brain structures (DSC=0.79) compared to the normative only model (DSC=0.74) indicative of a trend toward greater segmentation accuracy of the anomalous inclusion model (mean difference=0.05, W(3)=5, p=0.13). The greatest improvements in model fit of the anomalous inclusion model were in the left (mean difference=0.29, W(3)=5, p=0.13) and right (mean difference=0.27, W(3)=5, p=0.13) lateral ventricles. Differences in cortical and subcortical volumes were identified between infants with typical development and ventriculomegaly consistent with severity of clinical presentations (z-score range -5.26 to 6.65).

Conclusions: Though limited by our small sample, inclusion of anomalous data in a normative-based automated segmentation model improved segmentation accuracy of anomalous brains, particularly for the lateral ventricles. A high volume of anomalous MRI data is needed to develop neurologic diagnosis-specific segmentation models such as ventriculomegaly. Exploration of volumetric data in infants with ventriculomegaly could support prognostic capabilities.

P1-I-48 An exploratory analysis of neural connectivity metrics in parent-infant EEG hyperscanning

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Summary: Electroencelography (EEG) hyperscanning allows the study of inter-neural synchrony (INS) in social interactions. In developmental research it is frequently used to analyse parent-infant interactions. This study explores how different connectivity metrics could provide complementary aspects of INS after an induced perturbation.

Details: This study aimed to assess variations in INS through imaginary coherence (ICoh) and phase-locking-value (PLV) before and after an experimentally-induced interactive perturbation, and to investigate the correlation between INS and behavioral coupling.

A sample of 20 mother-infant dyads, with 9-month-old infants participated in the Face-to-Face Still-Face paradigm: (a) Play (2 min) - face-to-face play interaction; (b) Still-Face (1 min) - mothers maintained a neutral facial expression; and (c) Reunion (2 min) - resumed interactive play.

EEG data were acquired using the Smarting PRO hyperscanning system at a sampling rate of 250 Hz. Infant and maternal behaviors were microanalytically coded. Neural synchrony was assessed using ICoh, a functional connectivity metric that isolates lagged neural interactions and PLV, a measure of frequency-specific transient of phase locking. INS was computed over frontal and central regions in the theta (4-7 Hz) and alpha (6-9 Hz) frequency bands.

Repeated-measures ANOVA was performed to explore ICoh and PLV changes among the phases of the FFSF procedure. Pearson's correlation coefficients were computed to evaluate correlations between INS values and behavioral measures.

Preliminary findings showed a significant reduction of PLV in the theta coupling in frontal electrodes and a significant increase of ICoh

in the theta coupling over central electrodes following perturbation (Play vs. Reunion). A significant correlation emerged between ICoh values in the frontal regions and the percentage of time spent in mutual gaze during the Reunion episode in alpha and theta band. Additionally, a significant correlation emerged between PLV values in the central regions and the percentage of time spent in mutual gaze during the Play episode.

This exploratory study assessed distinct aspects of INS in mother-infant interaction using ICoh and PLV. The observed reduction in PLV following the interactive perturbation suggests a disruption in neural attunement. In addition, the increase in theta-band ICoh during the Reunion episode suggests an active synchronization recovery process, indicating that reconnection requires neural effort and temporal coordination. Furthermore, the association between frontal ICoh and mutual gaze percentage supports the functional role of lagged neural synchrony in social reconnection. Future research should validate these findings in larger samples.

The study is part of the 2-BRAINED project funded by Italian MoH (RF 2021).

P1-I-49 Feasibility of a mobile low-density EEG System in a South African birth cohort

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Summary: EEG is a potentially scalable non-invasive tool for investigating human brain function across all ages. We compare the data quality and concordance of resting EEG from a portable, low-cost, and more accessible EEG system (Emotiv EPOC Flex) to spectra from a "gold-standard" high-density EEG system (EGI-Magstim) in infants.

Details: EEG is a powerful tool that provides important information about human brain function across development. Many EEG systems are costly to buy and set-up, immobile, and resource-intensive both in terms of expertise required and ongoing maintenance. This poses challenges for use at scale in global majority world settings. Identifying cost-effective and scalable EEG hardware offers potential for the advancement of neurodevelopmental research in low- and middle- income countries, where the greatest proportion of the world's children reside. We compared data quality and resting-state EEG spectral power measures from a research-grade high-density EEG system (Figure 1A) and a consumer-grade, low-density EEG system (Figure 1B) within the same infants in a South African population birth cohort at 3 months of age (M = 91.9 days, SD = 16.24). High- and low- density 3-minute long resting-state EEG data were collected using EGI Hydrocel 128-channel nets (n = 181) and Emotiv 32-channel nets (n = 191) respectively. Both sets of EEG data were processed using HAPPE v4.0 software. Following quality checking, 128 participants had usable high-density data, and 96 participants had usable low-density data with comparable excellent internal consistency reliability. A subset of 70 participants had usable data for both high- and low-density EEG and were therefore used for the following analyses. EEG Power was generated via HAPPE and Pearson's correlations were used to test correspondence between systems. We observed moderate significant positive correlations between high- and low-density systems across delta (2-4hz; r = 0.31, p = <.001) (Figure 2A), theta (4-6hz; r = 0.45, p = <.001) (Figure 2B), low alpha (6-9hz; r = 0.46, p = <.001) (Figure 2C), high alpha (9-12hz; r = 0.3, p = 0.01) (Figure 2D), beta (13-3hz; r = 0.29, p = 0.01) (Figure 2E) and gamma (30-45hz; r = 0.39, p = <.001) (Figure 2F) frequency bands. These findings suggest that the Emotiv EPOC Flex system might offer a scalable solution for developmental EEG research use in lower resource settings, even in the very early weeks and months of life. Notably, the Emotiv EPOC Flex system is priced at less than 5 % of the cost of standard research-grade EEG systems. There are, however, meaningful differences between the two systems that require further exploration, such as optimizing preprocessing strategies for these emerging, low-cost solutions.

P1-I-50 Divide and conquer: Sequential dual u-net for ex vivo infant brain MRI segmentation

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Summary: Ex vivo infant brain MRI segmentation is vital for studying early brain development and disorders but it is challenging due to high-resolution data, low contrast, and postmortem tissue changes. Robust methods are needed to accurately distinguish tissue boundaries while being efficient to manage the high computational demands of increased data size.

Details: Segmenting ex vivo infant brain MRIs is challenging due to rapid developmental changes in the early years, postmortem artifacts, poor contrast, and the computational demands of high-resolution data (Figure 1). Compared to in vivo data, the higher resolution images require compact network architectures for training on commercial GPUs, while, for cerebral tissue segmentation tasks, the dual goals of segmenting white/gray matter and preserving hemispheric separation intensify the challenge due to limited model capacity. The cerebellum, with intensity values similar to cerebral tissue, further increases the complexity of the task. We propose a two-step framework for cerebral segmentation: separating left/right hemispheres while removing the cerebellum, followed by unilateral white/gray matter segmentation. Each phase is managed by a small, efficient network, efficiently handling the segmentation task, while staying within memory constraints.

Our dataset consists of 6 postmortem infant structural brain MRIs with 0.55-0.7 mm isotropic resolution (see Figure 1 for examples). The cerebral white and gray matter for both left and right hemispheres were annotated by experts (SY, AS). All data underwent preprocessing through quantile matching to normalize intensity distributions across data points. An example of one of the data and its manual segmentation are displayed in Figure 2.

U-Nets have demonstrated strong performance in medical image segmentation [1], so we employ them as our base networks. Our proposed framework is illustrated in Figure 3. An initial Split U-Net generates a mask to delineate the cerebral area and distinguishes between the left and right hemispheres. The resulting binarized mask is applied to the input MRI, which is then fed into the Seg U-Net to annotate white and gray matter, irrespective of hemispheric laterality. As shown in Figure 3, the two networks are jointly trained. To generate the final output, the left/right hemisphere mask is applied to the tissue segmentation.

In our experiments, we used 4 subjects for training, 1 for validation, and 1 for testing. We compared our results with a standard U-Net [1], and SAMSEG [2] using a custom infant brain atlas. The average Dice overlap scores computed over the predicted labels are shown in Table 1, and results from all methods are shown in Figure 4 for a qualitative evaluation. Our divide-and-conquer strategy effectively

masks the cerebellum and robustly segments gray and white matter while preserving hemispheric separation. The standard U-Net achieves comparable Dice score but retains cerebellar remnants, whereas SAMSEG shrinks the brain volume.

We proposed a modular framework for segmenting ex vivo postmortem infant brain MRIs. By dividing tasks into subtasks handled by smaller models, our approach reduced the computational load and enhanced pattern recognition. Masking irrelevant areas in the input enhanced performance, though it may have increased background areas in predictions, as observed in Figure 4. In future work, we will further explore the proposed modular approach, incorporating cross-validation, shifting from sequential to parallel network chaining with a shared encoder to minimize excessive masking, and further improving the performance of the models.

[1] Ronneberger, O., et al. MICCAI 2015, 234–241.
[2] Puonti, O., et al. (2016). NeuroImage, 143:235–249.

P1-I-51 Longitudinal evaluation of central sulcus morphology and its link to behavior in infancy

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Summary: Developing early on, the sensorimotor system is a foundation of brain maturation. We investigate its early development in typical infants by assessing CS morphological changes, supposed to relate to its functional organization. Such framework could help identify developmental alterations early on in infants at risk of neurodevelopmental disorders.

Details: One of the most impressive changes with brain development is the appearance of folds known as sulci delineating gyri [1]. The central sulcus (CS) is one of the first to fold [2]. As the anatomical boundary between primary somatosensory and motor regions, its developing morphology may inform on the underlying developing somatotopic organization shaped by the acquisition of sensorimotor skills [3]. We aimed to identify potential asynchronous morphological changes along the CS during infancy, with the hypothesis that this may reflect the gradual emergence of body usage.

Using 3T magnetic resonance imaging (MRI), we acquired anatomical T2-weighted images on 22 infants (11 girls) with longitudinal assessments at both 1 month (1M; mean ± standard deviation: 45.33 ± 0.61 weeks) and 3 months (3M; mean ± standard deviation: 53.27 ± 0.86 weeks) of age. Segmentation of brain tissues (grey and white matter, cortico-spinal fluid) and reconstruction of cortical surfaces were performed using iBEAT2 [4], and further processed using BrainVISA software [5] through the « Morphologist » processing pipeline [6] to identify the CS. Two infants with a discontinuous CS were excluded as outliers prior to analysis. Subsequently, depth and absolute curvature of the sulcus were computed and compared across groups first along its entire length (distributing 100 positions along the CS), and then in four regions of interest (ROIs) presumed to correspond to different functional representations of body parts, with one centered on the hand knob (HK) identified for each infant (Figure. A). We also explored the relationship between age-related changes in CS morphological features and the global motor scaled scores evaluated at 3 months of age with the Bayley Scales of Infant and Toddler Development, 3rd edition [7].

Permutation testing along the CS positions revealed a significant increase in CS depth between 1M and 3M, primarily localized in central positions, while no difference was observed for absolute curvature (Figure. B). However, when considering the relative changes in CS features between 1M and 3M on each ROI, one-sample Student's t-tests versus zero demonstrated significant increases in both depth and absolute curvature within the medial and central ROIs (Figure. C). These findings suggest more intense changes in the central regions that are supposed to include the hand representation, than in the medial and lateral regions representing more the lower limbs and face. Besides, a linear model testing the relationship between global motor scores at 3M and age-related changes in CS features revealed a positive trend only for depth ($p = 0.07$) in the central-medial (HK-related) ROI, possibly linked to an increasing hand usage between 1M and 3M.

Although replication on larger groups and at other ages will be needed, this unique longitudinal and multimodal study demonstrates the potential of defining CS morphological features as key markers of early sensorimotor development. This framework could help the early identification of neurodevelopmental alterations in infants at risk of sensorimotor disorders.

References: [1] De Vareilles et al., Dev. Cogn. Neurosci., 2023. [2] Chi et al., Arch. Neurol., 1977. [3] Germann et al., Cereb. Cortex, 2020. [4] Wang et al., Nat. Protoc., 2023. [5] Rivière et al., NeuroImage, 2009. [6] Fischer et al., Hum Brain Mapp, 2012. [7] Jackson et al., Pediatr. Phys. Ther., 2012.

P1-I-52 Applying the harmonized hippocampal subfields protocol to neonatal MRI scans (WIP)

Tracy Riggins [1], Zehua Cui [2], Franziska Gronow [3], Katharina Pittner [3], Tom Schröder [3], Nora Moog [4], Martin Bauer [3], Yee Lee Shing [5], Claudia Buss [3]

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Summary: The hippocampus is a complex neural structure consisting of multiple subfields, including the Cornu Ammonis (CA) fields 1-4, dentate gyrus, and subiculum. Recently, a field-wide harmonized protocol for delineating these regions in children and adults has become available. This poster will present efforts to adapt this protocol for use in neonates.

Details: The hippocampus is a complex neural structure consisting of multiple subfields (CA1-4, dentate gyrus, and subiculum). Data in non-human primates suggests the dentate gyrus and CA3 subfields have a protracted developmental course and are sensitive to environmental influences. However, data from human infants corroborating these effects is limited due to difficulties in acquiring and processing data. Recent efforts in the field have yielded methods for acquiring structural MRI scans in infants during natural sleep and a harmonized protocol for delineating hippocampal subfields. The objective of this study is to gauge the feasibility and assess the reliability of applying this harmonized segmentation protocol to structural MRI scans from neonates. Ultimately, we seek to develop

an automated and robust method that provides accurate infant hippocampal subfield segmentation. Development of such tools can support future research studies investigating the normative developmental trajectories of the hippocampus during infancy and how factors in the prenatal and postnatal environments might produce individual differences.

Method: Participants: At the time of this submission, 57 neonates have completed the scanning protocol. (22 female, age range = 14 to 60 days, mean age = 30.85 days). Data collection is ongoing. The final sample size will be dependent on reviews of each infant's data quality.

Image Acquisition: Neuroimaging data were collected on a Siemens 3.0T MRI scanner with a 64-channel head coil using an ultra-high resolution structural T2-weighted scan of the medial temporal lobe.

Manual Segmentation: The manual hippocampal subfield segmentation protocol that will be used yields all subfield regions of interest (ROIs) in the body of the hippocampus (Daugherty et al., under review). Three researchers will trace all cases with suitable quality data, and one of them will re-trace a subset of their cases. Inter- and intra-rater reliability will be assessed through Dice Similarity Coefficients (DSCs) and Intra-class correlation coefficients (ICCs).

P1-I-116 The HEALthy brain and child development (HBCD) study initial data release

Tracy Riggins [1]

[1] *University of Maryland*

Summary: The HBCD Study, the largest longitudinal study of early child development, will generate a unique data resource from a large cohort of participants across the U.S. A major goal of the HBCD Study is to make this valuable data resource available for the scientific community for analysis and generation of scientific hypotheses for further study.

Details: The HBCD Study, sponsored by the National Institutes of Health, is the largest long-term study of early brain and child development in the United States. The HBCD Study will enroll over 7,000 participating families across the United States and follow them from pregnancy through early childhood. The long-term goal is to better understand how child development is affected by exposure to social and environmental experiences and conditions. Knowledge gained from this research will have lasting impacts on future generations of children.

The HBCD Study is pleased to announce its first annual data release on the NIH Brain Development Cohorts (NBDC) Data Hub. This inaugural release includes data from over 1400 pregnant participants during the prenatal period. For about half of these participants, follow-up data from their babies is also included. Specifically, data domains encompass prenatal health, pregnancy exposures including substance use, social and environmental determinants of health, infant brain imaging and activity, cognition and behavior, physical growth, and wearable biosensors. Raw and derived brain imaging, EEG, and motion (actigraphy) data using the BIDS standard for data organization are available.

For more information about the HBCD Study, please visit https://hbcdstudy.org.

K – Other

P1-K-54 Exploring human milk exosomal microRNAs as predictors of infant white matter development: A pilot study

Blakely Lockhart [1], Brittany Howell [1]

[1] *Virginia Tech*

Summary: Human milk supports infant brain development via bioactive components like microRNAs (miRNAs) in extracellular vesicles. This study explores how miRNA expression across lactation stages relates to early white matter growth, potentially revealing pathways to improve neurodevelopmental outcomes in all infants.

Details: Human milk is the preferred source of infant nutrition and plays a critical role in early brain development. Differences in white matter (WM) development between breastfed and formula-fed infants suggest that human milk contains unique components not found in formula that support neurodevelopment. One such candidate is microRNA (miRNA), small non-coding RNAs that regulate gene expression and are delivered through extracellular vesicles (hmEVs) in milk, which are absent in formula.

We conducted a pilot study that examined associations between human milk miRNA expression across lactation and neurodevelopmental outcomes in exclusively breastfed infants. Six full-term mother-infant dyads were recruited and followed from birth to 3 months. Milk samples were collected across the three stages of lactation—colostrum, transitional, and mature—and exosomes were isolated within 24 hours. Non-sedated sleep MRIs were performed at 2 weeks and 3 months to assess WM development. miRNA analyses included RNASeq and qPCR (miR-92, miR-199, miR-148, miR-145, miR-17, Let-7), and MRI data are being processed using infant-specific pipelines (BIBSNet).

qPCR results indicate multiple miRNAs, previously identified as associated with growth and neurodevelopment. RNASeq revealed that several miRNAs present in colostrum are predictors ($p<0.05$) of WM growth at 3 months, while miRNAs in mature milk are predictive of the rate of infant weight gain. These findings suggest a lactation stage-specific role for milk-derived miRNAs in regulating both brain and physical development during early life.

Identifying these expression patterns not only informs our understanding of infant growth and neurodevelopmental trajectories but also provides deeper insight into milk as a dynamic biological system. This knowledge lays the groundwork for enhancing human milk alternatives with targeted bioactive components, with the ultimate goal of improving health outcomes for all infants.

L – Prenatal Programming

P1-L-56 Longitudinal associations between prenatal cannabis exposure, white matter microstructural organization in neonates, and infant temperament

Shelby Leverett [1], Caleb Gardner [1], Jeanette Kenley [1], Ryan Bogdan [1], Arpana Agrawal [1], Christopher Smyser [1], Cynthia Rogers [1]

[1] *Washington University in St. Louis*

Summary: Alongside increasingly permissive laws, sociocultural attitudes, and perceived therapeutic benefits, prenatal cannabis use (PCU) has significantly increased. As cannabinoid receptors play crucial roles in brain development, PCU likely affects early brain development and offspring outcomes; however, this has not been tested prospectively in humans.

Details: Objective: Cannabinoid receptors– expressed in the developing brain as early as 6 weeks of gestation– play crucial roles in axonal pathfinding and synaptogenesis. Abnormal activation of these receptors (e.g., by PCU) hinders these processes, which may disrupt early white matter (WM) microstructural organization – particularly axonal organization – and relate to early temperamental traits that are predictive of future socioemotional problems. In this longitudinal study of mother-infant dyads, we will test associations between PCU, neonatal WM microstructural organization, and temperament at 6 months.

Hypothesis: PCU-exposed neonates will exhibit (H1) poorer axonal organization, as indexed by average-tract diffusion metrics and (H2) greater variability in axonal organization along the length of WM tracts at birth, as indexed by standard deviation of along-tract diffusion metrics. H3: Both axonal organization and along-tract variability in axonal organization will relate to measures of temperament (e.g., negative reactivity) at age 6 months.

Study Design: Data are derived from the ongoing CUDDEL study at Washington University in St Louis. Participants were recruited from pregnancy clinics and completed self-reported cannabis use questionnaires and urinary drug screens (UDS) for cannabis and other substances in each trimester. Case or control status was assigned based on self-report and UDS throughout the entirety of pregnancy. Diffusion MRI (dMRI) scans were acquired from sleeping non-sedated neonates (40-46 weeks postmenstrual age). DSI studio deterministic tractography extracted metrics of axonal organization (fractional anisotropy [FA] and axial diffusivity [AD]). The Infant Behavior Questionnaire-Revised (IBQ-R) assessed temperament at 6 months of age.

Data analysis plan: WM tracts of interest will include limbic tracts (fornix, uncinate, cingulum), which are central to emotional processing and regulation. For each tract, one-way ANCOVAs [group: case vs control] will assess group differences in (H1) overall axonal organization using average-tract metrics of FA and AD, and (H2) variability in organization along the length of WM tracts using standard deviations of along-tract metrics of FA and AD. Generalized additive models with examine associations between average-tract and standard deviation of along-tract metrics of FA and AD with IBQ-R scores (H3). All analyses will control for age at birth, age at scan, sex, and income-to needs. Multiple comparisons will be corrected using the False Discovery Rate (FDR). Note: analyses focus on FA and AD in limbic tracts, but data will be available for additional tracts and dMRI metrics (e.g., MD, RD).

Study implications: Results will deepen our understanding of how in utero cannabis exposure affects the developing brain and infant temperament. As such, this study will have important implications for clinicians and public policy makers alike in advising pregnant women who may consider using cannabis. This is particularly significant given the increasingly permissive attitudes towards and the perceived benefits of PCU like aiding in sleep and alleviating nausea.

Progress to date: We have collected information about PCU in each trimester of pregnancy and have collected and preprocessed high-quality dMRI scans for N=177 mother-infant dyads. IBQ-Rs at 6 months are completed for N=160 mother-infant dyads. All analyses will be completed by the conference.

M – Variation/Relation to Symptoms

P1-M-57 Genetic predisposition for long or short sleep duration influences thalamic functional connectivity in neonates

Emily Chiem [1], Sai Sruthi Amirtha Ganesh [1], Jack Dodson [1], Mirella Dapretto [1], Leanna Hernandez [1]

[1] *University of California, Los Angeles*

Summary: Sleep is essential for optimal neurodevelopment. Abnormally long or short sleep duration has been linked to psychiatric conditions and adverse health outcomes in adults. While genetic variation influences sleep duration variability, its role in early brain development and later behavioral outcomes remains unclear.

Details: Objective: Here, we examined the relationship between polygenic scores (PGS) for long and short sleep duration and thalamic functional connectivity in neonates, as well as their association with later behavioral measures, to evaluate the early neural impact of genetic risk for abnormal sleep duration and its potential developmental consequences.

Methods: Resting-state functional MRI and genetic data were obtained from the Developing Human Connectome Project for 288 neonates of European ancestry, who were scanned between 37-45 weeks postconceptual age. The preprocessed data underwent additional global signal regression to reduce noise. PGS were calculated using summary statistics from a genome wide association study of short (≤5 hr) and long (≥10 hr) sleep duration (Austin-Zimmerman et al., 2023). PGS for long or short sleep duration were used as bottom-up regressors in group analyses using FSL FEAT, controlling for scan age, sex, and 5 ancestry principal components. Linear regression models examined how long or short sleep duration PGS influence behavioral outcomes at 18 months of age, as assessed by the Child Behavior Checklist (CBCL), Bayley Scales of Infant and Toddler Development (BSID), and Quantitative Checklist for Autism in Toddlers (QCHAT).

Results: Short sleep duration PGS (Short PGS) was associated with stronger intrathalamic functional connectivity, as well as thalamic connectivity to the cingulate gyrus ($Z>2.3$, $p<0.05$). Long sleep duration PGS (Long PGS) was associated with stronger intrathalamic connectivity and thalamic connectivity with the right insula, caudate, and parietal cortex ($Z>2.3$, $p<0.05$). In addition, Long PGS was associated with weaker thalamic-frontal cortex connectivity. Behaviorally, Short PGS was positively correlated with CBCL sleep ($t=2.0$, $p=0.047$) and aggressive problems ($t=2.21$, $p=0.028$), negatively correlated with the BSID cognitive scale ($t=-2.35$, $p=0.019$), and

displayed a trending association with the QCHAT score (t=1.84, p=0.067). Long PGS was positively associated with CBCL aggressive (t=1.99, p=0.047) and withdrawn problems (t=2.06, p=0.0402).

Conclusions: Our findings suggest that genetic predisposition for unusually long or short sleep duration leads to altered thalamic functional connectivity in neonates and confers greater behavioral challenges in toddlerhood. This study highlights how genetic risk for abnormal sleep duration may shape brain development during the neonatal period, potentially triggering cascading effects on behavior later in life.

P1-M-58 Trajectory clustering of cognitive development and neural oscillatory power in infants at elevated likelihood of Autism and ADHD (WIP)

Anita Song [1], Jannath Begum Ali [2], Mark Johnson [3], Tony Charman [4], Rianne Haartsen [1], František Váša [4], Emily Jones [1], The Staars Team [2]

[1] Birkbeck College; University of London, [2] Centre for Brain and Cognitive Development; Birkbeck College; University of London, [3] University of Cambridge, [4] King's College London

Summary: Autism and ADHD often occur together, so studying them together may help us better understand the biological causes for shared difficulties. Some babies are more likely to develop these conditions based on their family history. We studied how these babies' brains and behaviour of change over time, to understand shared pathways of development.

Details: Astle (2022) suggests that diagnostic categories fail to capture the underlying basis about how developmental difficulties arise and a transdiagnostic view may be more appropriate when considering the needs of children with neurodevelopmental conditions. This means to cut across diagnostic categories when studying developmental differences. Specifically, it is hypothesised that the same brain difference could lead to multiple cognitive outcomes, known as multifinality. While the same cognitive profile could also result from multiple brain profiles, known as equifinality. Previously, we used clustering to investigate cognitive and neural profiles in 24-month-old infants and found a lack of association between cognitive and neural subgroups. However, this has not been examined in terms of longitudinal trajectories of development. Currently, we aim to extend our previous findings from a single time point and cluster trajectories of cognitive abilities and EEG oscillatory power in infants from the British Autism Study of Infant Siblings (BASIS) - Studying Autism and ADHD in the eaRly yearS (STAARS).

BASIS-STAARS is a prospective longitudinal study for infants at elevated likelihood of autism and ADHD based on a family history design. Hierarchical density-based clustering with applications to noise (HDBSCAN) will be applied separately to cognitive and EEG data from three timepoints (age = 10, 14, 24 months). Subscale scores from Mullen Scales for Early Learning (MSEL) will be used for cognitive stratification (N = 117). Meanwhile, relative EEG power in developmentally-relevant frequency bands will be used for neural stratification (N = 81). We will examine the relationship between cognitive and EEG subgroups using a chi-square test and alluvial plot. We will validate cognitive subgroups using adaptive behaviour scores (age = 10, 14, 24 months), and characterise diagnostic features of the subgroups using autistic and ADHD trait scores (age = 36 months), and family history of autism and ADHD. A detailed summary of all planned comparisons can be found in the uploaded graphical abstract.

Results will be obtained prior to the conference. Based on previous findings from clustering cross-sectional data, we expect two clusters to emerge: a main cluster characterised by higher average and smaller spread of values, a smaller cluster and outliers with a lower average and larger spread of values. If cognitive clusters are not associated with neural clusters, this supports the view of multifinality and equifinality. An alternative explanation is that EEG might not detect signals relevant to cognitive development; however, this seems less probable given existing evidence linking theta EEG power to cognitive development (Jones et al., 2020). If subgroups do not align with family history, autism, or ADHD traits, the transdiagnostic view of neurodevelopmental conditions in early development will be supported.

POSTER SESSION 2
MONDAY, SEPTEMBER 8, 2025 15:20 - 16:45

A – Big Data

P2-A-59 Cortical and white matter T1w/T2w development proceed in concert during early infancy

Stephanie Zika [1], Kelly Chang [2], John Kruper [2], Orhon Altan [2], Ariel Rokem 2, Mareike Grotheer [1]

[1] *Philipps-Universität Marburg,* [2] *University of Washington*

Summary: The infant brain undergoes rapid myelin growth in both gray and white matter. This microstructural development has been characterized for each tissue type independently, but the link between gray and white matter myelination remains unexplored. Understanding this link enhances our understanding of the importance for brain health.

Details: Infancy marks a time of extraordinary brain development, including the rapid formation of myelin. Rapid and widespread myelin growth, which occurs in both gray and white matter, is a cornerstone of early brain development and a key indicator of long-term brain health. To test the hypothesis that myelination of white matter tracts is linked to myelination of their corresponding gray matter targets, we analyzed a large cohort (N=279) from the Developing Human Connectome Project (dHCP). This sample included both preterm and full-term infants scanned between 0 and 16.71 weeks after birth. The gestational age at birth ranged from 24.57 to 42.29 weeks (mean ± SD: 38.04 ± 3.73 weeks). Scans were performed between 29.29 and 44.71 weeks post-conceptional age. In each individual, we identified 24 white matter tracts using automated software (pyBabyAFQ) and mapped their termination in cortex (Fig. 1A). We then correlated T1w/T2w, a myelin-sensitive imaging contrast, measured along the tracts with T1w/T2w measured at the gray matter termination of each tract. We found a correlation between T1w/T2w measured along the tracts and T1w/T2w measured at their cortical targets (Fig.1B; $r^2 = 0.55$, $p = 1.45e\text{-}5$), which was stronger in full-term than preterm infants (full-term infants: $r^2 = 0.53$, $p = 2.69e\text{-}5$; preterm infants: $r^2 = 0.43$, $p = 0.0002$). The rate of change (slope) of myelination in white matter and cortex over time was also correlated (Fig.1C; $r^2 = 0.49$, $p = 6.28e\text{-}5$). Finally, across individuals, higher synchrony of myelination between white matter and cortex was correlated with better language outcomes at 17 - 25 months of age ($r^2 = 0.02$; $p = 0.04$). As T1w/T2w is associated with myelin content, these findings highlight the intricate interplay between white and gray matter myelination during early brain development. We propose that these observations may be explained by experience-dependent myelination, as neural activity elicited by social interactions, sensory stimulation, or learning may simultaneously promote myelination of both local cortical and long-range white matter connections.

P2-A-60 Genetic foundations of a metric of neural Excitation-Inhibition balance in infancy (WIP)

Lauren Wagner [1], Emily Chiem [1], Leanna Hernandez [1]

[1] *University of California, Los Angeles*

Summary: Healthy brain function and development depend on balanced excitatory and inhibitory activity. Although early infancy is critical for establishing excitation-inhibition (E/I) balance, little is known about its normative development in early life and how it may contribute to the emergence of conditions like autism, in which E/I disruption is common.

Details: Objective: This work-in-progress study will use multimodal data from the Developing Human Connectome Project (dHCP; Edwards et al., 2022), a large-scale, multi-site study of fetal and neonatal brain development, to map E/I ratio across the infant cortex and to assess the impact of genetically regulated expression (GREx) of E/I-related genes and genetic liability for ASD on E/I metrics.

Methods: Neonatal imaging data collected at 37-45 weeks post–conceptional age will be used in combination with genotype data. We will apply a cutting-edge approach for calculating E/I ratio from resting-state fMRI data (Zhang et al., 2024) to derive regional measures of E/I ratio in 469 neonates from the dHCP study. Next, leveraging functional genomics reference panels developed by the PsychENCODE Consortium, we will calculate GREx for E/I-related genes in 288 dHCP participants who also have genotype data. We have already derived polygenic scores (PGS) for autism in this dataset using an existing genome-wide association study of ASD (Grove et al., 2019). Linear mixed-effects models will be used to estimate the extent to which E/I GREx and ASD PGS moderate individual differences in the E/I metric, using the lme4 package in R. Postconceptional age at scan will be examined as a predictor of interest for regional E/I ratio and will also be included as a potential nuisance regressor for the genetic models.

Expected Results: Increased GREx of excitatory genes should predict higher E/I ratio across the brain, whereas increased GREx of inhibitory genes will predict a lower E/I ratio. Greater genetic ASD liability (i.e., higher PGS) will predict a higher E/I ratio, particularly in sensorimotor cortices, reflecting diminished inhibition of sensorimotor systems and disrupted progression of E/I development along the sensorimotor-to-association axis (Larsen et al., 2023).

Conclusions/Significance: This will be the first study to investigate a novel E/I marker in infancy. Investigating infant E/I balance and its genetic antecedents will yield a more holistic understanding of previously observed E/I dysfunctions in ASD (Uzunova et al., 2016) and other psychopathologies. This study will reveal how neonatal E/I balance across diverse brain regions may arise from common genetic variability by tethering systems-level differences in brain function to individual differences in genetic regulation of cerebral gene expression.

B – Clinical Populations

P2-B-61 Beta1 and aperiodic EEG activity in visually impaired children: Linking resting-state cortical activity to reach-to-grasp performance (WIP)

Stefania Petri [1], Helene Vitali [1], Martina Riberto [1], Claudio Campus [1], Monica Gori [1]

[1] *Istituto Italiano di Tecnologia*

Summary: This study investigates how early visual impairment affects resting brain activity and its relation to motor abilities in children. By analyzing EEG signals and reach-to-grasp performance, we aim to better understand the neural basis of sensorimotor development without visual input.

Details: The early years of life show a strong link between sensory input and motor output (Piaget, 1952). Vision plays a key role in guiding other senses in shaping spatial and body awareness (Bremner et al., 2008; Gori et al., 2021), supported by structural and functional brain changes (Shonkoff & Phillips, 2000). Early visual impairment (VI) affects the cortical organization and its oscillatory EEG rhythms, suggesting that visual input is crucial for brain development (Campus et al., 2021).

More recently, increasing attention has been directed toward the aperiodic component of the EEG spectrum—1/f-like activity—which reflects broadband neural dynamics and is considered a marker of brain maturation (Ostlund et al., 2022). However, little is known about how these EEG features manifest at rest in VI children and how they relate to emerging motor abilities, particularly goal-directed action.

In this study, we analyzed resting-state EEG in VI and sighted (S) children, examining both oscillatory and aperiodic spectral components. We focused on Beta1 activity (14–21 Hz) in centro-parietal regions, typically associated with sensorimotor processing (Chung et al., 2017), and explored associations with performance in a reach-to-grasp task.

Thirteen sighted (8F, mean age 39.6 ± 14.7 months) and ten VI children (4F, mean age 30.7 ± 17.5 months, residual vision 0.7–1.3 LogMAR) participated, all without epilepsy or cognitive impairment. Resting-state EEG was recorded using a 129-channel Geodesic Sensor Net (EGI system, Cz reference, 1000 Hz sampling) with eyes open in a dark, quiet room.

Children then completed a reach-to-grasp task involving three black spheres (3, 5, 8 cm) placed in left, center, and right positions under dim lighting. The task was video recorded, and two parameters indicative of early sensorimotor processing during interaction with the environment were independently extracted by two raters, namely Movement Time (MT)—from movement onset to first hand contact—and Pick-up Time (PT)—from contact to successful grasp. These behavioral markers were considered. EEG was not recorded during the task to observe a maximally ecological behavior.

We found that VI children showed less centro-parietal Beta1 activity compared to S children. Within the VI group, higher Beta1 activity seems to be associated with longer PT, with this link varying by age. Furthermore, VI children tended to show a steeper aperiodic EEG slope, with age- and group-related variations in its link to PT.

Together, these preliminary findings suggest that early visual impairment may affect both oscillatory and aperiodic EEG features related to sensorimotor processing, and that these associations may shift across development.

P2-B-62 - Dynamic functional connectivity during sleep in term and preterm infants

Katharine Lee [1], Borja Blanco [1], Andrea Edwards [2], Jem Hebden [3], Rob Cooper [3], Kelle Pammenter [2], Julie Uchitel [1], César Caballero-Gaudes [4], Topun Austin [1]

[1] University of Cambridge, [2] Cambridge University Hospitals NHS Foundation Trust, [3] University College London, [4] Basque Center on Cognition, Brain and Language

Summary: Sleep is important to early brain development and may be disrupted in preterm neonates exposed to early ex utero stimuli. This high-density diffuse optical tomography study compares dynamic functional connectivity across sleep states in term and preterm infants, offering insight into the relationship between sleep and early network development.

Details: Introduction: Poor sleep early in life has been shown to negatively impact neurocognitive functions (McCann, 2018). The impact of sleep on neuronal maturation is a critical area of study, especially in preterm neonates. Preterm birth has been associated with cognitive, social, and sleep difficulties later in life, outcomes that may be exacerbated by affected sleep (Gao, 2017, Stangenes, 2017). The relationship between sleep states, gestational age (GA), and functional brain development remains poorly understood. Studying the role of protected sleep in the NICU may reveal neuroprotective benefits and improve long-term clinical outcomes.

High-Density Diffuse Optical Tomography (HD-DOT), a functional near-infrared spectroscopy technology, has been used to investigate static resting-state functional connectivity (FC) during active sleep (AS) and quiet sleep (QS) states in term-aged infants (Uchitel, 2023). Dynamic FC analysis investigates time-varying patterns in brain activity to shed light on the non-stationary nature of resting state brain function. One method proposed for this objective identifies recurring co-activation patterns (CAPs) using clustering algorithms which group instantaneous brain configurations (Liu, 2018). This study examines dynamic FC in term and preterm infants during sleep to better understand the functional relationship between sleep states and early brain connectivity.

Methods: HD-DOT data were acquired from sleeping newborns at the Rosie Hospital, Cambridge UK (term cohort: n = 44, GA = 40+0 weeks (median), 38+1 - 42+1 weeks (range); preterm cohort: n = 26, GA = 35+0 weeks (median), 29+1 - 36+6 weeks (range). Sleep state was labelled using synchronized video or electroencephalography. For three regions of interest (ROI), the top 15% of frames ordered by seed activity for k-means clustering (see Figure 1). The clustered frames were averaged to identify the CAPs. Dynamic FC was compared across sleep states by calculating CAP consistency, fractional occupancy, dwell time, and transition likelihood. Additionally, regional lateralization was compared across sleep states for each CAP using an unpaired t-test. The post-clustering analysis has been performed for the term cohort and will be applied to the preterm cohort for comparison.

Results: Distinct CAPs were identified for each ROI (left ROI CAPs shown in Figure 2), presenting a novel dynamic characterization of known resting-state networks in term and preterm infants during sleep. These CAPs have high consistency scores, validating the efficacy of the CAP methodology in newborn HD-DOT data. Notably, several CAPs exhibit fronto-parietal connectivity, which previous studies relate to an immature and modular precursor of the default mode network. In the term sleep analysis, CAP activity revealed an association of left-lateralization with QS and right-lateralization with AS.

Conclusions: This study marks the first application of CAP analysis to term and preterm HD-DOT data revealing novel spatial patterns that dynamically characterize known brain networks. The lateralization analysis showed significant differences between sleep states, suggesting AS and QS may serve different purposes in early brain development. The upcoming analysis of the preterm cohort CAPs may reveal differences in CAP metrics correlated with GA. The results of the remaining analysis will provide novel insight into the dynamic formation and maturation of brain networks in preterm infants.

C – Cognitive Development

P2-C-63 Case study of neural evidence for persistence of infant memories into toddlerhood but not later childhood

Tristan Yates [1], Sheri Dawoon Choi [2], Juliana Trach [2], Lillian Behm [2], Cameron Ellis [3], Nicholas Turk-Browne [2]

[1] Columbia University, [2] Yale University, [3] Stanford University

Summary: Infant memories are not available to adults, but it is unclear how long they remain accessible to children. A challenge for studying the persistence of infant memory is the lack of ground truth about early experiences. We leveraged a rare opportunity to collect fMRI data from children who watched head-mounted camera footage of their own infancy.

Details: The ability of humans to remember past experiences is central to our identity, knowledge, and choices. Although adults can recall both recent and remote experiences, there is a gap in autobiographical memory for the first years of life. One potential explanation for this "infantile amnesia" is that the infant brain may not be developed enough to form and store episodic memories. Consistent with this encoding account, the hippocampus of non-human primates is immature at birth, especially the trisynaptic pathway (connecting entorhinal cortex to dentate gyrus, CA3, and CA1 hippocampal subfields) that is critical for episodic encoding. An alternative explanation, consistent with recent findings that the infant hippocampus of rodents and humans can encode memories, is that infantile amnesia instead reflects an inability to access these memories later in life. If this retrieval account is correct, then we would expect infant memories to persist beyond infancy and remain accessible for some period of childhood, even if ultimately lost by adulthood. We tested this hypothesis in an fMRI study with a 3-year-old toddler and a 9-year-old child who had participated in the SAYCam study as infants (Sullivan et al., 2021). In the original SAYCam study, three infants wore head-mounted cameras that recorded their daily experiences from an egocentric perspective. In our study years later, two of those participants viewed videos from both their own infancy (Self), for which they could have memory, and the other child's infancy (Other), for which they could not. In some videos, we manipulated the visual and/or auditory content to test whether infant memories are sensitive to mismatches and can be reinstated from partial cues. We compared BOLD responses to Self vs. Other videos in a bilateral hippocampal region of interest defined with anatomical segmentation and across the whole brain in a voxel-wise analysis. Sessions were matched across participants in many respects, including the amount of data, motion exclusions, signal-to-noise ratio, visual attention, and visuocortical responses. Despite having comparable data overall, the hippocampus of the toddler but not the older child responded more strongly to intact videos of their own first-person infant experiences. The striatum, parahippocampal cortex, and anterior temporal cortex of the toddler but not the older child responded to distortions of their own videos that introduced relational violations. This limited but rare case study, where the ground truth of human infant experience was documented, provides a proof-of-concept that infant memories are not only encoded but can be retrieved during toddlerhood.

P2-C-64 Early brain development of functional networks and impact of preterm birth

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Summary: Early brain development is a critical period when neural networks are formed, establishing the foundation for cognitive functions. We examined the typical development of functional networks in neonates and the impact of preterm birth using the fMRI data from dHCP. We also explored whether network features are linked to neurodevelopmental outcomes.

Details: Background: Early brain development is a critical period for the formation of neural networks, establishing the foundation for higher cognitive functions. Understanding this process is important, as atypical functional connectivity during the perinatal period and following preterm birth has been linked to a higher likelihood of subsequent neurodevelopmental conditions. This study aims to understand early functional connectivity development and the impact of preterm birth.

Method: fMRI data acquired from 394 neonates (325 term-born, 69 preterm-born) at term-equivalent age (postmenstrual age at scan ≥ 37 weeks) from the developing Human Connectome Project (dHCP) were used in this study. A whole-brain atlas was constructed using cortical ROIs from the 7-network Schaefer atlas (400 parcels), subcortical ROIs from the dHCP template, and cerebellar ROIs from the SUIT atlas. The atlas was transformed to the neonatal 40-week dHCP template. After band-pass filtering (0.01-0.1 Hz), functional connectivity was computed as the pairwise Pearson correlation of average timeseries between ROIs, with only positive correlations retained. Proportional thresholding was applied at different network densities (5% to 50%, at 1% steps). Network features, including mean functional connectivity strength (FCS), network integration (measured by normalised global efficiency), and network segregation (measured by normalised local efficiency), were calculated at each density and averaged across all network densities. First, effects of PMA at scan and birth status (term/preterm-born) on network features were examined using linear regression, controlling for sex and head motion outliers (and PMA at scan for birth status). Second, associations between network features at birth and neurodevelopmental outcomes (Balyley III, Q-CHAT, CBCL) at 18 months were assessed using partial correlation, controlling for sex, PMA at scan, and corrected age at assessment.

Results: Normalised global efficiency ($r = 0.280$, $p < 0.001$), and normalised local efficiency ($r = 0.239$, $p < 0.001$) were positively associated with PMA at scan (Fig. 1). Preterm-born neonates showed significantly lower mean FCS ($r = 0.21$, $p < 0.001$), normalised global efficiency ($r = 0.129$, $p = 0.011$), and normalised local efficiency ($r = 0.148$, $p = 0.003$) compared to term-born neonates. Normalised global efficiency ($r = -0.124$, $p = 0.032$, uncorrected) and normalised global efficiency ($r = -0.131$, $p = 0.023$, uncorrected) were negatively correlated with CBCL sleep score accross the whole sample (including term and preterm neonates) (Fig. 2).

Discussion: We characterised the typical development of neonatal functional networks, showing that network integration and segregation increase with age. Our findings suggest that preterm birth lowered mean functional connectivity strength, network integration and segregation. We found that larger normalized global and local efficiency were associated with better sleep across the whole sample. Sleep disruption commonly accompanies neurodivergence. However, 18 months is still a very early stage of development and whether these early network features predict neurodevelopmental characteristics in later childhood or even adolescence and adulthood is an outstanding question.

P2-C-65 - Neurophysiological changes in periodic, aperiodic, and complexity measures during infant reaching skill acquisition

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Summary: We aimed to discover neural correlates of volitional movement in this healthy population. These correlates may point towards the mechanisms behind the development and execution of volitional movement, and allow atypical development to be identified early and non-invasively.

Details: Introduction: The electrophysiology of motor planning and execution in infants is relatively understudied in comparison to adolescent and adult populations, yet critical motor learning processes take place at this stage. The development of volitional movement, such as reaching, typically occurs by 6 months of age.

Methods: Here, we analyzed electroencephalographic (EEG) markers in typically-developing infants 2-6 months of age as they gained reaching skills. We compared periodic, aperiodic, and complexity parameters for the central somatosensory electrode Cz within infants at two levels of reach skill development during reach tests.

Results: Once the infant's attained high reaching skill levels, mu frequency periodic power (6-9 Hz) increased significantly during reach trials. In contrast, as the infants attained high reaching skill levels, a decrease in the aperiodic offset and increase in complexity parameter during reach trials relative to baseline trials were no longer observed.

Discussion: Mu frequency activity is critical in adolescent and adult motor control, yet the timing of its emergence in children is not clear. This study may help narrow down the window for this key developmental milestone. This well-characterized electrophysiological measure, as well as the previously unreported changes in aperiodic and complexity measures, are potential biomarkers for typical motor development. These biomarkers may also point towards the mechanisms behind the development and execution of volitional movement, and allow atypical development to be identified early and non-invasively**.**

P2-C-66 Building blocks of infant fNIRS-neurofeedback: from an effective training paradigm to a reliable online signal (WIP)

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Summary: The infant brain undergoes rapid changes in anatomy and connectivity. Can this heightened plasticity be directed non-invasively by neurofeedback? In this research, we lay the foundations for developing an infant neurofeedback paradigm using fNIRS to explore causal relationships between neural processes underlying behavior.

Details: Neurofeedback is a non-invasive tool used in basic science research to establish causality, and clinically, as a brain-based intervention. By developing an infant-friendly paradigm using fNIRS, its utility could be expanded to this critical age, offering a novel perspective on the causal relationships between neural activation, connectivity, and infant behavior. Given its clinical relevance, it may also serve as a non-invasive strategy for early interventions at this important developmental stage. In this study, we assess the feasibility of designing a protocol for infant neurofeedback using fNIRS by exploring prediction, a core ability in human behavior.

This research had three aims: to establish an effective training paradigm; to reproduce findings on cortical activation and functional connectivity during a prediction paradigm to determine signal stability and optimal processing; and to evaluate a control task. Study 1 examined spontaneous, or unlearned, infant preferences through three experiments. In each, 20 infants (age range: 5–13 months) were shown two audiovisual stimuli on a split screen. The stimuli varied in speed, saturation, or both. Results revealed infants' consistent preference (longer looking times) for faster over slower stimuli, more saturated over less saturated colors, and their combination. In Study 2, 25 infants (age range: 5–9 months) were shown stimuli in either predictable or unpredictable sequences. This study aimed to estimate within- and between-infant variability and stability in cortical activation and connectivity associated with prediction, identify optimal parameters for real-time signal processing using offline methods, and determine the functionality of the neurofeedback algorithm based on infant connectivity patterns. Preliminary results reproduced known trends in cortical activation. Study 3 included two pilot experiments, one on tactile discrimination and one on fine motor functions, to assess a control task that differs from the experimental task in both cognitive function and neural regions.

These studies form a foundation for developing an fNIRS-based neurofeedback protocol with infants. The first study demonstrates potential unlearned preferences that may motivate neural activation in future neurofeedback work. The second provides the basis for the neurofeedback algorithm and processing pipeline. The third supports the selection of a suitable control task with distinct cortical activation.

P2-C-67 What is the role of infants' attention in object learning during social interactions? (WIP)

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Summary: While contingent naming facilitates early learning, the exact role of infants' attention is underexplored. This study investigates whether heart rate variability, a physiological measure of infants' sustained attention, is sensitive to how adults respond to what they are looking at during object learning.

Details: Infants demonstrate exceptional learning abilities (Field et al., 1984), and these abilities are enhanced in social contexts. For instance, in-person interactions promote early learning more effectively than online interactions (Troseth et al., 2017). Social contingent naming where an adult labels an object that the infant is already focusing on also enhances early learning (Goupil et al., 2024; Tomassello & Farar, 1986). However, the exact role of attention while an infant is learning about a novel object category under social contingency remains underexplored. The present study offers a new perspective on this question by investigating whether heart rate variability (HRV), a physiological index of sustained attention in infancy (Richards & Casey, 1991), captures infants' attentional response to social contingent pointing and naming while infants learn about an artificial object category.

To investigate this question, 12-month-old infants will first be tested using a frequency-tagging paradigm and exposed to sequences of

images flickering at 6 Hz (6 images/second) with two artificial object categories embedded at 1.2 Hz (1 out of 5 items) and 1.5 Hz (1 out of 4 items) in the sequences (pre-intervention). During an intervention phase, they will then be assigned to either an in-person (group 1) or an online teaching procedure (group 2). In each case, an experimenter will teach half of the infants about object category 1 ("dax") and half of the infants about object category 2 ("riff") while the exemplars of the two categories will be presented on two separated screens, for 8 trials. Infants' first fixation will be used as an index of their spontaneous preference for one or the other object category. Then, the experimenter will respond to this fixation with either a contingent or a non-contingent pointing and naming cue (e.g., the label "dax" or "riff") depending on whether the infant looked at the category they have been assigned to, or not, and their HRV will be recorded during this period. Finally, infants' learning outcomes will be assessed at post-intervention via their exposure to the pre-intervention frequency-tagging sequences and a complementary preferential looking-while-listening task combining the items of the learned and non-learned object category.

In line with Troseth et al. (2017) and with the assumption that attention is a mechanism supporting early learning (Raz et al., 2020), we hypothesize that HRV will be more pronounced during an in-person than an online interaction. We also expect HRV to be increased during adults' contingent vs. non-contingent response to infants' first fixation. Overall, these results will shed light on the importance of infants' sustained attention during object learning under social contingency. Data are currently being collected.

P2-C-68 Assessing hippocampal contributions to relational memory in infants

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Summary: The hippocampus exhibits protracted structural development throughout infancy and toddlerhood. We recently demonstrated that, despite ongoing development, the infant hippocampus can encode individual items in memory. Here, we test whether the infant hippocampus also supports a more complex memory ability, the encoding of relations between items.

Details: Episodic memories integrate multiple elements of an experience in space and time. The process of linking discrete elements into a unified representation is referred to as relational binding. In adults, relational binding depends critically on the hippocampus. Infants are also able to complete certain behavioral tasks of relational memory, which presents a mystery because the infant hippocampus is often considered immature due to the protracted structural development of this brain region. We recently demonstrated that, despite this ongoing anatomical development, the hippocampus is able to encode individual items in memory during infancy, especially in infants older than one year and in the posterior end of the hippocampus. In an ongoing study, we are testing whether these functions of the infant hippocampus extend to more complex memory abilities like the encoding of relations between items. We have collected fMRI data from a partial sample of awake and behaving infants engaged in a classic face/scene relational binding task while we monitored their gaze behavior. We presented a series of encoding trials that began with a dynamic video of a landscape scene on which a dynamic face video appeared after a few seconds. To probe relational memory for these scene-face pairs, we interleaved test trials approximately 60 s after the corresponding encoding trials. During the test trials, we cued infants with a familiar scene and then superimposed two familiar faces to create a visual paired comparison between a target (the face paired with the scene during encoding) and a foil (a face encoded with a different scene). We used familiarity preference (i.e., greater looking to the target versus foil at test) as a behavioral marker that the target face and scene relation had been bound successfully during encoding. We used infant-trained automated hippocampal segmentation to define a bilateral region of interest for the whole hippocampus which we also manually bisected into anterior and posterior portions. If the infant hippocampus supported relational binding, we expected more hippocampal activity during encoding of subsequently remembered than subsequently forgotten associations. To that end, we compared BOLD activity in the hippocampus during encoding trials for which the relation was later remembered versus forgotten. Preliminary results mirror our earlier findings with individual item recognition: we found tentative evidence that the hippocampus supports relational binding in infants older than one year and that it is clearer in the posterior portion. Overall, these findings suggest that the hippocampus begins to support even sophisticated memory abilities during infancy.

P2-C-69 Individual differences of prediction error and error commission responses: A longitudinal analysis of frontal theta and temperament (WIP)

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Summary: We studied how infants differ in the timing and trajectory of noticing changes in their environment and if/how they adjust to those changes. EEG gives us a consistent measure of the response to those changes and is also sensitive to temperament differences. We use temperament to predict the timing and trajectory of early attentional control

Details: The objective of this study is to analyze individual differences in the emergence and trajectories of prediction error and error commission during early development. Previous studies have indicated that prediction error can emerge as early as 7-9 months of age (Berger & Posner, 2023; Berger et al., 2006), while other research indicates 11-13 months (Begus et al., 2019). Additionally, there is reason to suspect that temperament may predict this development from prior research on its relation to early executive attention (Posner et al., 2012) and emotional and motivational reactions to contingency disruption (Lewis et al., 2015).

Thirty-seven infants completed monthly visits from 5 to 12 months of age, as a part of a study of the development of early inhibitory control. EEG was collected during a looking version of the A-not-B task (Bell, 2002) in which the infant selected the location of a hidden toy by looking at one of two potential hiding locations. After two successful selections, the location of the toy switched, which constitutes a very basic form of prediction error. Frontal theta during task performance will be analyzed as an assessment of prediction error and error commission during the switch trials. Temperament data collected by questionnaire (IBQ-SF; Putnam et al., 2013), completed by parents at each timepoint, will measure temperament difference.

Using a multilevel modeling framework, we will analyze the growth trajectory of frontal theta power during reversal trials, correct and incorrect. Crucially this model will allow 1) the partitioning of variance components to analyze individual differences in trajectory, 2) the relation of interindividual difference at 5 months of age to intraindividual change over the first year of life, 3) and the ability to identify

group level age of emergence. Level-two temperament predictors (IBQ-SF factors of Negative Emotionality, Positive Affectivity/Surgency, and Orienting/Regulatory Capacity), will explore the extent to which biologically based individual differences explain the emergence and trajectory of early prediction error responses.

When considering developmental context, this work will describe the relations of biologically based individual differences and the precursor to executive functions and cognitive control. This information can be leveraged to understand how early differences between individuals can project into later gaps in achievement (Moffit, 2011; Blair & Razza, 2007) and forecast potential behavioral problems and psychopathology (Morales et al., 2016)

P2-C-70 Neural correlates of sustained attention in toddlers with and without a family history of autism (WIP)

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Summary: We test which patterns of EEG oscillatory power correlate with heart rate-defined periods of sustained attention in autistic and non-autistic toddlers. This allows us to identify reliable neural markers of sustained attention that can be used in future research investigating individual differences in attention in diverse population.

Details: Sustained attention is a key cognitive ability characterised by an increase in arousal and higher attention allocation. At the brain level, a state of sustained attention has been characterised by an increase in theta power from 3 months and a decrease in alpha power from 10 months of age. However, it is unclear whether these neural markers also correlate with periods of sustained attention in older children and whether they apply to autistic populations.

Here, we combine EEG with heart-rate and eye-tracking data to investigate which pattern of EEG oscillatory power is the most reliable neural correlate of sustained attention in toddlers. Identifying reliable neural signatures of attention engagement in both neurotypical and neurodiverse toddlers has important implications, especially given that (social) attention is a core area of interest in autism research. Our specific research questions are (a) whether theta and alpha power differ between periods of heart rate-defined sustained and non-sustained attention, (b) whether theta and alpha power differ in response to social and non-social stimuli during periods of sustained attention, and (c) whether differences in theta and alpha power emerge between autistic and non-autistic toddlers during sustained attention.

EEG (128 channels), eye-tracking and heart-rate data from toddlers between 24 and 36 months will be analysed. Our sample, taken from the STAARS project, includes toddlers with (N=81) and without (N=45) a family history of autism who watched social (women singing) and non-social (toys moving) videos on a screen. We define sustained attention based on looking behaviour and heart rate deceleration: a phase begins when the median of five consecutive interbeat intervals (IBI) is lower than the median of the five IBIs preceding a look onset and ends when this pattern reverses.

Analyses are ongoing and results will be presented at FITNG. We hypothesize that theta power will increase and alpha power will decrease during heart rate-defined sustained attention, in line with infant findings. Further, we expect increased theta and decreased alpha power during periods of sustained attention particularly when toddlers are watching social stimuli. Finally, we expect these oscillatory dynamics to differ between toddlers with and without a family history of autism, indicating emerging neurodiversity in allocating attentional resources to social and non-social stimuli. If we find that theta and alpha power do not differ between periods of heart rate-defined sustained attention, it is possible that heart rate no longer reflects attention in this age range and alternative analyses for our 3 research questions will be conducted by comparing alpha and theta power during epochs of longer vs. shorter looks.

This study will provide novel information on EEG markers underlying attention engagement in neurodiverse populations that are suitable for naturalistic experiments where subjects interact with each other face-to-face in an ecologically valid setting. Moreover, extending this research beyond infancy and into toddlerhood provides critical insights into the development of attentional processes. Our findings will thus contribute to a broader understanding of neural correlates of sustained attention in the developing brain and inform future research in both typical and atypical developmental trajectories.

P2-C-71 Assessing the neural basis of newborn verbal memory by word learning and recognition using high density fNIRS (WIP)

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Summary: It is unclear what the cognitive and neural mechanisms support newborns' verbal memory. This study aims to investigate newborn brain activity during the learning of new verbal information as well as when the newborn recognizes learnt words, using state of the art high density fNIRS.

Details: Memory plays a crucial role in learning and brain plasticity, yet its functioning at birth remains underexplored. The IN-MIND project aims to investigate early memory and language abilities, by looking at brain activity during verbal memory formation and verbal recognition trajectories, and the factors that modulate this capacity in infancy.The project integrates two neuroimaging methods, respiration acquisition, and video recordings to obtain a complete picture of infant brain activity during a resting state (rs) and when exposed to verbal auditory stimuli.

The present study examines brain recognition responses in newborns. When using functional near infrared spectroscopy (fNIRS) it has been shown that a distributed network including temporo-parietal and frontal areas show significant contrast in their response when differentiating between a novel and familiar word (Benavides-Varela et al., 2011; 2012; 2017). However, these studies used low density fNIRS measurements (24 channels), which limited their spatial specificity. This study uses a high density (HD) fNIRS/Diffuse optical tomography (DOT) Lumo (Gowerlabs, London UK) device with up to 2700 channels across the surface of the cortex, allowing for superior spatial specificity (Figure 1A). These form our first aim, to identify specific areas of the brain responsible for verbal recognition and verbal memory formation, by measuring the brain's haemodynamic response.

This study recruited 98 newborns (mean gestational age 39 weeks, SD 1 week, mean birth weight 3311 grams, SD 403 grams) and used a 20 minute paradigm that consisted in a silent resting state (0-5 min), 8 blocks of encoding a single familiar pseudoword (5-10 min),

a post-encoding silent resting state (10-15 min) and a test (15-20 min) splitting newborns into two groups. Group 1 was presented with 2 blocks of the same familiar word and group 2 with 2 blocks of a new novel word. Both groups then followed by the alternation of the same familiar and novel word across 6 remaining blocks (Figure 1B).

Significant differences ($p \leq 0.05$, not corrected) in the mean change in oxyhaemoglobin (HbO) were found between the familiar v.s new word groups across different areas of the brain through blocks 9-16 (figure 1C). Initial novel word recognition (block 9) in the frontal and central areas (Fz and C1, referencing to EEG 10-5), and then stronger recognition of the novel word in block 12 in the left temporal-parietal areas (TP7, CP3, P3 and P5), with novel recognition for block 16 only seen in channels around the P5 location.

These results suggest that the frontal and left parietal regions mediate the recognition and novelty detection of verbal material at birth. Preliminary coding of sleeping states was performed at 15s epochs, a validation against respiration data is in progress. HD-DOT and rs functional connectivity (FC) analysis is planned, to attempt to detect verbal memory in newborns, and how sleep states affect this.

Conclusion: fNIRS data has been collected on 98 newborns during a 20 minute verbal memory task, with EEG, video recording and respiration data collected where possible. Initial analysis of the fNIRS data shows novel word recognition in the left frontal, central and parietal areas of the brain. HD-DOT, resting state functional connectivity and sleep state classifications are in progress to explore the memory development process, both as a function of sleep state and during and after encoding.

P2-C-72 Structural brain organization trajectories of surface area covariance in the early neonatal period

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Summary: Neonates of the same postmenstrual age (PMA) but different birth timing undergo critical neurodevelopmental stages in different environments. In this study, we aim to describe surface area metrics related to gestational age at birth (GAB) and contextualize findings to PMA-specific gradients of structural brain organization.

Details: The perinatal period is characterized by rapid physiological changes and exposure to new stimuli. Given the distinct environmental circumstances of intra- and extrauterine development, neonates with the same postmenstrual age (PMA) but different gestational age at birth (GAB) potentially follow divergent trajectories of brain maturation. Here, we use surface area (SA) measurements to describe cortical expansion in the early neonatal period.

Leveraging data of n = 550 neonates from dHCP (Fig 1a), we extracted SA measurements in 300 cortical parcels (Fig 1b). Subjects were then stratified into eight bins depending on their PMA (37-44 weeks; Fig 1a). For statistical analysis, we fit surface-based linear models including GAB, age, sex, and intracranial volume to SA data. Within each age group, we calculated group-level structural covariance (CV), defined as the partial correlation between SA values within a parcel while correcting for global SA. For term- and preterm-born subjects in all age groups, we determined the correlation of group-level CV to a birth time reference CV, derived from 40w PMA, term-born neonates. Then, we used principal component analysis to derive gradients of structural organization within each PMA cohort, with Procrustes alignment to the 40w PMA gradient.

SA appeared to increase with GAB, most notably in anterior frontal and temporal regions. Sex difference analysis hinted towards higher SA in the left anterior insula in male neonates (Fig 1c). Term-born neonates exhibited notably higher correlation to the birth time reference as compared to preterm-borns (Fig 2). Primary CV gradients exhibited a largely anterior-posterior distribution, appearing anchored in the occipital cortex and extending to frontotemporal regions around 40-42w PMA, whereas secondary gradients reached more transmodal regions, including the prefrontal cortex and precuneus (Fig 3a). T-values quantifying changes with GAB were mapped onto the primary and secondary gradients and appeared significantly related to both axes in the 37-38 and 44-week subgroups, whereas t-statistics relating to sex differences adhered to the primary gradient almost throughout (Fig 3 b,c).

Our preliminary findings underline differential structural expansion in term- and preterm-born neonates at similar PMA, and delineate anterior-posterior axes of structural brain organization in the neonatal period that appear associated with sex differences and partly align with surface maps of GAB-specific differences in early- and late-term-equivalent PMA groups.

P2-C-73 Understanding longitudinal changes in sleep-dependent memory consolidation and underlying mechanisms

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Summary: We integrate findings from mid-density polysomnography (sleep EEG) which provide insight into both the brain mechanisms underlying memory consolidation across these age ranges and have themselves been proposed as a marker of brain development. Moreover, we focus on the ages of 16-31 months, filling a gap in the literature as a whole.

Details: Sleep supports memory consolidation. Systems consolidation theory holds that memories are reactivated in hippocampal CA3 during sleep and corresponding hippocampal ripples are coincident with sleep spindles and cortical slow oscillations. This coupled activity supports hippocampal-neocortical transfer and stabilization of memories in the cortex. Hippocampal CA3 undergoes protracted development leading to a hypothesis that such memory consolidation during sleep cannot occur until after 18-24 months. To date, similar sleep benefits have been observed across infancy to childhood. However, prior studies have focused on a single age group with widely varying tasks. We are conducting a longitudinal study across this developmental period. We have recruited 38 children who were 16 or 21 months at enrollment and returned 5- and 10-months later. At each timepoint, children performed a learning task followed by a 12-hr interval of overnight sleep or daytime wake (within subject) before memory was reassessed. Mid density polysomnography was collected during sleep. Memories were protected by sleep similarly across all age groups ($F(3,86)=0.363$, $p=.780$). However, memories decayed less across wake with age $F(3,84)=3.930$, $p=.011$). Thus we have evidence that sleep benefits memory from a very young age and likely via similar mechanisms (no difference in sleep stage associations). My talk will discuss how findings inform our understanding of memory consolidation during sleep at very young ages.

P2-C-74 Functional organization of the Anterior and Posterior Hippocampus in the Fetal Brain

Emily Nichols [1], Sarah Al-Saoud [2], Michelle Fang [1], Roy Eagleson [1], Barbra De Vrijer [1], Charles Mckenzie [1], Sandrine De Ribaupierre [1], Emma Duerden [1]

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Summary: Investigating long-axis hippocampal connectivity in the third trimester fetus offers a unique opportunity to address fundamental questions about brain development. Given the importance of the hippocampus in human cognitive and affective function, mapping its early functional development can help us understand both the typical and atypical brain.

Details: The hippocampus, in both children and adults, has shown long-axis functional specialization, with the anterior region associated with emotional processing and the posterior region with spatial memory and navigation. This specialization is also reflected in separate patterns of functional connectivity, but it is unclear whether it is present before birth. Here, we collected resting-state fMRI data in 51 healthy third-trimester fetuses to examine long-axis functional specialization in utero. Using structural regions of interest in the anterior and posterior hippocampus, a seed-based connectivity analysis was performed. We identified distinct networks of functional organization for the anterior and posterior hippocampus. These patterns showed spatial organization and anti-correlation consistent with long-axis specialization. While less mature than those observed in postnatal human and preclinical models, the fetal patterns suggest that the foundation for hippocampal functional differentiation supporting early affective and cognitive processing is already present before birth.

P2-C-75 Preliminary examination of recruitment and retention efforts within HBCD (Pre-registered report)

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Summary: There is limited literature on factors influencing recruitment and retention of pregnant and mother-child dyads in observational infant neuroimaging research, including those with substance use during pregnancy. Identifying these factors is important to improving participation and understanding neurodevelopmental outcomes.

Details: For scientific research to continue enabling better health outcomes through advancements in understanding infant development, we need participation of many families to conduct studies. Though literature exists addressing ways to engage women in studies, understanding how to recruit pregnant individuals and retain mother-child dyads in neuroimaging and human development studies is limited, especially for individuals with histories of substance use (SU). Research personnel can serve as a bridge to identify tractable factors that influence the recruitment and retention (R&R) of families, as they are the ones speaking to the community about engaging in research. The purpose of this investigation is to identify factors influencing the R&R of diverse families into the HEALthy Brain and Child Development (HBCD) study. A qualitative approach was taken, which utilized interviews of R&R staff and a demographic survey. The preliminary data presented is a subset of the dataset. Interviews were completed by 41 HBCD personnel within the first-year recruitment period. Data from 14% (n=6) of the total sample was transcribed first by a computer through a captioning system and then transcribed verbatim and cleaned for accuracy by a human. A thematic analysis was conducted to identify themes and subthemes using inductive coding. The analysis provided themes of direct and indirect strategies utilized by multiple HBCD sites, such as word of mouth, flyers, relationship building, direct mailing, etc. Having a study navigator and recruiting at clinics that served the SU population were identified as some of the ways that worked well for recruiting individuals with SU histories. Some of the themes identified within the barrier domain were transportation, staffing, access to the internet, and time to participate. Non-genuine communication, information dumping, and lack of in person interaction were some of the themes within the strategies domain that did not work well when recruiting SU individuals. The combination of these preliminary data provides information about strategies being used and barriers being encountered, serving as a foundation for identifying key factors that are currently impacting the participation of pregnant individuals in neuroimaging and human development longitudinal observational studies. Further analysis will be conducted with the entire sample to fully and comprehensively identify the factors and processes that influence R&R, including the examination of site structure.

D – Developmental Psychology

P2-D-76 Effects of motor development on somatotopy during action processing (WIP)

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Summary: As infants observe other people's actions, there is activation of motor brain areas. There is a question of whether this activation reflects the goal of the action only, or also the means of performing it. One way to answer this is to examine the activation of hand- or foot-related areas during related actions, and how this changes developmentally.

Details: Infants, like adults, show activation of movement-related brain areas when watching other people perform actions. This motor activation occurs during goal-directed action but not during incidental movements, suggesting that it reflects action processing. An established behavioural and neuroscience literature suggests that infants can detect and even predict others' goals from at least six months of age, but findings on how they encode the process of achieving those goals are mixed.

In somatotopic EEG, touch- and movement-related brain activity is localised to regions related to the effector in question (e.g. watching or performing hand movements to hand areas of motor cortex). If infants encode the means of performing an action, we expect greater somatotopic motor activity over areas involved in that action. Results of studies in this area have been mixed, with one study of 12-month-olds showing activation of hand areas during observation of both hand and foot actions (de Klerk et al., 2015) while another found somatotopic activation in 14-month-olds (Saby et al., 2013). The reason for this difference in results may be developmental, as 14-month-olds are more likely to have walking experience and consequently, better motor representation of leg actions.

In an accelerated longitudinal design, we are recording EEG from 5-, 9- and 13-month-olds as they watch recordings of actors pressing buttons on a toy with their hands and feet to create light and sound effects. We are also collecting parent-reported motor development via the Early Motor Questionnaire (EMQ, Libertus & Landa, 2013). The 6 to 9 Hz EEG frequency band is reflective of the infant mu rhythm,

an EEG rhythm which shows a decrease in power related to motor activity. We will run cluster-based permutation tests to identify, for each age group, mu desynchronization topography for hand and foot actions (relative to baseline), and differences in topography for hand versus foot actions. We anticipate more overlap in the hand and foot topographies for younger infants, and greater specialization with age.

Having identified these topographies - which we expect to be closer to the central midline for foot actions, and over lateral central electrodes for the hands, we will then compare activation in canonical hand and foot areas for each type of action across age groups, controlling for differences in motor skill development via the EMQ. We expect an interaction between action and location, such that there will be more mu desynchronization in hand areas in response to hand than foot actions (and vice versa for foot actions), and a further interaction with age in which activation in foot areas for foot actions will become stronger with age. Results along these lines will tell us whether motor activation in infants is responsive to the means of performing an action as well as its goal, and whether somatotopy during action processing develops with age and motor experience.

P2-D-77 Developmental differences in reward processing: Investigating the reward positivity ERP in an adapted doors task (WIP)

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Summary: Current research on reward often relies on money or points, but these tasks require abstract representation and may not work with young children.To investigate how reward processing develops in young children, we developed a more child-friendly task using prize boxes. We measured response to reward in one of the youngest samples yet: 3-5-year-olds.

Details: Existing literature has characterized the Reward Positivity (RewP), an event-related potential that indexes response to reward, in adults and school-aged children but rarely in infancy and toddlerhood when reward circuitry is starting to develop (Fareri et al., 2008). The primary experimental task (Doors Guessing Task) has limited application to toddlers and preschoolers, creating a gap in our understanding of the development of response to reward. The current project aims to determine whether a developmental adaptation of the Doors Guessing Task using two prize boxes with desirable and undesirable rewards (Figure 1) elicits the RewP in children ages 3-5 years — younger than any previously studied. Electroencephalography was recorded from preschoolers (n=43, 25 female) who completed 60 trials of the adapted Doors Guessing task. Standard artifact removal procedures were implemented with the Harvard Automated Processing Pipeline for EEG (HAPPE; Monachino et al., 2022). The RewP was computed by subtracting undesirable from desirable reward waveforms from 250 to 500ms after stimulus onset for a frontal region of interest (E11/Fz, E4, E16, E19). Across all ages, as expected, response to the desirable reward shows a larger mean positive amplitude in the 300-350 ms range compared to the undesirable reward, though not statistically significant (Figure 2). The difference between conditions (RewP) was observed to be largest for 5-year-olds and smallest for 3-year-olds; results did not reach statistical significance and data collection to obtain larger samples is ongoing (Figure 3). These results demonstrate the potential of the Adapted Doors Task to elicit the RewP. At age 3, the RewP (difference between the undesirable and desirable prizes) is smallest of all age groups but in the expected direction; larger samples are needed to confirm the presence of the RewP in 3-year-olds. Our results provide potential evidence of the reward positivity (RewP) in 3 year olds. We also establish the feasibility of the adapted doors task to elicit the RewP, which may advance our understanding of early reward processing mechanisms, especially in clinical populations (e.g., autism). Future directions can investigate early neural divergence associated with neurodevelopmental disabilities, laying the foundation for early identification and targeted intervention strategies to support social and cognitive outcomes in at-risk populations.

P2-D-78 The development of Excitation-Inhibition balance in infants: A longitudinal EEG design (WIP)

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Summary: We aim to understand how the balance between excitatory and inhibitory brain activity develops during infancy. Using EEG, we track this balance over time to explore its role in early brain development, which may help explain individual differences in later cognitive outcomes.

Details: The balance between excitatory and inhibitory (E/I) neural activity is a key mechanism shaping brain development in early life. During infancy, inhibitory systems gradually mature, possibly leading to shifts in E/I balance. It has been proposed that such changes in E/I balance optimize neural plasticity and learning, and regulate sensitive periods during which the brain is particularly receptive to experience-driven refinement (Dorrn et al., 2010; Werker & Hensch, 2015). Studying E/I balance in infancy therefore offers a unique window into the developmental dynamics that guide neural plasticity and early brain organization, with potential relevance for understanding individual differences in cognitive development. Cross-sectional findings in older children and adolescents have shown that the developmental trajectory of E/I balance is related to language abilities (Plueckebaum et al., 2023), highlighting the importance of mapping its early developmental course.

In this longitudinal study, we investigate the development of E/I balance during the first year of life using resting-state EEG data from 129 infants assessed at 6, 9, and 12 months of age. We employ two EEG-based markers of E/I balance: (1) a functional index derived from amplitude fluctuations and temporal autocorrelation of alpha oscillations in resting-state EEG (Bruining et al., 2023), and (2) the aperiodic slope of the power spectrum, which has been proposed as a proxy for cortical excitation-inhibition dynamics (Gao et al., 2017). Based on prior research, we hypothesize that both measures will indicate an increase in inhibitory activity with age.

By tracking E/I balance across the first year of life, this study aims to characterize its developmental trajectory and examine its potential as a neurophysiological marker of emerging sensitive periods. This work provides a foundation for future research into early deviations in E/I dynamics and their possible role in shaping individual differences in cognitive and neurodevelopmental outcomes.

P2-D-79 How much natural light propagates to the human fetal eye?

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Summary: Investigating the dynamics of natural light and the interface with maternal tissue holds implications for obstetric care, maternal well-being, and future work on artificial wombs including in partial ectogenesis (Partridge et al., 2017). This knowledge helps us to determine light spectrum and levels needed for optimal fetal visual development.

Details: Understanding the interplay between natural light and the fetal environment is integral to elucidating its potential impacts on fetal development. Light serves as a fundamental environmental cue, regulating circadian rhythms and in infuencing various physiological processes within the developing fetus (Lunshof et al., 1998; Serón-Ferré et al., 2001). Determining how natural light penetrates the uterine environment offers insights into the intricate relationship between external stimuli and intrauterine development, potentially unraveling novel pathways through which light exposure may shape fetal health outcomes. A Monte Carlo model of penetration of light to the uterus first reported in Isaac, Heerikhausen and Reid (2025) was modified by providing a broad illumination of the maternal abdomen. Monochromatic sources were simulated from across the visible spectrum and combined, resulting in a simulated "white light" source that was scaled to the strength of direct sunlight at sea level. We then estimated the upper bound uterine illumination for direct contact with skin. We extended this by simulating the impact of a cotton fabric shirt on the uterine environment. This model indicates that direct maternal abdominal exposure to natural light can result in a uterine illuminance comparable to a level between that of a full moon on a clear night and civil twilight. Introducing clothing reduces illuminance to levels more comparable to that of a quarter moon.

P2-D-80 Updated systematic review and meta-analysis: The functional foetal brain

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Summary: This systematic review and meta-analysis updates Dunn et al. (2015) by re-evaluating the field of fMRI and fMEG studies that investigated foetal sensory abilities. It gives a more comprehensive understanding of foetal sensory abilities and how methodological variability affect latency and amplitude values of foetal evoked responses.

Details: The present work updates Dunn et al. (2015) which examined methodological variations across studies that used functional magnetic resonance imaging (fMRI) and foetal magnetoencephalography (fMEG) to measure foetal evoked responses after auditory or visual stimulation in typically developing samples. In the current research, methodological factors on latency and amplitude, and the impacts of atypical development on the foetal brain responses were also analysed.

APA PsychNet, ProQuest Social Sciences, Scopus, PubMed, and Science Direct were searched for eligible studies with either "fetal AND (fMRI OR fMEG)" or "fetal AND (fMRI OR fMEG) AND evoked response".

A total of 528 records were identified and 41 articles describing 46 studies were included in the final analyses which were carried out in RStudio using the random effect model. Only six studies had foetuses showing atypical development. Results show that auditory stimuli consistently activate fronto-temporal areas while visual stimuli activate frontal areas. In contrast, amplitude and latency values are moderated by modality, gestational age, and several methodological factors, such as the interstimulus interval, the type, and the delivery method of the stimulus. There is also large methodological variability between studies particularly in terms of how the data was acquired and analysed. Furthermore, the results are often described incompletely thereby limiting comparisons across this small field.

This works shows that the field has not yet achieved a coherent understanding of how sensory stimuli are processed during gestation. Further work should adhere to the recommendations of Dunn et al. (2015). Specifically, larger sample sizes, standardized protocols, and comprehensive descriptions of paradigms and results are required to improve interpretations of data across both medical and psychological fields.

P2-D-81 Relationship between eccentricity and category selectivity in infant visual cortex

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Summary: The adult brain organizes vision by what we see (like words or scenes) and where we see it (central or peripheral vision), but how these organizational properties develop is unknown. By independently studying the time course of these two properties in infancy, we gain insights into how visual specialization emerges during the first year of life.

Details: Two of the most important organizing properties of the mature primate visual system are retinotopic maps and category selectivity. Retinotopic maps recapitulate space in the organization of visual cortex (Wandell et al., 2007), while category selectivity regions are specialized for processing content like faces, scenes, and words (Kanwisher et al., 1997; Epstein et al., 1999; Cohen et al., 2002; Bao et al., 2020). Research in adults suggests that these category-selective regions are embedded within retinotopic maps, such that different regions have different foveal versus peripheral biases (Levy et al., 2001; Hasson et al., 2002). However, it remains unknown whether these eccentricity biases are already present in infancy. How do eccentricity and category selectivity emerge in infant visual cortex? This study investigated the relationship between eccentricity and category organization in infants aged 2–10 months. Using awake fMRI, infants viewed blocks of scenes and words presented either foveally or peripherally in the visual field. We validated this paradigm in adults under free-viewing conditions, confirming that reliable measures of eccentricity and category responses can be obtained despite eye movements that are typical in infants. We measured neural responses in the occipitotemporal sulcus (OTS), which in adults shows a foveal bias and is selective for words; the collateral sulcus (COS), which shows a peripheral bias and is selective for scenes; and early visual cortex (EVC), which is not category-selective but displays a gradient in sensitivity of foveally and peripherally presented stimuli. Data collection is ongoing, with a target sample of 24 infants: 12 between 2–6 months and 12 between 6–10 months. We hypothesize that eccentricity organization will be present in infants regardless of age, while category selectivity—particularly for

scenes—will emerge only in older infants (6–10 months). Findings from this study will elucidate the connection between eccentricity and category organization, offering insight into how functional selectivity arises in the mature brain.

P2-D-82 Do infants detect prosodic violations in an unknown language at birth?

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Summary: In this work, we investigated whether newborns can detect violations of prosodic contours in the input speech even when stimuli are presented in an unfamiliar language. To this end, we presented French utterances, with standard and deviant prosodic contours, to Italian monolingual newborns, and measured their brain responses with fNIRS.

Details: Objectives: Prosody, i.e., the melody and the rhythm of speech, is the fundamental organizing principle of spoken language. Previous studies demonstrated that, already at birth, infants are sensitive to prosodic components of speech (e.g., Abboub et al., 2016; Benavides-Varela & Gervain, 2017) and this early sensitivity may be particularly relevant for the acquisition of later grammatical, lexical and morphosyntactic abilities (e.g. Gervain & Werker, 2013). Recently, Martinez-Alvarez and colleagues (2023) provided evidence for newborns' abilities to detect utterance-level prosodic violations in the language they heard prenatally, i.e., French. Similarly to adults, this discrimination ability was right-lateralized in the neonatal brain. Is this ability based on prenatal experience with the native language, or do newborns possess a universal sensitivity to the shape of prosodic contours? To answer this question, we tested infants prenatally exposed to Italian with the same French stimuli as in Martinez-Alvarez et al. (2023), with near-infrared spectroscopy (fNIRS).

Methods: 41 full-term Italian newborns (GA:37-42 weeks) were recruited and tested at the Maternity Ward of the Padua University Hospital in Padua (Italy). The experiment consisted in administering auditory stimuli in the form of utterances, in French, a language unfamiliar to the tested infants. Within a block, the same utterance was either repeated three times with the standard prosody (Standard) or two times with the standard prosody and one time with a deviant prosody (Deviant). In total, 24 blocks per condition were presented (mean duration: 5.8 seconds, interblock interval: 20-30 s). NIRS data was pre-processed using a commonly employed routine (Gemignani & Gervain, 2021). After data quality inspection and rejection of bad quality trials, 25 newborns were included in the final analysis. Statistical analyses included cluster-based permutation tests and between-group comparisons, using data collected with the same design on French-monolingual infants (Martinez-Alvarez et al., 2023).

Results: Results Italian newborns display significant responses to both standard and deviant prosody as compared to baseline, but show no difference between the two conditions, using HbO. Using HbR, three clusters of channels, one in the LH and two in the RH (Figure 1a) display larger responses (i.e., more negative) for Standard compared to Deviant. Moreover, the between-groups ANOVA highlighted an increase in activation over time to the Standard condition and a decrease in the Deviant condition in the Italian-exposed, but not in the French-exposed group (Figure 1b), thus suggesting significant habituation to the Deviant utterances, for the Italian infants only.

Conclusions: These findings show that the ability to discriminate violations of the prosodic contours does not necessitate prior experience with a given language, as Italian infants do show differential responses to the two stimuli, although with HbR only. However, the timing and localization of these responses is different from those obtained on French infants, native of the language employed for the stimuli. Taken together, these findings suggest that a universal sensitivity to prosodic contours is in place at birth, but that such sensitivity is further modulated by prenatal experience, giving rise to the between-groups differences.

P2-D-83 Temperament and electrocortical development: Examination of infant alpha EEG coherence

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Summary: Temperament has been linked to EEG alpha activity (Hinrichs & Machleidt, 1992; Srinivasan et al., 2007). This study will be the first to examine EEG alpha coherence and infant temperament across the first year. We aim to identify associations between functional connectivity and early temperamental traits that may persist developmentally.

Details: Temperament and its development have been associated with the alpha band of EEG coherence in previous research that focused on adolescent and adult populations, results suggest that this measure stands as a reliable indicator of emotional states. In the current study, five data sets from previously conducted studies were analyzed to determine if resting state alpha coherence measures differ in various brain regions and are associated with variation in levels of temperament. Additionally, we aimed to determine if, as age increases, a synchronous result in coherence may be seen (specifically, from posterior to anterior), in accordance with neurophysiological development. Regression analyses suggested that the negative affectivity temperamental qualities did not significantly associate with coherence. Repeated-measures analyses yielded significant results in favor of the electrocortical development hypothesis and, through exploratory analysis, more reactive temperament scores depicting positive affectivity, emotional/self-regulation, and activity level displayed in infants who had higher coherence in posterior regions. The study was suggestive of high coherence values associating with highly reactive temperamental attributes in posterior regions in the 3- to 12-month-old participants and higher coherence values displaying in posterior regions compared to anterior regions consistently across age groups.

P2-D-84 Leveraging neuroimaging approaches to parse the nature of child-to-mother effects in early development

Rebecca Brooker [1], Elizabeth Kiel [2]

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Summary: The proposed presentation will demonstrate the utility of using EEG-based imaging techniques to advance the growing area of research on infant-to-mother effects on emotional development.

Details: A sizeable literature, including work from our group, has used imaging techniques to understand how the characteristics and behaviors of early caregivers, predominantly mothers, may influence emotional development across the fetal, infant, and early childhood periods (Brooker, 2018; Brooker & Buss, 2014; Kling et al., 2023; Nyman-Mallis et al, 2025). Despite significant advancements, this literature tends to depict infants and young children as passive recipients of the early caregiving environment when, in fact, classic developmental theories recognize children as active agents in their own developmental context (Bronfenbrenner & Morris, 1998; Piaget, 1962). The work presented in this talk will demonstrate the utility of neuroscience approaches (chiefly electroencephalography [EEG]-based methods) for investigations that demonstrate how children are active agents of development. Namely, individual differences in behavioral and neural function in infants and young children predict critical elements of maternal development that will scaffold traditional mother-based elements of the infants' own early environment. This presentation will combine data from completed and in-progress work to highlight when and how infant to mother effects in the domain of emotional development may manifest in the infant, toddler, and preschool years.

First, we will present infant emotion characteristics, measured as both observed behavior and neural activity (EEG asymmetry and event-related potentials), as predictors of longitudinal maternal depression and anxiety symptoms across the peripartum period (Brooker et al, 2023) and mothers' parenting behaviors during early childhood (Brooker & McNamee, in prep). Results show that behavioral and psychophysiological markers of greater negative emotion on infants predict sustained high levels of symptoms and increases in insensitive parenting in mothers over time. Critically, both maternal symptoms and parenting behaviors have direct implications for subsequent infant development.

Then, we will present data that leverage imaging approaches to identify potential nuances in the effects of the infant-mother relationship on maternal emotion processing. Results in partial samples suggest that (1) behavioral markers linked to insecure attachment predict greater amplitudes of ERP-based markers maternal neural reactivity, but no differences in ERP-based markers of reappraisal one year later, suggesting a possible specificity of effects within the domain of emotional reactivity (Kiel et al., in prep) and (2) the coupling of neural activity, measured using EEG, between infants and mothers may be more less protective than traditionally depicted for children of mothers who are high in maternal symptoms (Malllin et al., in prep). Subsequent analyses will also consider the implications of infant-mother neural coupling for maternal development over time, complementing an overall story of infant-to-mother effects.

Overall, results demonstrate a broad range of infant-to-mother effects that are intended to offer novel insight and also inspire subsequent work that characterizes children, and their neural function, as predictors of developing mothers and unfolding infant-mother relationships.

P2-D-85 Examining the main effects of prenatal cannabis exposure on neonatal multi-modal network connectivity (WIP)

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Summary: Rates of cannabis use during pregnancy have steadily increased across the last two decades, putting birthers and offspring at subsequent risk for physical and mental health challenges. This study contributes to our understanding of the neurobiological effects of prenatal cannabis exposure on neonatal brain development.

Details: Objective: Cannabis is the most frequently used illicit substance during pregnancy, with rates increasing from 3.4% in 2002 to 8.14% in 2019 (Warner et al., 2014; Volkow et al., 2019). There are many factors contributing to the rise in cannabis use during pregnancy including legalization of recreational cannabis across 24 US states, misinformation surrounding the safety of cannabis during pregnancy, and an ongoing perinatal mental health crisis. Rising rates of prenatal cannabis exposure (PCE) introduce complications for both the birther and fetus, including elevated risk for gestational hypertension, preeclampsia, and low birth weight (Ainiti et al., 2023; Young-Wolff et al., 2024; National Academies of Science, Engineering, and Medicine, 2017). The gestational environment and birth complications may influence the offspring for years to come. In the context of PCE, neonates are at subsequent risk for mental and physical health challenges come early childhood and adolescence, including attentional and behavioral problems, impaired executive functioning, and elevated risk for neurodevelopmental diagnoses including attention deficit/hyperactivity disorder and autism spectrum disorder (Baranger et al., 2022; Keim et al., 2024; Tadesse et al., 2024). Most research examining the effects of PCE on offspring structural and functional network connectivity is restricted to self-report substance use measures. We addressed this limitation by biologically quantifying cannabis in maternal and neonatal samples. Furthermore, research has primarily focused on child and adolescent populations given the innate challenges of scanning infants and toddlers. Scanning children years after PCE, however, introduces environmental, genetic, social, and biological interactions that may influence brain development (Virolainen et al., 2022). To limit external influence, neonates were scanned as close to birth as possible at 2-4 weeks postnatal. The objective of this study was to evaluate differences in structural and functional connectivity between neonates exposed and not exposed to cannabis during pregnancy (20 exposed, 24 nonexposed).

Methods: The analysis focused on data from a multimodal prospective pre-birth cohort study of mother-infant dyads selected based on prenatal cannabis use at least two times per week in the absence of illicit drug, alcohol, or tobacco use. The study took place in a state with legalized recreational cannabis (Colorado, United States). PCE was biologically quantified via the presence of 12 cannabinoids and their metabolites using high-performance liquid chromatography-tandem mass spectrometry in maternal and neonatal biological samples. Secondary monitoring of other substances was done via self-report and medical chart review. Neonatal MRI was conducted between 2-4 weeks postnatal to measure both structural and functional connectivity, with a focus on frontolimbic connectivity.

Analysis Plan: FSL (FSL Development Team, 2012) will be used to preprocess DWI data, including correction for eddy current, motion,

and susceptibility-induced distortions. DSI Studio (Yeh, 2025) will be used to perform tractography and generate structural connectivity matrices. Connectivity matrices for fMRI data will be generated using Nibabies (Goncalves et al., 2023) and XCP-D (XCP-D Development Team, 2024). Group differences in whole-brain functional and structural connectivity will be tested using Network-Based Statistics (Zalesky et al., 2010).

P2-D-86 Understanding the neural mechanisms underlying infant visual habituation using EEG (pre-registered report)

Ryan Stanyard [1], Claire Monroy [1]

[1] *Keele University*

Summary: Characterising how neural signatures of habituation in young infants relate to cognitive development will provide insights into the emergence of early infant cogn ition. This provides a ground truth for comparisons against infants born deaf, for whom such auditory information is not fully readily available, impacting learning and cognition.

Details: Infants born with hearing loss (HL) demonstrate slower habituation to visual stimuli (Monroy et al. 2019) than typically developing (TD) hearing peers. Slower habituation is associated with less efficient information processing in TD infants. However, differences observed in deaf infants may arise from "difficulties" encoding information (i.e. a deficit) or slower, deeper encoding (i.e. compensation) (Colombo et al., 2019). Objective: We seek to first characterise neural mechanisms underlying visual habituation in typically developing (TD) infants using electroencephalography (EEG). Subsequent work will explore age-matched comparisons between TD and HL infants as part of an ongoing project. Methods: Infants aged 8-12 months (preliminary data: 13.20±5.76 months [M, SD], n = 16, F = 11, M = 5) experienced an adapted version of the Monroy et al., (2019) habituation paradigm, adapted for EEG. Briefly, infants were repeatedly exposed to a novel visual stimulus (habituation phase, HP) until natural complete disengagement was evident (suggesting complete encoding). Next, in blocks presented during a dishabituation phase (DhP), a novel image was pseudorandomly nestled amongst familiar images. Linear mixed effects modelling will be used to analyse (HP) theta amplitude (as a marker of encoding efficiency), (DhP) Nc amplitude (indexing attention) and (DhP) late-slow-wave amplitude (indexing memory encoding). In addition, associations between trials-to-habituation and within-phase variability in the aperiodic exponent (AE, indexing information processing) and aperiodic-adjusted theta will reveal how the extent of information processing relates to speed of habituation. Relationships between neural measures and (parent-report-based) age-normed measures of language and communication ability (U.K. Communication development inventory, CDI) and temperament (infant behaviour questionnaire revised, IBQ-R; early childhood behaviour questionnaire, ECBQ-S) will be investigated. Results: We hypothesise that after accounting for age, infants slower to habituate will demonstrate reduced ERP amplitudes and smaller AE variability across trials. Further, differences in EEG measures of habituation will be associated with early behavioural outcomes of language and communication, and will differ by temperament. Discussion: Understanding the neural mechanisms underlying visual habituation is key given recent work suggests that visual habituation is associated with the emergence of cognition (Colombo and Mitchell, 2009), and can vary by age, temperament and stimulus type (Mink et al., 2013). We sought to delineate neural signatures of habituation in young infants, characterising how variability in habituation relates to cognitive development. Unlike in auditory habituation contexts where unfamiliar stimuli elicit greater response amplitudes (Kautis et al., 2023), it is difficult to translate such findings to infants born deaf. Conversely, in the visual domain, a deeper understanding of habituation mechanisms in TD infants provides a greater understanding than behavioural evidence alone, given multiple mechanisms could give rise to similar behaviours. Additionally, understanding visual habituation in TD infants provides grounding for subsequent case-control comparisons, with infants with HL, including pre-post cochlear implantation comparisons.

E – Early Life Stress

P2-E-87 Associations between parental early life stress and infant white matter organization

Jing Xie [1], Alex Dufford [1]

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Summary: Exposure to early life stress in development is associated with negative mental health outcomes including risk for anxiety and depression. Few studies have focused on early life stress and white matter organization in infants. Elucidating this association can improve understanding of both the risk factors and pathology of anxiety and depression.

Details: Our objective was to determine an association between early life stress with white matter organization using a whole-brain approach known as correlational tractography12. We defined stress by two different methods: (1) number of total stressful events and (2) perceived distress of these events. We measured white matter organization using quantitative anisotropy (QA). QA is associated with axonal density7,13 and is less affected by edema compared to other diffusion metrics such as fractional anisotropy and axial diffusivity12.

Analysis for this study focused on 6-shell diffusion-weighted imaging (DWI) scans from participants, aged 0-5 years, from the Baby Connectome Project (BCP)4.DWI data were provided via the DSI Studio Fiber Data Hub and were preprocessed using TOPUP and eddy. Participants were removed from analysis due to poor data quality (neighboring DWI correlation < 0.5). Diffusion data were reconstructed using generalized q-sample imaging and quantitative anisotropy (QA) were extracted and used in the connectometry analysis, with a seeding region placed at the whole brain level. To measure early life stress, we used the Major Life Events Questionnaire (MLE), a 20-item survey where parents reported major life events that occurred in the household within the last 12 months. After removing one participant that was an outlier on the MLE questionnaire, a total of 115 participants (47.8% female) were included in this study, with a mean age of 13.5 months (SD = 6.8 months). Whole-brain correlational tractography was used to identify regions that have QA values that were correlated with the number of life events reported and the average severity of distress (two separate models). Correlation tractography uses a nonparametric Spearman partial correlation. Age at scan; site of scan; sex; DWI quality; age at MLE questionnaire; and who completed the survey were removed as covariates in the model. Permutation testing (4000 iterations) was used to generate a null distribution and an FDR threshold of 0.01 was used to corrected for multiple comparisons11.

In the first stress model, Infants that had experienced a greater number of stressful major life events had higher QA values in the right

cingulum bundle (frontoparietal), the right uncinate fasciculus, and the forceps minor corpus callosum bundle (t(114) = 4.0, q<.001). In the second stress model, mean distress severity score was also associated with higher QA values in the same bundles (t(114) = 4.0, q <.001).

We found that both the number of major life events and mean distress severity score were associated greater white matter organization across two frontolimbic tracts (the cingulum bundle and uncinate fasciculus) and the forceps minor (a callosal tract). The directionality of the findings is in alignment with the Stress Acceleration Hypothesis2, which suggests early life stress exposure may accelerate early brain development and is consistent with our finding that greater exposure was associated with greater regional white matter organization. Other studies have shown that both the cingulum bundle and uncinate fasciculus are involved in anxiety disorders later in life3,10. These findings are significant, as altered connectivity of the cingulum bundle and uncinate fasciculus is found across mood disorders1,14. Future studies will examine associations between early life stressful events, frontolimbic white matter organization, and early symptoms of mood disorders in toddlerhood.

P2-E-89 The roles of prenatal disadvantage and postnatal enrichment on structural development of the cortex from birth to age three

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Summary: In this study, we are using a longitudinal cohort of infants to study how poverty, as well as enriching life experiences, affect cortical expansion in the first three years of life. This work may allow us to identify potential interventions to support healthy brain development.

Details: Objective: Between birth and age three years cortical surface area increases greatly, having implications for subsequent cognitive and socio-emotional development. Different brain regions mature at varying rates, which may reflect different temporal windows of sensitivity to exposures like poverty or enriching experiences. However, it remains unclear if these exposures influence patterns of cortical expansion.

Methods: We analyzed MRI data from a cohort of full-term infants oversampled for poverty using the anatomically constrained multi-modal surface matching (aMSM) pipeline, which optimizes point correspondence between sequential cortical surface reconstructions to create smooth maps of cortical expansion for each child. 83 children underwent structural MRIs at birth and age 2 years; 64 at birth and age 3; and 38 at ages 2 and 3, giving us a total of 185 pairs of longitudinal scans across 111 unique children. Our two composite exposures of interest were prenatal social disadvantage (maternal education, neighborhood poverty, insurance status, healthy eating, and income to needs ratio) and postnatal enrichment "Thrive" (child sleep, positive parenting, neighborhood safety, child nutrition, and environmental stimulation). Using Bayesian hierarchical models with partial pooling, we assessed whether disadvantage and Thrive predicted both mean expansion and variability in expansion across the cortex using the Glasser parcellation, while controlling for age at first scan, time between scans, gestational age at birth, and sex.

Results: The effect of disadvantage on mean expansion varied across the cortex (Figure 1). Disadvantage was negatively associated with mean expansion in occipital and posterior association regions, indicating reduced expansion in individuals experiencing more disadvantage, but was positively associated with mean expansion in the insula and medial frontal lobe. Additionally, higher disadvantage was associated with greater variability in expansion between subjects (significant across all cortical regions). In contrast, higher Thrive was associated with increased mean expansion across the entire cortex but was unrelated to variability in cortical expansion.

Conclusions: This suggests that exposure to poverty and enriching life experiences may have an impact on the structural development of the cortex. As the brain's structure has implications for cognition and mental health, these results highlight the importance of early life experiences.

P2-E-90 Peripheral immune proteins predict reduced cortical thickness in 5-year-old children

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Summary: Peripheral inflammation is implicated in prenatal brain development, affective/psychiatric disorders, and neurodegeneration. However, there are almost no neuroimaging studies in children examining its role in human brain development. Thus, it is unknown whether immune physiology is associated with brain structure in typically-developing children.

Details: This study utilised immune proteomics and multimodal magnetic resonance images (MRIs) analysis, studying hundreds of immune proteins and multiple whole-brain structural parameters simultaneously to characterise the role of inflammation in brain structure in children.

Participants were 5-year-old children from the FinnBrain Birth Cohort Study (N=126). Blood was collected and serum immune proteomics analysed using Olink Explore Inflammation 384, comprising 356 immune proteins which were summarised into 6 clusters by Gaussian mixture modelling. Children underwent T1- and diffusion-weighted MRI, and the resulting images were pre-processed to create maps of grey matter volume, white matter fractional anisotropy and mean diffusivity, and cortical thickness and surface area. Voxel- and vertex-level data were combined by linked independent component analysis to produce 10 independent components summarizing the maximum structural variance across all modalities.

Partial correlation analysis identified a strong negative association between one immune cluster and IC4, which is weighed almost entirely by whole-brain cortical thickness. This cluster comprises 49 proteins, representing 13% of the measured immune proteome, and it is characterised by pro-inflammatory type I cytokines such as TNFα, IFNγ, IL-6, IL-17A, and IL-18. Each protein in this cluster was regressed against IC4, adjusting for age, sex, and BMI. 14 proteins were nominally significant ($p < 0.05$), while 3 proteins, IL-17A ($R2 = 0.18$), CXCL10 ($R2 = 0.10$), and SIRPB1 ($R2 = 0.09$), were significant after false discovery rate adjustment. These three proteins were

added to vertex-wise models to determine if they predict regional cortical thickness by linear regression adjusted for age, sex, and BMI. IL-17A, CXCL10, and SIRPB1 each predicted reduced cortical thickness of one cluster in the left fusiform gyrus, right postcentral/posterior parietal cortex, and left superior temporal gyrus, respectively (pFDR < 0.025, threshold adjusted for testing each hemisphere separately).

Combining immune proteomics with multimodal neuroimaging analysis identified a cluster of immune proteins associated with reduced cortical thickness, three of which - IL17A, CXCL10, and SIRPB1 - have strong, negative associations with global and regional cortical thickness. Given that these are typically-developing children, the findings are relevant to the general population, implicating peripheral inflammation in human cortical development.

F – Emotional Development

P2-F-91 Neonatal white matter microstructure predicts infant attention disengagement from fearful faces

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Summary: The neural pathways underlying emotional development in infancy are unknown. Our study uses eye tracking and diffusion MRI to identify neural pathways at birth that are association to an attentional bias towards facial expressions in infancy.

Details: Infants develop an attentional bias towards faces already at birth, with further specification towards fearful faces emerging at 6 months and diminishing around 11 months of age. However, the neurobiological origins of attentional bias to fear are still poorly understood. To understand the neural structures underlying facial expressions perception, the current study utilized newborn diffusion magnetic resonance images (N = 86; 41 females; M = 27.15 days) and eye tracking from the same infants at 8-months (M = 8.75 months) as a behavioural measure. An overlap paradigm was used to measure attention disengagement from fearful, happy, and neutral faces. Tract-based spatial statistics revealed that higher white matter mean diffusivity in widespread regions across the brain was associated with lower attention disengagement from fearful faces. The same association was found with happy faces but limited only in the splenium of the corpus callosum and sensorimotor pathways. Sex-based stratification analysis revealed the results were driven by males. The findings indicate newborn white matter microstructure predicts attentional bias in infancy relevant for socioemotional development. Neonatal WM microstructure may reflect individual differences in growth that is predictive of attentional bias development later in infancy.

G – Methods: Analytics/Statistics

P2-G-92 Longitudinal normative models of infant and toddler brain growth for individualised developmental trajectory estimation

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[1] King's College London, [2] Stavanger University, [3] University College London, [4] University of Cape Town, [5] Brown University

Summary: MRI derived models of childhood neuroanatomical development have seen an increase in popularity thanks to wider data access. While traditionally created using cross-sectional data, here we try to extend to longitudinal data, modelling instead the age slope and allowing for the predicted developmental trajectories to be specific to an individual.

Details: Introduction: Models of brain growth have seen increased use for estimating childhood development and providing a reference for characteristics like regional brain volume. These models have been traditionally constructed using cross-sectional data and may struggle in modelling the variability in timing and magnitude of growth spurts. Additionally, they are constructed using conventional MRI (1.5 or 3T) from higher income, urban settings, with limited coverage of low-to-medium income countries (LMICs) or rural populations and have difficulty accommodating regional or population specific effects.

We propose the creation of multi-session longitudinal models, that provide individualised predictions of future brain growth conditioned on an initial observation (i.e. volume at time 1) and demographics. We demonstrate this applied to populations in the US (conventional 3T MRI) and South Africa (ultra-low field 64mT MRI).

Methods: Data from the BAMBAM study at Brown University (3T, 1150 sessions from 595 infants and children aged between 68-4590 days) and University of Cape Town (UCT) Khula study (64mT, 786 sessions from 319 infants aged between 2-27 months) were used for this work. BAMBAM images had regional volumes extracted using freesurfer synthseg while UCT had an alternative set of regional volumes extracted using in-house segmentation.

Of the data available, 282 BAMBAM and 183 Khula subjects had the minimum 2 scan sessions necessary for longitudinal modelling. Where a subject had multiple scans (>2), the initial and oldest scans were used, where the initial scan volume is a covariate in the longitudinal models and the oldest scan volume is the target (dependant) variable for both model types.

Separate cross-sectional and longitudinal Gaussian Process (GP) regression models were fit to each region in both the BAMBAM and UCT cohorts. Cross-sectional models utilised only age-at-scan and sex to predict regional volume while longitudinal models added an individual's regional volume at an initial scan as an additional covariate.

Model accuracy was calculated between the actual and predicted regional volume difference using mean absolute error (MAE) and root mean square error (RMSE).

Results: Regional MAE and MSE scores were lower in longitudinal models for BAMBAM (thalamus MAE improved from 0.65 to 0.5 RMSE from 0.6 to 0.46) and UTC (thalamus MAE improved from 0.87 to 0.7 RMSE from 0.56 to 0.44), full results in in Table-1&2. Cross-sectional predictive plots are shown in Fig-1 for grey matter and thalamus in BAMBAM (A-B) and total tissue and Khula (C-D). Longitudinal and equivalent cross-sectional predictive plots are shown for one individual from BAMBAM (E-F) and Khula (G-H).

Discussion: Here, we develop a longitudinal normative model that incorporates data from a first timepoint to quantify "typical" regional volume growth at an individual level.

As shown in Fig-1 A-D, cross-sectional models produce reasonable estimates of expected tissue volumes, even with sparse data. Fig-1 E-H show how inclusion of longitudinal information improves prediction of later tissue growth, giving a trajectory specific to that individual. This improvement is quantified in the lower MAE and RMSE scores for the longitudinal models in both the BAMBAM and Khula cohorts.

Conclusion: These results are a promising first step for integrating longitudinal information for accurate estimate of individualised later brain development in both conventional and ultra-low field imaging.

P2-G-93 Uncovering how brain structural topology gives rise to functional dynamics over early development (WIP)

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Summary: This work contributes to efforts to uncover how the brain's structural connectome relates to its diverse functional dynamics. Investigating how structure enables functional states across early life, a period of unparalleled pace of brain development, is crucial for understanding both typical development and neurodevelopmental disorders.

Details: Functional brain dynamics emerge atop networks of structural connections, yet how structural topology supports the unfolding of diverse functional dynamics across human development remains largely unknown. Network control theory (NCT) is an approach for studying this question by quantifying the energetic ease with which the brain transitions between functional states governed by its structural topology. Existing work finds age-related decreases in average controllability, or the energy required to transition between all possible dynamical states within a given developmental period (Gu et al., 2015; Sun et al., 2023; Tang et al., 2017). However, open questions remain about how structural connectome topology drives functional states unfolding within individuals over early development.

The goals of this study are: (1) To quantify and compare how changes in structural connectivity across development alter the energy required for the brain to transition to all possible brain states. (2) To quantify and compare the control energy required to transition across (a) resting states within a given developmental time point (e.g., across resting state samples) and (b) states defined at different developmental time points (e.g., 6 mo, 9 mo). (3) To identify the brain networks that are most influential for driving these transitions. We hypothesize more efficient transitions with age, increasing energy requirements for transitions spanning greater developmental distance, and transitions driven by primary sensorimotor regions.

We leverage longitudinal data from the Baby Connectome Project (BCP; N = 220, n = 467 sessions; Fig 1) ages 2 to 24 months (median nper person = 2, range = 1-3) that have passed diffusion imaging quality control. Connectivity matrices will be constructed using diffusion tractography and functional states will be defined from rsfMRI. Data are pre-processed, subjected to quality control criteria, harmonized across site, and parcellated using the UNC 90-region infant AAL atlas (Shi et al., 2011) (Fig 2).

Results from this project will provide insight into the relation between brain structure and function across early life, a period of unparalleled brain development. We will acquire new understanding of how emerging structural topology enables contemporaneous and future dynamical activity. Findings will inform understanding of typical development and open new network-based approaches for investigating processes of atypical neurodevelopment.

P2-G-94 Newborn pituitary gland segmentation using a 3D U-Net

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Summary: MRI-based measures of the pituitary gland are linked to puberty and transdiagnostic psychological issues in youth, but existing studies rely on modest sample sizes, limiting reproducibility. Current segmentation methods require human input, making them impractical for large-scale research on pituitary development.

Details: The human pituitary gland is often overlooked in human developmental neuroimaging despite its well-established role regulating growth, metabolism, stress, and mood through hypothalamus-regulated hormone production. While recent deep-learning approaches have demonstrated the feasibility of automated pituitary segmentation in adults, these methods are unlikely to generalize to pediatric populations and currently require a level of manual intervention. In response, we present a fully-automated multi-scale 3D U-Net for neonatal pituitary segmentation based on T1-weighted MRI data. Whole pituitary labels in N=66 newborn images were generated semi-automatically using a snake method (ITK-SNAP) by two expert independent raters (raters 1a and 2). One rater repeated labeling separated by two weeks-time (rater 1b) to establish intra- (1a vs 1b) and inter-rater (1a vs 2) performance benchmarks. Rater 1a labels were used to develop and test the 3D U-Net. The dataset was split into training and test sets using 5-fold cross-validation. For each training session, on-the-fly augmentation (translation/rotation/deformation/flipping/intensity; 40 augments per training sample) was used to generate additional synthetic data for an efficient learning process with increased generalizability. Hold-out test samples were used for comparison against intra- and inter-rater benchmarks (Dice score). A linear regression model testing for an association with DXA-based body-weight (hormonally controlled lean/fat mass growth) after adjusting for postmenstrual age at scan, sex, intracranial volume, and DXA-based bone-mass (skeletal growth) was used to demonstrate predictive validity. Results demonstrated accurate automatic segmentation of the newborn pituitary gland (Dice 1a vs 1b: 0.96±0.03; Dice 1a vs 2: 0.92±0.05; Dice 1a vs NN: 0.92±0.04; volume R2 1a vs 1b: 75%; volume R2 1a vs NN: 58%; Figure 1a-b). In addition, pituitary volume was strongly associated with body-weight/mass after adjusting for potentially confounding factors (t1a=2.6; r21a =11%; tNN=3.6; r2NN =19%; both $p<0.01$; Figure 1c) suggesting a potential image-based biomarker for hormonal growth factors. Collectively, these findings indicate that deep learning-based neonatal pituitary segmentation is feasible and scalable, with further validation needed to confirm robustness across diverse datasets and demonstrate further predictive validity in clinical and research environments.

P2-G-115 EEG-based brain age prediction in infants: Validating the brain age model with Singapore birth cohorts (https://doi.org/10.17605/OSF.IO/MN3AT)

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Summary: This study is the first to cross-culturally validate a brain-age model using large cohorts of EEG data collected from children aged 0 to 3 years. Successful validation would support the potential utility of EEG brain-age models as non-invasive biomarkers for early altered brain development across diverse populations.

Details: Background: The first three years of life are marked by rapid brain development in infants. Neurodevelopmental changes during these early years can be measured using both periodic and aperiodic components of EEG data. Predicting chronological age using neuroimaging offers valuable insights into both typical and atypical patterns of brain maturation. However, existing studies remain limited to samples from relatively homogenous populations, often with a predominant racial or ethnic group, and there has been limited cross-cultural validation of brain age prediction models in early development. We aim to use EEG collected in Singapore to validate a published brain age model that was originally trained using 938 EEG recordings from a large cohort in the U.S. (An et al, Developmental Cognitive Neuroscience, 2025).

Methods: We first harmonized the pre-processing and processing of resting-state EEG with the research group who published the brain age model. We used a sample of EEG recordings from 144 Singaporean children aged 1–18 months and generated aperiodic power spectra to compare with those from the U.S. sample (Figure 1). Singapore is a multi-ethnic country with its citizen population comprising of 76% Chinese, 16% Malays, and 8% Indians. Given that this pilot testing was promising, we plan to utilize 613 EEG recordings from healthy children aged 3-36 months in 3 Singapore longitudinal birth cohort studies. Pre-processing of this larger sample of EEG data will be completed with the Batch Electroencephalography Automated Processing Platform (BEAPP; Levin et al., Front. Neurosci., 2018) using the integrated Harvard Automated Preprocessing Pipeline for EEG (HAPPE; Gabard-Durnam et al., Front. Neurosci., 2018). HAPPE quality metrics were then used to determine usability of EEG data for further analyses (Wilkinson et al., Nat. Commun., 2024). Briefly, Power Spectral Density (PSD) will be computed for each electrode using multitaper spectral analysis, then averaged across electrodes within each region of interest: left frontal, right frontal, central, left temporal, right temporal, and posterior. The resulting PSD will be parameterized into aperiodic and periodic components using SpecParam version 1.0.0.. The same set of features will be extracted for the age prediction model, including aperiodic offset and slope, power within canonical frequency bands, peak frequency and amplitude, as well as kurtosis and skewness of the power distribution. Principal component analysis will be performed to identify intrinsic functions that make up alpha and beta broad bands. The weight of each principal component will be used as features in the age prediction models. All EEG features extracted will then be applied to the brain-age model.

Hypothesis & conclusion: We predict that the brain age model will demonstrate comparable performance when applied to the Singapore cohorts, as evaluated using proportion of variance explained (R^2) and Mean Absolute Error (MAE) metrics. Successfully validating the brain age model in this context would provide evidence that changes in EEG aperiodic and periodic activity measured using resting EEG in young children reliably reflect underlying neurodevelopmental processes, thereby supporting potential utility of EEG brain-age models as a non-invasive biomarker for early altered brain development across diverse populations.

H – Methods: Data Acquisition

P2-H-95 Optimizing optically pumped Magnetometer - Magnetoencephalography for recording brain function during infant feeding

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Summary: Infant nutrition is important for brain development, yet there is a paucity of research on how infant feeding impacts the brain in real time. This research will show the first OPM-MEG recordings during infant feeding.

Details: During infancy, milk is one of the most significant contributors to infant development. The nutrients and bioactives within milk provide all the components necessary for healthy brain development, and feeding offers an example of one of the most salient interactions between infants and their caregivers. However, examining the impacts of nutrition and these crucial interactions has been limited to modalities with limited spatial resolution (ex., fNIRS, EEG). Optically Pumped Magnetometer - Magnetoencephalography (OPM-MEG) provides the potential for high spatial and temporal resolution, making this method ideal for studying infant brain function during these key interactions. This study will examine the feasibility of adapting OPM-MEG for infant use and caregiver-infant dyadic feeding interactions.

Participants included in this study are full-term, typically developing infants with no prior birth complications and between the ages of 3 to 9 months. Upon enrollment and consent into the study, families take sagittal and frontal pictures of their infant's head for helmet fitting. The helmet can be selected to fit the size and shape of each individual's head. To ensure minimal helmet movement, infants are fitted with a breathable bonnet with fasteners to align with the rigid helmet. Generation 3 QuSpin OPM sensors are secured into the helmet, the magnetically shielded room is degaussed, and the nulling coils are engaged.

During the feeding sessions, participants are held by their caregiver with supportive pillows as needed. Caregivers indicated via button press or verbal indication for milk letdown, infant latch, when their infant fell asleep, and when infants stopped latching. To date, we have successfully collected OPM feeding data from 3 sessions. Information on protocol procedures, feasibility statistics (i.e., infant compliance), and OPM-MEG data from infant feeding sessions will be provided. Our findings will help demonstrate the feasibility of OPM-MEG for infant use and provide empirical guidance to move forward with OPM-MEG research.

P2-H-96 Fetal visual evoked responses measured with OPMs

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Summary: Until recently, fetal MEG – the measurement of fetal brainwaves – was only available at 2 labs worldwide. A new technology, optically pumped magnetometers (OPMs), has emerged as a versatile and economical way to measure MEG in adults and children. We demonstrate that the same systems can measure fetal MEG, greatly increasing access to fetal MEG.

Details: Fetal MEG, the magnetic signals generated by the developing brain of the human fetus, can be measured with magnetometers placed on the mother's abdomen. We attempted to measure fetal MEG responses to light flashes with optically pumped magnetometers (OPMs).

We placed 16 FieldLine OPMs over the abdomen during the third trimester of pregnancy. The measurements were made while the mother relaxed on her side on an MEG-compatible bed in a magnetically shielded room. 1200 red light flashes of 2 ms duration were projected onto the abdomen to elicit fetal brain responses. Both maternal and fetal cardiac signals were clearly evident in the raw data. The data were then averaged across trials and processed with independent components analysis (ICA) to remove cardiac interference and other artifacts. This revealed an evoked response peaking between 190 and 240 ms, consistent with literature showing SQUID-based fetal visual evoked responses. The evoked response topographies were concentrated over the lower abdomen, consistent with the head-down fetal positions that were observed with ultrasound, and distinguishing it from fetal and maternal cardiac signals. To our knowledge, these are the first OPM measurements of the fetal visual response.

P2-H-97 Validity of a mobile, low-density EEG system for ERP studies in global contexts

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Summary: Mobile, low-cost EEG systems pose a potential solution to conducting EEG in resource-constrained settings. However, these systems are usually designed for resting-state EEG, and do not accommodate complex task designs. In this study, we use the VEP to test the Emotiv EPOC Flex as a solution to performing task-based neuroscience research at scale.

Details: EEG is a powerful and non-invasive measure of brain function that can be used for understanding neurodevelopment. Assessing event-related potentials (ERPs) through EEG is one way in which we can learn more about how the brain processes and responds to external stimuli with millisecond precision. One such ERP is the visual evoked potential (VEP), a robust indicator of visual cortex function that develops rapidly during the first year of life and has been associated with later cognitive outcomes (Jensen et al., 2019; Majnemer & Rosenblatt, 2000). Most research-grade EEG systems for measuring ERPs typically require a large upfront investment and have elaborate electrical and physical set-up and maintenance needs. These constraints make it difficult to implement high-density systems in a variety of resource settings, including in many global majority settings. While some lower-cost EEG systems have been validated for resting-state and auditory ERPs in adults (Badcock et al., 2013; Williams et al., 2020), none have been validated for infant ERP research. In order to address this important gap in our understanding of neurodevelopment at a global scale, we compare one of the most commonly used high-density EEG systems, Magstim EGI Hydrocel GSN, to the Emotiv EPOC Flex 2.0, a cost-effective, mobile, low-density EEG system. We first created and will describe a system timing tester using an Arduino circuit for the Emotiv system to measure and correct for timing delays in ERP research. We collected VEP data in a cohort of South African three-month-old infants (M = 92.60 days, SD = 12.97 days) using both EGI Hydrocel 128-channel nets (n=118) and Emotiv 32-channel caps (n=102) with 65 participants having usable data on both systems. VEP data were collected using a phase-reversal task, which consisted of 150 trials. Data were processed with identical parameters using custom MATLAB scripts. Descriptively, we observe similar VEP responses in the two systems with similar timing (Fig. 1). Moreover, we find a moderate positive correlation in the P1 latency ($r=0.52$, $p<0.05$) (Fig. 2). Given that few have collected ERP data using low-density EEG (and to our knowledge, we are the first in infancy) we are still in the process of best optimizing the pre-processing of these data. Future analyses will further evaluate similarities and differences between the systems and discuss the strengths and limitations of the Emotiv system. These preliminary results indicate that the Emotiv EPOC Flex system might be a promising solution to making the study of functional neurodevelopment accessible and scalable in global majority settings.

P2-H-98 Optimizing infant MRI imaging: Identifying the optimal coil position for improved SNR and uniformity

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Summary: The average head circumference of a 4-month-old is 40-42cm, smaller than the 53–58cms typical of adults. When using a Siemens 64-channel head and neck coil, the infant's head is off-center, reducing SNR and uniformity, especially in the subcortical areas of the brain. This stud y aims to identify the optimal positioning for improved image quality.

Details: Introduction: The signal-to-noise ratio (SNR) in magnetic resonance imaging (MRI) is a critical metric in routine quality control (QC). Infant MRI presents unique challenges due to the smaller head size of infants compared to adults. The average head circumference of a 3-month-old is 41.1 cm, significantly smaller than the 53–58 cms typical of adults. When using a Siemens 64-channel head and neck coil, the smaller size results in the infant's head being off-center relative to the coil elements. This misalignment leads to reduced SNR and uniformity, particularly in the subcortical brain regions. As a result, image quality may be compromised. This study aims to identify the optimal coil positioning to improve image quality, ensuring better SNR and uniformity for infant MRI scans.

Methods: The study utilized a 3111361 Siemens MRI 1000mL Plastic Bottle Phantom, a honeydew melon (circumference = 41.6 cm), and an automated IQ (Image Quality) tool to evaluate data in accordance with National Electrical Manufacturers Association (NEMA)-proposed standards for SNR and uniformity. The analysis was performed across three different head position configurations, with measurements taken using the standard Siemens Product Height cushion, which has a height of 2.5 cm per level within the coil

to assess the impact on image quality (see Figure 1). Both the phantom and melon were marked with a cod liver oil capsule as a central marker for the slice positioning (see Figure 2). The cod liver oil capsule was used as a reference marker for initial laser alignment and was further adjusted using the Siemens Iso-Loc table positioning mode to ensure accurate placement at the scanner's isocenter (see Figure 3). The standard Siemens T1_TRA_SE sequence was scanned consecutively to employ the NEMA subtraction method parameters.

Analysis: To accurately estimate the SNR and minimize the influence of confounding factors, it is essential to apply corrections to the standard deviation (SD) used in the calculation. One effective approach is the Subtraction Method, which isolates noise by eliminating the signal component. This method requires acquiring two consecutive images under stable scanning conditions. The IQ tool was used for NEMA analysis and storing of the Regions of Interest (ROI) to ensure consistency across calculations.

Results: Using the subtraction method, we found that positioning the phantom or honeydew melon closer to the center of the magnet (Level 3, 19.5 cm from the base, centrally located within the 64-channel head and neck coil) increased the SNR in the central slice by up to 181.1 compared to the lowest position and 71.3 compared to the highest position (see Table 1). Additionally, overall uniformity improved by 2-5% at the Level 3 position. An ROI plot further demonstrated lower AAD and higher SNR at Level 3 (see Table 2) compared to Levels 1 and 5.

Conclusion: Accurate SNR measurement requires careful consideration of signal uniformity and artifact correction. Optimal placement, centrally within the coil—significantly enhances SNR and image uniformity. This yielded the highest SNR values and the most consistent signal distribution, highlighting the importance of standardized setup for reliable image quality assessment.

P2-H-99 Testing mechanisms of sensory over-responsivity in early childhood using integrated fNIRS-virtual reality technology (WIP)

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Summary: Many children experience sensory over-responsivity, i.e., heightened responses to everyday sensory stimuli. Activity in frontal brain areas and frontal-parietal networks regulate responses to evocative emotional stimuli (e.g., angry faces). Whether these networks play a similar role in regulating response to sensory stimuli is not known.

Details: Objective: To use virtual reality technology to simulate everyday environments with changing sensory inputs, focusing on the auditory domain. We will test the impact of increased auditory input on behavioural and physiological response, and the role of frontal regions/networks in regulating response. We will test this in children with and without sensory over-responsivity.

Methods: We have created a novel supermarket paradigm, which requires completing a gamified Go/NoGo task under conditions of low and high background noise (~10 minutes). We collect data on task accuracy, heart response and cortical activity (using two mobile fNIRS systems). These two systems will capture frontal and bilateral temporo-parietal regions, covering a total of 48 channels. We will test 1) the impact of increased auditory input on behavioural and physiological response, 2) the role of frontal regions/networks in regulating response, and 3) whether these processes differ in children with sensory over-responsivity. Pilot data with 14 children shows acceptability of the paradigm. We expect to have data from ~100 3-year-old children by September.

Results: HOMER2 will be used to convert raw intensity data to optical density and to correct motion artifacts. Low-quality channels will be removed if Scalp Coupling Index (SCI) < 60% and Peak Spectral Power (PSP) < 6% or show excess noise or saturation using QT-NIRS. The optical density data will be bandpass filtered (0.009–0.08 Hz) and converted to relative haemoglobin concentrations using the modified Beer–Lambert law (DPF = 5.4, 4.6). To account for movement-related noise, signals from short-separation channels will be regressed out. After preprocessing, channels will be averaged into 10 regions of interest (ROIs) using an MRI. ANOVAs will be used to examine the effects of increased sensory input on task performance, HbO2 and HHb activation and heart rate. Linear regression analyses will assess the associations between heart rate and frontal and fronto-parietal network activation to explore links between physiological and neural responses.

Conclusion: Integrated neuroimaging-virtual reality technology has the potential to study brain functioning in more realistic environments. Here, we created a novel supermarket task to capture the cortical mechanisms involved in regulating arousal evoked by different sensory inputs. Better understanding of these mechanisms will support targeted interventions for children with sensory over-responsivity.

P2-H-100 A 3D model of the human uterine visual environment

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Summary: This model encompasses the heterogeneous nature of uterine tissue and the non-planar geometry of the womb. Through so doing, it bridges the gap between theoretical simulations and the anatomical reality of intrauterine conditions.

Details: This work reports the development and implementation of a Monte Carlo model examining light penetration to the human uterus. By incorporating the complexities of non-planar tissue layers - notably skin, adipose, muscle, uterine wall, and amniotic fluid, we can then include multidirectional light sources from all regions surrounding the maternal abdomen into simulations. This enables us to unravel the intricate interplay between light exposure and the uterine environment in addition to accounting for the temporal evolution of this interplay across gestation by adjusting the layer thickness ratios across the abdomen as a function of gestational time. We found that variation in light intensity occurs across the abdomen, with more light entering from the front of the uterus than the back or sides. This work represents the first non abstracted model of illuminance within the uterine environment. This is valuable for future experimental purposes and further opens research avenues in modelling specific experimental stimuli. An understanding of the degree to which the fetal eye's orientation with respect to the delivered stimuli affects the delivered intensity is crucial for experimental design and data interpretation - both of which are areas wherein this model can provide useful insights for work with light delivered to the

fetal eye as seen in Reid et al. (2017) and Ronga et al. (2025). Future research in this field requires this basic information in order that the interplay between light, the human uterine environment, and the fetal visual system, may be understood.

P2-H-101 Harnessing optically-pumped magnetometers to measure infant brain activity: Development of an infant-friendly set-up

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Summary: So far it has been difficult to pick up simultaneously where and when brain activity of babies occurred. Newly developed sensors, optically-pumped magnetometers (OPMs), now allow this. We will present a novel infant-friendly OPM set-up and first brain measures with OPMs from 4- to 6-month-olds. This allows novel research on early brain development.

Details: Measuring infant brain activity offers crucial insights in processes of infant cognition. Neuroscientific techniques are therefore necessary tools to unravel the neural underpinnings of early social-cognitive development. Until recently, however, neuroscience tools feasible to study infants have been limited to either high spatial (fMRI, fNIRS) or high temporal (EEG) resolution. Identifying where and when neural activity in the infant brain originated was out of reach, but a novel technology to measure infants' brain activity now offers the breakthrough. The recent advent of magnetoencephalography with optically-pumped magnetometers (OPM-MEG) now allows measuring with both, excellent temporal (millisecond) and high spatial (5-10 mm) resolution. OPM-MEG is also more flexible and promises to become a more affordable alternative to cryogenic MEG. Still, due to the lack of infant-friendly OPM-MEG testing set-ups this promising technique has not yet been harnessed for social-cognitive research with typically developing infants. As one of the first infant laboratories in Europe, we developed a novel OPM-MEG set-up for social-cognitive brain research feasible for 3- to 10-month-old infants. For this purpose, we designed a 3D-printed OPM headrest in which OPM sensors are embedded (see Figure 1). The headrest is installed in a customized infant car seat. Adapting the headrest to different head sizes allows placing the OPMs as close as possible to the infant's head thereby increasing the signal-to-noise ratio. We plan to make the blueprints of the 3D headrests openly accessible. The current set-up uses 32 OPM sensors distributed in the headrest to cover occipital, parietal, temporal and central brain areas. In this first proof-of-principle study, we are using this novel set-up to test whether we can replicate established neural effects in infants previously shown in EEG and cryogenic MEG research. More specifically, we are testing 50 4- to 6-month-old infants with two stimuli sets using a visual and an auditory paradigm to test differences between processing faces versus houses and between processing standard versus oddball tones. Data collection is currently ongoing (N=13) and setting up of the data analysis pipeline, including video coding of the testing sessions is in progress. We will present the novel design of the experimental set-up and the outcomes of the data analysis at the conference. In a nutshell, exploiting the combination of high temporal and spatial resolution with this novel OPM-MEG set-up can pave the way for addressing developmental questions previously out of reach.

I – Methods: Data Processing

P2-I-102 Optimizing the tractography reconstructions of white matter bundles in preterm born infants with diffusion MRI (WIP)

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Summary: Prematurity disrupts brain development, increasing the risk of brain lesions and neurodevelopmental disorders [1]. Not all networks mature concurrently, contributing to their varying vulnerability. This has driven interest in MRI techniques to assess white matter myelination and quantify microstructural properties in preterm infants [2].

Details: Our study aims to develop a robust pipeline with diffusion MRI (dMRI) and tractography to automatically extract a wide range of white matter bundles in the whole brain of preterm infants at term equivalent age with anatomical particularities such as cerebral lesions, increased volumes of cerebral ventricules and extracerebral cerebrospinal fluid (CSF). As a first step, we here focused on sensory and motor tracts (cortico-spinal tract, CST) to characterize the developing microstructural properties.

We collected and analyzed 3T-MRI data of 150 very and extremely preterm babies (gestational age at birth: 24-32 weeks), scanned at term equivalent age (38-43 weeks of post-mentrual age - wPMA).

We used the baby-XTRACT tool implemented in FSL that provides tractography protocols for mapping 42 white matter bundles (19 bilateral and 4 central tracts) defining seeding, stop and exclusion regions on the Schuh neonatal template [3]. A key point of this study was to obtain a robust registration of individual images to the template despite the brain anatomical specificities of our population. We optimized this registration by creating masks from a combination of iBEAT and drawEM segmentations [4][5] of super-resolved T2w images (0.8mm isotropic), which enabled us to remove part of the CSF. Individual dMRI images without diffusion weighting (b=0) were then coregistered to T2-weighted images, which were themselves registered to the template [6]. The registrations were conducted using Ants 2.5.3 with finely tuned parameters.

Besides, following the pre-processing of dMRI data (b=1000 s/mm2 with 42 directions), multiple fibre orientations were estimated with BEDPOSTX with a two fibres model [7]. Tractography was performed with PROBTRACKX through the baby-XTRACT framework and tract reconstructions were visually checked for the CST. Maps of diffusion tensor imaging (DTI) metrics were estimated, allowing us to compute the tract-density-weighted averages of metrics in the CST. To further evaluate the approach robustness, we assessed the correlation between metrics and PMA at scan.

Despite a wide range of brain anatomical features, we were able to achieve optimal registration for all infants (Figure a) as well as correct CST reconstructions (Figure b).

The exploration of CST microstructure confirmed a decrease of mean, axial and radial diffusivities with PMA at scan, as well as an increase in fractional anisotropy (Figure c).

This study provides a proof of concept for applying the baby-XTRACT tool to diffusion MRI data in very preterm infants with cerebral injury. This approach allowed us to obtain accurate extraction of the CST and will be generalized to other white matter tracts. By characterizing the tract microstructural properties, we will explore the effects of several clinical factors beyond PMA at scan (e.g., gestational age at birth, respiratory, digestive and infection complications, brain severity score proposed by Kidokoro et al [8]). This approach will also be applied to MRI data collected at 2 months of corrected age in a subgroup of 39 babies with longitudinal data to evaluate the effect of an early motor training [9].

[1]de Kieviet et al. JAMA 2009 [2]Ouyang et al. Neuroimage 2019 [3]Warrington et al. Sci Adv 2022 [4]Makropoulos et al. IEEE Transactions on Med. Imaging 2014 [5]Wang et al. Nat Protoc 2023 [6]Schuh et al. bioRxiv 2018 [7]Hernández et al. PLoS One 2013 [8]Kidokoro et al. AJNR 2013 [9]Dumuids-Vernet et al. Frontiers in pediatrics 2023

P2-I-103 Automated segmentation of fetal brain substructures in 3D ultrasound using MRI labels

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Summary: We aim to address the challenge of accurately segmenting fetal brain structures in 3D ultrasound volumes. Using MRI-derived labels, we developed an automated method for large-scale AI-driven analysis, with the final goal of facilitating prenatal brain growth studies and supporting clinical practice with precise, automated measurements.

Details: Ultrasound (US) is widely used for monitoring fetal development due to its affordability, non-invasiveness, and real-time capabilities. However, measuring brain volumes with US rather than the standard 2D measurement remains challenging due to noise levels, low soft tissue contrast, and reflection artifacts. Fetal MRI offers better image contrast and therefore often considered the golden standard of fetal imaging; however, it is more expensive and predominantly used in a clinical setting. Previous research has focused on segmenting intracranial volume (ICV) in US or substructure segmentation using weak labels and manual US segmentations (de Zwarte, S.M.C. et al., 2024; Namburete, A.I.L. et al., 2023). To date, there are no automated approaches that leverage MRI-derived anatomical knowledge for US segmentation. In this study, we used MRI-acquired labels to train a fully automated deep learning network for segmenting 3D US data. We applied the model to a large population sample from the YOUth Baby and Child cohort (Onland-Moret, C.N. et al., 2020), measured around 30 weeks of gestation, and investigated the growth trajectories of fetal ICV and cerebellum (CB). We compared these trajectories to existing literature and examined biological sex differences in fetal ICV/CB as a proof-of-principle and validation for our automated method (N = 1012 individuals with 4949 US volumes).

Labeled MRI scans were available from 12 participants with 44 volumes who underwent both US and MRI within 24 hours. The MRI scans were registered with the US, and the labels for ICV, CB, brain stem (ST), and cavum septum pellucidum (CSP) were transferred to the US. The labeled US were used to train, test, and validate our model. The segmentation process involved three distinct deep learning stages: (1) localization and cropping of the brain, (2) alignment using three primary anatomical structures (ICV, CB, CSP), and (3) segmentation of ICV, CB, ST, and CSP using nnUnet (Fig. 1). The cropping and alignment step were based on the center of masses (CoM) of the segmentations. Performance metrics, Dice similarity coefficient (DICE), 95% Hausdorff (HD) and CoM distance, were calculated on the test set (N = 4 individuals, 14 volumes). The final network produced consistent and high-quality segmentations of ICV, CB and ST (Fig. 2). However, the lower DICE score for CSP (DICE=0.61) indicate that the CSP segmentations were less accurate, likely due to its small size and indistinct boundaries.

When applying the model in the large population sample, outliers were removed based on the interquartile range and growth curves were visualized. The calculated volumes per individual were averaged. The curves for ICV and CB were compared with previous literature (Fig. 3A, Fig. 4A). For both ICV and CB, growth curves from other studies, except one, lie within the 95% confidence interval (CI) of our growth curves, indicating good resemblance with other studies. Boys were found to have significantly larger ICV and CB volumes as compared to girls (ICV boys: 277.81 ml, ICV girls: 260.11 ml, $p < 0.001$, Fig. 3B; CB boys: 7.36 ml, CB girls: 7.00 ml, $p < 0.001$, Fig. 4B).

Our results suggest that label transfer from MRI to US can be used to develop an automated brain segmentation model for US, with the potential to improve the efficiency of fetal brain structure analysis by facilitating accurate, fast, large-scale analysis. Further testing in other datasets is recommended to validate our model.

P2-I-104 Fractal dimensionality as a marker of neonatal brain maturation: A structural MRI study

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Summary: Understanding brain maturation is key to mapping cognitive development and identifying neurodevelopmental risks. Fractal dimensionality (FD), a measure of structural complexity, offers a simple, accessible alternative to traditional methods by capturing cortical changes from standard MRI with low computational demand.

Details: Objective: Fractal dimensionality (FD) is a measure of structural complexity. It quantifies this complexity by measuring how surface details change across different scales. In brain imaging, FD is used to assess the intricacy of cortical and subcortical structures in the context of neuropathology. This study investigates FD across cortical and subcortical structures in neonates, aiming to utilize this measure to characterize the spatial distribution of maturation, its hemispheric differences as well as sex differences, shedding light on maturation patterns during the first weeks of postnatal life.

Methods: T1- and T2-weighted MRI scans were acquired from 125 neonates with a post menstrual age from 268 to 343 days. Brain segmentation and parcellation were performed first using the BibsNet pipeline to precompute grey and white matter delineations, followed by processing with the nibabies pipeline according to the Desikan atlas. FD was computed for each region of interest (ROI) by iteratively dilating a 3D binary mask of the brain region of interest and analyzing how its surface complexity scales with increasing dilation. Correlations of FD values with post menstrual age across all ROIs were analyzed and mapped onto a 3D brain segmentation and parcellation. Hemispheric differences as well as sex specific differences were identified by using Fisher's r-to-z transformation followed by a z-test for comparing dependent correlations. All tests have been corrected by the Benjamini-Hochberg method.

Results: Correlations between FD and post menstrual age show significant variation across brain regions, with the highest associations discovered in the cerebellum and the pallidum as well as in the left cuneus and the right lateral orbitofrontal. The smallest correlations were found in the left medial orbitofrontal region, the left ethinoral, the right caudate and the right insula. Regions that are significantly different between hemispheres were identified in caudate, transverse temporal region, putamen, isthmuscingulate, medial orbitofrontal region and precuneus. Whilst caudate and transverse temporal showed a stronger association between FD and post menstrual age in the left hemisphere, putamen, isthmuscingulate, medial orbitofrontal region and precuneus were stronger associated in the right hemisphere. Significant sex differences in the correlation of FD with post menstrual age were identified in the left and right cerebellum as well as in the right parstriangularis, both with a higher correlation in males suggesting early neurodevelopmental divergence.

Conclusions: These findings suggest FD as a robust marker of neonatal brain development, capable of capturing maturational differences across regions and sexes. In order to apply FD as an indicator of acceleration versus delay in maturation, the rate of FD by increase in postmenstrual age would be necessary. The sample size presented here is not large enough to detect this effect reliably. This analyses yet provides a foundation for future research exploring FD in neonatal populations and its potential for clinical applications.

P2-I-105 The compatibility of open datasets and publicly-available segmentation methods for infant MRI

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Summary: Tissue segmentation is widely used in the FIT'NG community, yet it's unclear how comparable different labelling protocols and their derived measures, e.g volume, between methods are. We evaluate 3 open-source segmentation tools on 4 infant MRI datasets to assess how segmentation methods and annotation protocols may influence the derived outputs.

Details: Objective: Brain segmentation plays a key role in neuroimaging pipelines, enabling growth measures, such as volume, by grouping similar tissue types. Numerous automated segmentation algorithms now exist, tailored to different age groups and labelling protocols (i.e. different number of ROIs). In this study, we assess the compatibility of ground truth (GT) labels and labels produced by 3 open-source segmentation methods across 4 publicly available infant MRI datasets.

Method: We applied 3 segmentations algorithms: BIBSNet (nROI=40), InfantFS (nROI=40), and VINNA (nROI=88) to 4 infant MRI datasets between birth and 8 month: BOBs (nscans=71), ALBERTs (nscans=20), BASEL (nscans=833), iSeg-2019 (n_scans=23), shown in Fig 1-2. Three of the datasets had GT labels. There was large variation in data format and pre-processing (Fig 1), e.g. with/without skull-stripped. The datasets also spanned different periods of infancy (Fig 4). Thus, some datasets were incompatible with some algorithms (Fig 4). Due to variability in the number (nROI ranged between 3 to 88) and different definition of ROIs between the methods, we unified the comparisons by aggregating labels into three broad tissue categories: cortical grey matter (GM), white matter (WM), and subcortical structures (Sub), Fig 3.

Results: Figure 3-4 presents the unified tissue segmentations across methods and datasets. Qualitatively and quantitatively, substantial inconsistencies between segmentation protocols were observed. Volume comparisons show systematic differences between algorithms and datasets, with large variations in WM volume between different datasets, GT and segmentation algorithms outputs (Fig 4).

Conclusion: The choice of segmentation algorithm influences derived tissue volumes, highlighting the need for caution when comparing results across studies using different methods and data. These discrepancies are likely due to the underlying differences in initial labelling protocols. Further, due to data and methodological design choices, we were only able to perform 6/12 possible dataset-method analysis. The BOBs dataset was successfully applied to each method, likely due to the dataset following the BIDs convention. InfantFS was found to be the most robust to dataset variation, successfully segmenting ¾ available datasets. Future efforts should focus on developing a standard labelling protocols and data formatting convention to ensure consistency and comparability across studies and developmental stages.

P2-I-107 MiniMORPH: A morphometry pipeline for low-field MRI in infants

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Summary: Infancy is critical for brain development, but MRI access is limited in low-resource settings. Ultra-low field (ULF) MRI increases accessibility, yet low contrast and resolution hinder analysis. We present a pipeline for reliably quantifying infant brain tissue volumes from low-resolution ULF T2-weighted scans.

Details: Introduction: We present MiniMORPH, an open-source, cloud-based pipeline for quantifying brain tissue volumes from ultra-low field (ULF) MRI in infants. The pipeline is designed to support neurodevelopmental research in global health contexts.

Methods: Acquisition: Data were collected at UCT-Khula (South Africa) and Makerere University/Kawempe Hospital (Uganda) using the Hyperfine Swoop 0.064T system.

Image processing: Three orthogonal T2-weighted (T2-w) scans were resampled using FLIRT to 1.5mm isotropic resolution and combined using ANTs to produce isotropic volumes.

Template building: Age-specific templates (3–24 months) were built using high-quality UCT-Khula datasets. mri_synthstrip and FSL edge maps were used for brain extraction and template construction in ANTs.

Segmentation: Tissue and CSF priors were generated by registering the BCP atlas to study templates. A skull prior was created by dilating the brain mask. Subcortical grey matter and callosal masks were obtained from registering the BCP and Penn-CHOP Atlas, respectively, to study templates. Ventricle masks were manually drawn and checked by an independent expert.

Native T2w volumes were registered to the appropriate template, and priors and masks were resampled to native space. Segmentation was performed using ANTs Atropos (prior weighting=0.3). CSF maps were multiplied by ventricle masks to isolate ventricular CSF, and tissue segmentations were multiplied by subcortical grey matter and callosal masks to extract subcortical structures and the corpus callosum.

Statistical Analysis: Age and sex effects were modelled using mixed-effects regression. BIC was used to assess linear vs quadratic fits. Birthweight effects (low vs normal) were assessed across both cohorts.

Results: After QC, 77 Kampala infants (mean age=6.2 months; 52 female; 62 longitudinal) and 286 UCT-Khula infants (mean age=10.6 months; 141 female; 184 longitudinal) were included.

Age and sex effects: Significant regional effects of age and sex were observed; adjusting for ICV reduced sex differences. Non-linear growth patterns were evident.

Birthweight effects: Normal birthweight infants showed larger uncorrected volumes in Total CSF, Thalamus, Caudate, and Putamen. After ICV correction, differences remained in Total Tissue, CSF, Thalamus, Caudate, Putamen, and Globus Pallidus.

Discussion: MiniMORPH provides a reliable method for segmenting infant brain images acquired at ULF. The pipeline supports the study of neurodevelopmental trajectories in settings with limited access to conventional MRI, and is freely available at: https://github.com/UNITY-Physics/fw-minimorph

P2-I-108 Contrast-invariant self-supervised segmentation for quantitative placental MRI

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Summary: Placental dysfunction affects fetal neurodevelopment, requiring accurate MRI assessment. Multi-echo T2*-MRI faces segmentation challenges: contrast variation, limited annotations, and motion artifacts. We leverage contrast variation for self-supervised learning, enabling accurate segmentation for reliable placental assessment.

Details: Accurate placental segmentation is essential for quantitative analysis of the placenta. However, this task is particularly challenging in T2*-weighted placental imaging due to: (1) weak and inconsistent boundary contrast across individual echoes; (2) the absence of manual ground truth annotations for all echo times; and (3) motion artifacts across echoes caused by fetal and maternal movement. In this work, we propose a contrast-augmented segmentation framework that leverages complementary information across multi-echo T2*-weighted MRI to learn robust, contrast-invariant representations. Our method integrates: (i) masked autoencoding (MAE) for self-supervised pretraining on unlabeled multi-echo slices; (ii) masked pseudo-labeling (MPL) for unsupervised domain adaptation across echo times; and (iii) global-local collaboration to align fine-grained features with global anatomical context. We further introduce a semantic matching loss to encourage representation consistency across echoes of the same subject. Experiments on a clinical multi-echo placental MRI dataset demonstrate that our approach generalizes effectively across echo times and outperforms both single-echo and naive fusion baselines. To our knowledge, this is the first work to systematically exploit multi-echo T2*-weighted MRI for placental segmentation.

J – Methods: Tool sharing and data dissemination

P2-J-109 The goldilocks effect: A retrospective evaluation on finding the best FIT in fetal/infant MRI scanning (WIP)

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Summary: Given the unique challenges of fetal/infant neuroimaging, selecting the best MRI scanner can be difficult. Each scanner has pros and cons, which may make them a better fit in some settings, and less suitable in others. We aim to highlight our experiences and describe our strategy in selecting the MRI scanner best for our research protocols.

Details: Magnetic resonance imaging (MRI) is a valuable diagnostic tool in pediatric healthcare. However, fetal and infant neuroimaging presents unique challenges that make selecting an MRI scanner particularly important. Despite comparable technical specifications across scanner types, there are other quantitative and qualitative variables that influence the success of a scan.1 The ideal MRI scanner requires using the Goldilocks principle, selecting one that is not too complex or too limited to achieve high image quality, optimal patient comfort, and efficient workflow feasibility. For example, Siemen Prisma 3T scanners are popular in the neuroimaging community, but their narrower bore limits fetal scanning on certain participants. For longitudinal studies, different scanners optimized for each period (i.e., fetal and infant) can be used. Alternatively, a single scanner that comprises on one or multiple times may be preferable to minimize hardware confounds. Finally, scanners that are family friendly, such as having an attached room for families to put the infant asleep, may be preferred over scanners with small technical improvements.

This retrospective evaluation describes our testing of three MRI scanners across different sites to identify the optimal system and setup for fetal and infant neuroimaging. Using an existing sample of pregnant women and infants, we will compare the systems across quantitative criteria, such as signal-to-noise ratio, head motion artifacts, scan success rate, acquisition time, and qualitative criteria, such as staff and technician experience, scanner proximity to prep areas, mother and infant comfort, caregiver experience, and workflow integration.

The Goldilocks effect of finding an MRI scanner that is just right involved not only assessing imaging performance, but also accounting for the workflow demands in a rapidly evolving and highly sensitive scanning environment. Initial observations suggest that, for our research protocols, a robust and conducive scanning environment is the best. Key factors include having a space to prepare infants for scanning that is connected or next to the scanner and having a scanner that accommodates fetal scanning from a wide range of body types for pregnant individual. These early insights guide the development of a scanner selection framework that prioritizes the unique needs of fetal and infant neuroimaging.

References: Spann, M. N., Wisnowski, J. L., HBCD Phase I Scanning Young Populations Working Group, Smyser, C. D., Fetal, Infant, and Toddler Neuroimaging Group (FIT'NG), Howell, B., & Dean, D. C., 3rd (2023). The Art, Science, and Secrets of Scanning Young Children. Biological psychiatry, 93(10), 858–860. https://doi.org/10.1016/j.biopsych.2022.09.025

K – Other

P2-K-53 Mapping the functional organization of the neonatal basal ganglia and thalamus

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Summary: Resting-state fMRI has shown that subcortico-cortical functional connectivity aligns with neuroanatomically-defined circuitry, exhibiting localized representation of individual networks in the basal ganglia and thalamus in children and adults. Whether this organization is present at birth or requires postnatal experience is unknown.

Details: Here, we investigate neonatal subcortical functional organization by mapping the representation of individual functional networks. This study used at least 10 minutes of low-motion, whole-brain fMRI data that were collected during natural sleep from 261 healthy, full-term infants (PMA at scan: 38-45 weeks) as part of the Early Life Adversity and Biological Embedding (eLABE) study. First, subcortico-cortical functional connectivity (FC) was generated by correlating the timeseries from each voxel in the basal ganglia (BG) and thalamus (THAL) with the average timeseries from each cortical functional network defined by previously described adult network assignments (Fig. 1A), excluding cortical vertices within 20mm. Each subcortical voxel was assigned a single functional network using a "winner-take-all" approach based on FC and repeated with split halves. The winner-take-all approach revealed localized representation of individual functional networks in the BG and THAL (Fig. 1B, split half overlap 81% voxels) are largely in line with the functional organization seen in children and adults. Interestingly, early developing sensorimotor systems (e.g., somatomotor) were both strongly correlated (FC>0.1; Fig. 1A) and overrepresented in the THAL (70%; Fig. 1B), yet representations of some late developing association networks (e.g., salience, default mode, frontoparietal) were also present in both the BG and THAL at birth. These findings provide insight into the emergence of subcortico-cortical functional organization and the relative roles of prenatal developmental programming and early postnatal experience on these brain circuits. Neonatal subcortico-cortical FC shares many similarities with that of children and adults, potentially indicating that prenatal developmental processes (e.g., neural migration, spontaneous activity) drive this organization. However, important differences in neonatal subcortical functional organization remain, including overrepresentation of sensorimotor network, which may reflect current experiences of the neonate (e.g., sensory/motor experiences) and/or the need for continued development to refine the representation of information from multiple functional networks. This characterization of the state of subcortico-cortical functional organization in healthy, full-terms at birth may provide important context for investigations of prenatal exposures or premature delivery that disrupt prenatal developmental processes.

P2-K-110 Regional patterns of subplate development: Insights from fetal MRI

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Summary: We investigate the fetal subplate (SP), a critical structure in early neuronal migration, circuit formation, and cortical activity1. Mapping typical SP thickness development with fetal MRI, we aim to establish normative benchmarks that will help identify atypical neurodevelopmental trajectories linked to disorders2.

Details: We analyzed T2-weighted fetal brain MRI scans of 59 typically developing fetuses (31/27/1 male/female/unknown; mean gestational age (GA): 27.09 weeks; range: 22.00–31.14) collected at Boston Children's Hospital between 2014-2023. Data were processed using an optimized pipeline that included brain masking, N4 bias correction, and slice-to-volume reconstruction to 0.5 mm isotropic resolution3. The SP was delineated semi-automatically with a 2D U-Net ensemble retrained for SP segmentation4, with manual corrections. The outer SP surface (boundary between SP and cortical plate) was extracted via marching cubes and deformed toward the inner SP boundary with scheduling optimized for subject's gyrification index to account for evolving morphology5. SP thickness was computed as the Euclidean distance between corresponding surface vertices. Regions of interest (ROIs) were defined by aligning individual cortical surfaces to a fetal surface template containing a modified Desikan-Killiany atlas map, adapted for fetal brain sulcal emergence and SP segmentation quality, resulting in 18 bilateral regions (Fig1A). We characterized general trends of regional variation in SP thickness, assessed differences in the developmental changes of SP thickness across regions between early and middle prenatal periods, and examined asymmetries in SP development between homotopic regions.

Results confirmed a significant linear increase in median SP thickness with GA (0.22x -2.94, permuted p-val<0.001). We observed significant regional variation in SP thickness (Fig1B), confirmed by a repeated-measures ANCOVA, which showed a significant effect of ROI ($F=116.6$, $p<0.001$, partial $\eta2=0.672$) and interaction with GA ($F=20.1$, $p<0.001$, partial $\eta2=0.261$). These indicate both pronounced regional heterogeneity in SP thickness and age-related changes in its developmental trajectory during the evaluated period (Fig1C). Developmental changes between fetuses grouped into early (≤27 wGA, N=29) and middle (>27 wGA, N=30) prenatal periods revealed notable increases in SP thickness around the Sylvian fissure and primary sensory-motor areas, potentially reflecting thalamo-cortical fiber growth6 underlying emerging sensorimotor connectivity during this period7.

Analysis of homotopic ROIs revealed asymmetries in SP growth (Z-scores based on group differences, converted to p-values at alpha = 0.05). After correction for multiple comparisons, greater changes (p-value<0.05) were observed in the left precentral gyrus, inferior and middle temporal gyri, and lateral occipital cortex. Interestingly, the right postcentral gyrus showed more pronounced changes in SP thickness, diverging from prior findings on cortical morphology8,9. These asymmetries may reflect early functional specialization of sensory and motor systems and are more readily detectable in the SP due to its central role in the establishment of structural and functional connectivity. Such early differences may lay the groundwork for broader hemispheric specialization observed later in development10.

Overall, this study provides an initial comprehensive characterization of SP thickness development during early to mid-prenatal periods. Future studies should investigate finer age-related SP changes and their relationship with white matter development to further understand fetal brain growth dynamics.

P2-K-111 Precision functional mapping of the individual human brain at birth reveals reliable and individual-specific cortical area boundaries

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Summary: This project probes the individual specificity of areal organization in neonates using precision functional mapping (PFM).

Details: Introduction: It is not known whether boundaries of cortical areas are established at the time of birth or emerge over the first several years of life. Neuroimaging can be used to study cortical areas in vivo in humans by detecting abrupt transitions in functional connectivity (FC), which delineate putative cortical area boundaries. As such, when averaging data across large groups of adults, 90% of the cortical surface can be parcellated into ~300 reliable, distinct cortical areas. Conversely, when averaging across large groups of neonates, only about 50% of the cortical surface can be divided into reliable cortical areas using this method. It is not clear whether this result indicates that neonatal cortical areas are not yet established, or if instead group-averaging obscures mature cortical boundaries due to heterogeneity across neonates. The goals of this study were to use precision functional mapping (PFM) to (1) test whether cortical areas can be reliably identified in individual neonates, (2) determine whether reliable cortical areas in individual neonates cover 90% of the cortical surface, and (3) test whether the arrangement of neonatal cortical areas is individually specific. Methods: We collected PFM data from six neonates (median 83 minutes of low-motion data per subject), each over several days, within the first weeks of birth (avg = 42.6 weeks postmenstrual age). We used previously established methods to identify transitions in FC across the cortical surface and identify cortical areas in roughly equal split-halves of data for each individual. The reliability and specificity of individual-specific cortical area parcellations were evaluated using homogeneity, which was defined as the percent variance in FC pattern explained by the first principal component across vertices in each cortical area. The significance of the homogeneity metric was established against spatially permuted null parcellations.

Results: Across all six neonates, individualized cortical area parcellations were reliable across unseen data from their own dataset as measured with homogeneity (mean (z) = 4.4 sd=1.4). Further, cortical areas defined in individual neonates covered ~90% of the cortical surface. The arrangement of cortical areas was individually specific, as cortical areas generated from an individual subject provided a significant fit to their own unseen data, but not unseen data from any other neonate's datasets (Figure 1). Conclusion: Cortical areas can be reliably measured in individual neonates, cover most of the neonatal cortical surface, and are individually specific. Thus, cortical areas appear to be reliable at birth, but individuals vary significantly in their arrangement. This individual variation poses challenges for studies examining groups of neonates.

P2-K-115 Development of manual skills and lateralized brain activity during infancy: A longitudinal fNIRS study

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Summary: This study examines how infant hand use and corresponding brain activity develop together, and how early brain injury disrupts this process. Our goal is to understand how early movement experiences shape the brain, to better support infant's motor development.

Details: Manual skills emerge over the first two years of life with rapid progressions in skill level, and fluctuations between unimanual and bimanual actions. Asymmetric perinatal brain injury disrupts this trajectory, often resulting in unilateral cerebral palsy (UCP)—the most common pediatric motor disability. Although behavioral studies have characterized early manual skill development in both neurotypical and clinical populations, less is known about how brain regions associated with control of goal-directed actions evolve in parallel with skillful movements. The objective of our study was to characterize development of infant manual skills in relation to developing cortical activity.

Neurotypical infants (NT) and infants diagnosed with UCP (total=20 infants) were observed longitudinally from 6 to 24 months of age (at 3-month intervals). Manual skills were assessed in a semi-naturalistic play session using a validated assessment and included presentation of ~25 infant-friendly objects/toys. Play sessions were digitally recorded and coded frame-by-frame using Datavyu. For each toy/object trial, active hand (left vs. right vs. bimanual), frequency of use, and duration of bouts were assessed for 1) reach-to-grasp, 2) unimanual manipulation, and 3) bimanual manipulation. Concurrently, functional near-infrared spectroscopy (fNIRS) (NIRSport2, NIRx) captured hemodynamic responses during performance of manual skills. fNIRS signal was synched to digital video recordings. Measurements were collected with an optode array (8 sources;12 detectors) centered bilaterally over somatosensory cortex. For all univariate analyses, significance was tested with a non-parametric permutation (5000 permutations) test based on Welch's t-statistic suitable for unequal variance and sample sizes. Longitudinal data of hand-use patterns were analyzed using a multilevel model with fixed and random effects.

From 6 to 24 months, we observed a shift in the proportion of manual skills that were unimanual compared to bimanual, with a greater proportion of bimanual actions at older ages ($p<.01$ for time x skill parameter). We also identified a development progression from symmetric bimanual actions at younger ages to asymmetric bimanual actions at older ages ($p<.01$). We quantified hemodynamic responses at the fNIRS channel level for individual sessions, with each session comprised of on average over 100+ unique bouts of object manipulation. On average, we observed a robust contralateral difference in peak activation of the left hemisphere with greater amplitude modulation occurring during right hand manipulation as compared to left hand manipulation ($p<.01$). We observed a similar trend for greater contralateral activation in the right hemisphere during left-handed manipulations, although this difference was not significant ($p=.06$). Greater lateralized activation was observed during asymmetric bimanual actions as compared to symmetric bimanual manipulations ($p<.05$). Notably, infants with UCP exhibited atypical asymmetrical activation as early as 6 months of age. By measuring real-time brain activity in dynamic, multi-sensory contexts, this study highlights how emerging manual skills shape experience-dependent development of the sensorimotor system. Our findings suggest that early disruptions to motor experiences in UCP may canalize atypical brain asymmetries, offering new insights into early intervention targets to promote optimal neurodevelopment.

P2-K-117 Longitudinal TBM shows greater age-related corpus callosum expansion in human milk-fed infants

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Summary: We address FIT'NG's focus on early-life factors by using longitudinal TBM to reveal human-milk–linked corpus-callosum expansion during 0–12 months, offering mechanistic insight beyond cross-sectional studies and showcasing reproducible mixed-effects analytics.

Details: Objective: Evidence suggests that Early postnatal nutrition influences white-matter maturation, yet longitudinal whole-brain evidence remains limited. We applied tensor-based morphometry (TBM) with voxel-wise linear mixed-effects (LME) modeling to test whether exclusive human-milk (HM) feeding is associated with white matter expansion across the first year of life.

Methods: T1-weighted MRIs from 86 healthy term infants enrolled in the Baby Connectome Project (median = 2 scans/infant; age 0–12 months) underwent rigorous QA, rigid alignment to a 18 week template, and SyN non-linear registration. Jacobian determinant maps quantifying local volumetric change were entered into AFNI 3dLME (random intercept per infant). Fixed effects: feeding group (HM n = 42 vs formula n = 44), gestational age, and socioeconomic index. Clusterwise family-wise-error control used 3dClustSim at $\alpha = 0.05$.

Results: A significant age × feeding interaction surfaced in the genu and body of the corpus callosum. HM-fed infants exhibited greater age-related expansion of callosal volume than formula-fed peers; no regions showed the opposite pattern. No main-effect group differences survived correction. Sensitivity analyses excluding mixed-feeders or infants with <2 scans yielded comparable clusters.

Conclusions: Exclusive HM intake is associated—not proven to cause—with enhanced longitudinal expansion of midline white matter in the first postnatal year. These findings extend cross-sectional reports by demonstrating nutrition-related differences in developmental slope and spotlight the corpus callosum as a potential target for early nutritional support.

Limitations & future work (1) Few time points per subject limited modelling of nonlinear trajectories; continued data collection will improve power. (2) TBM captures isotropic volume change and cannot resolve microstructural drivers; integrating diffusion imaging could clarify underlying biological processes.

L – Prenatal Programming

P2-L-112 Perinatal maternal depression: How timing and symptom dimensions relate to neonatal and toddler brain volume

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Summary: To our knowledge, no prior work on the relationships of prenatal depression to early brain development has considered whether dimensions of symptoms (anxiety, sad mood, anhedonia) relate to development differentially. Our study aims to determine whether relations between prenatal depression and child brain structure differ based on symptom type.

Details: Objective: Exposure to perinatal maternal depression is associated with altered child brain structure and function. Given prior mixed findings, how early brain structures are affected and when prenatal depression may be most impactful remains unclear. Little work has explored different symptoms of depression. Thus, we examined the relations of depression timing and symptom type (anhedonia, sad mood, anxiety) to brain volumes within the first few years of life. We hypothesized that prenatal, compared to postnatal, anhedonia would be most strongly associated with smaller brain volumes and that these relationships would be stronger in neonates than toddlers.

Method: 213 mother-child dyads, oversampled for poverty, were assessed each trimester, post-birth, and at ages 1, 2, and 3. Maternal depression was measured using the Edinburgh Postnatal Depression Scale at each trimester and 4, 8, and 12 months postnatal. Depressive symptoms were analyzed using a three-factor model: anxiety, sad mood (depression), and anhedonia. Structural data was acquired using a Siemens Prisma 3T scanner at birth, age 2, and age 3. Analyses controlled for child birthweight, sex, age at scan, and income-to-needs and adjusted for multiple comparisons. Analyses looking at trimester-specific effects controlled for the other trimesters.

Results: 1st-trimester anhedonia did not predict neonatal amygdala volumes, but did significantly predict right amygdala volume at age 2 and 3 ($\beta=61.86$, $p=.008$, $q=.02$), but not left amygdala volume ($\beta=43.91$, $p=.06$, $q=.18$), after controlling for neonatal volume and anhedonia in other trimesters. 2nd-trimester anhedonia significantly predicted neonatal right hippocampal volume ($\beta=88.59$, $p=.009$, $q=.03$), controlling for anhedonia in other trimesters, but did not predict total hippocampal volume after FDR correction ($\beta=101.79$, $p=.04$, $q=.12$). 2nd-trimester anhedonia did not predict right or total hippocampal volume at ages 2 and 3, after accounting for neonatal volumes (ps=.18 and .10). Anxiety and depression symptoms did not predict any brain volumes. No postnatal symptoms predicted child brain volumes.

Discussion: Findings highlight the importance of considering the timing and dimensions of maternal depressive symptoms and suggest that prenatal symptoms may be particularly relevant for early brain development. Symptoms of anhedonia in the first trimester predicted larger toddler amygdala volumes and in the second trimester predicted larger neonatal hippocampal volumes. Thus, early pregnancy may be a critical time for intervention and treatment. Further work is needed to understand why these trimesters may specifically be related to child brain development.

P2-L-113 Effect of pre- and post-natal anemia on infant visual excitation/inhibition balance over the first 2 postnatal years

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Summary: We investigated the effect of pre- and post-natal anemia on a noninvasive EEG marker of neuroplasticity. We found early postnatal anemia was related to decreased inhibition and therefore less mature visual cortical development. We did not observe significant results when testing the effect of prenatal anemia.

Details: Sensitive periods are tightly-regulated windows of elevated neuroplasticity, facilitating adaptation to early environments across domains. In non-human animal models, a normative decrease in balance of neural excitation to inhibition (E/I balance) initiates this window and governs the degree of neuroplasticity during the sensitive period. Evidence from animal literature also suggests perinatal nutrition, such as iron deficiency, can modulate postnatal sensitive period mechanisms, including E/I balance, to shape brain and behavior. Iron deficiency is the most common cause of anemia during pregnancy due to the increased iron demand. However, until recently, measuring E/I balance minimally invasively in humans was infeasible, and thus understanding of how anemia and iron deficiency shape human E/I balance and neuroplasticity is limited.

Here, we leverage recent advances to noninvasively estimate E/I balance in human infancy using the aperiodic exponent of power from resting-state electroencephalography (EEG) via spectral parameterization in a longitudinal cohort of infants and their mothers (n=293, 150 female) from an informal settlement in South Africa. We investigate how prenatal (mother) and postnatal (infant) hemoglobin levels, indexing anemia, shape postnatal EEG markers of E/I balance in an exemplar domain, the early visual cortical sensitive period.

Serum hemoglobin (Hb; g/dL) was collected from mothers in trimester 3 (M gestational age=34 weeks) and infants around 4 months (M=117 days). According to WHO cutoffs, in this study, 38.8% (n=47) of trimester-3 mothers and 36.5% (n=65) of 4-mo. infants with Hb measures were anemic. 726 EEG recordings were collected from 293 infants at up to 4 postnatal visits across the first 2 years (M age in days at: visit 1=125, v2=269, v3=427, v4=654). The aperiodic component in an occipital region of interest was extracted from resting-state EEG data using HAPPE with the integrated FOOOF wrapper. Exclusion criteria included <20 segments retained, R2<.95, error>.07 (files with error .05 to .07 were visually inspected for inc./exclusion).

Two longitudinal multilevel models were run to investigate the impact of continuous measures of Hb on the aperiodic exponent as a marker of E/I balance, one with prenatal maternal Hb in tri. 3 and the other with postnatal infant Hb around 4 mo. Predictors in both models included Hb (tri. 3 or 4 mo.), age at Hb collection (gest. age [wks.] or postnatal age [days]), infant EEG age (days), number of retained EEG segments, interaction between Hb and infant EEG age, and random intercept of participant. No significant effects of prenatal Hb were observed. In the postnatal model, age was significantly positively related to larger (i.e., steeper) aperiodic exponents (b=0.002, SE=0.001, t(363.28)=2.00, p=.047) and hemoglobin at 4 months was significantly positively related to larger aperiodic exponents (b=0.09, SE=0.04, t(439.47)=2.08, p=.038).

These results suggest that early postnatal anemia (indexed by serum hemoglobin) is related to decreased inhibition and potentially delayed neuroplasticity, and therefore less mature visual cortical development. Future work will further disentangle the effects of prenatal vs. postnatal anemia with longitudinal hemoglobin measures collected from mothers throughout pregnancy and infants across the first 2 years of life. Further, we will probe the etiology of anemia in our sample with serum measures of iron and inflammation in the same age range.

M – Variation/Relation to Symptoms

P2-M-114 Brain maturation in extremely preterm infants born at 22 to 26 weeks of gestation with chronic lung disease

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Summary: Chronic lung disease (Bronchopulmonary Dysplasia or BPD) is the most prevalent morbidity among survivors of extremely preterm birth (≤ 28 weeks of gestation), affecting more than 50% of this population. BPD is known to significantly impact development, but its direct influence on brain growth and maturation remains poorly understood.

Details: Objective: To determine the impact of bronchopulmonary dysplasia (BPD)—a chronic neonatal lung disease characterized by inflammation, scarring, and disrupted lung development, often resulting from mechanical ventilation and high concentrations of supplemental oxygen—on the postnatal brain maturation of extremely preterm (EP) neonates.

Methods: Subjects included neonates born between 22 0/7 and 26 0/7 weeks from 2006 to 2019 (N=272) at the University of Iowa who completed a 2-year follow-up visit with the National Institute of Child Health and Human Development (NICHD) Neonatal Research Network (NRN). BPD severity was determined by the mode of respiratory support at 36 weeks postmenstrual age (PMA) per Jensen et al. 2019 BPD criteria. Twenty-seven linear measurements of various brain regions, such as the corpus callosum and thalamus, were obtained during routine clinical two-dimensional head ultrasonography exams conducted on day 7 of life and at 36 weeks PMA. Confirmatory factor analysis using robust maximum likelihood estimation was conducted to identify several a priori factors related to fetal brain maturation, including ventricular and extra-axial space, gyrification/sulcation, and deep/midline brain structures. Multiple linear regression assessed the impact of BPD severity on (a) brain size at 36 weeks PMA and (b) brain growth from the initial week of life to 36 weeks PMA. Covariates included infant sex, gestational age at birth, maternal education, multiple births, and birth year.

Results: Neonates with severe BPD exhibited significantly larger ventricular/extra-axial spaces ($\beta = 0.573$, $P = 0.006$) at 36 weeks PMA. In contrast, those with moderate ($\beta = -0.598$, $P < 0.001$) and severe BPD ($\beta = -1.071$, $P < 0.001$) showed smaller deep/midline brain morphometry at 36 weeks PMA compared to infants without BPD or with mild BPD. Regarding brain growth, infants with severe BPD demonstrated increased growth in extra-axial spaces ($\beta = 0.087$, $P = 0.007$) and lateral ventricular size ($\beta = 0.036$, $P = 0.044$). Conversely, moderate ($\beta = -0.033$, $P < 0.001$) and severe BPD ($\beta = -0.066$, $P < 0.001$) were strongly associated with reduced growth of deep/midline brain structures.

Conclusion: These findings indicate that moderate-to-severe BPD leads to smaller and less developed brains by 36 weeks PMA, as evidenced by reduced white matter and diminished deep and midline brain structure growth. Clinically obtained head ultrasounds serve as a valuable research tool for understanding the adverse effects of BPD on brain development.

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