FIT'NG
Fetal, Infant, & Toddler Neuroimaging Group

Program

Annual Conference

Fetal, Infant, & Toddler Neuroimaging Group Conference

September 25-26, 2024
The Royal Sonesta Harbor Court
Baltimore, MD, United States

fitng.org

@FIT_NGIn
www.fitng.org
#fitng2024

Program At-A-Glance

Time	Wednesday 25-Sep	Thursday 26-Sep
8:30AM	Welcome Intro from FIT'NG	Session 3 **Methods Development** *Featuring Charlie Demene* 8:30am - 10:00am
8:45 AM		
9:00 AM	Session 1 **Brain and Behavioral States** *Featuring Mark Blumberg* 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		**Elephants in the Room** 10:30am - 12:00pm
10:45 AM	Session 2 **Early Cognitive Development** *Featuring Lauren Emberson* 10:45am - 12:15pm	
11:00 AM		
11:15 AM		
11:30 AM		
11:45 AM		
12:00 PM	**Lunch Break** *on your own* 12:15pm - 1:45pm	**Lunch Break** *on your own* 12:00pm - 1:30pm
12:15 PM		
12:30 PM		
12:45 PM		
1:00 PM		
1:15 PM		
1:30 PM		Session 4 **Early Network Development** *Featuring Minhui Ouyang* 1:30pm - 3:00pm
1:45 PM	**Keynote** *Ellen Grant* 1:45pm - 2:45pm	
2:00 PM		
2:15 PM		
2:30 PM		
2:45 PM	**Flash Talks** (2:45pm - 3:10pm)	**Flash Talks** (3:00pm - 3:25pm)
3:00 PM	**Poster Session #1** **and coffee break** 3:10pm - 5:00pm	**Poster Session #2** **and coffee break** 3:25pm - 5:00pm
3:15 PM		
3:30 PM		
3:45 PM		
4:00 PM		
4:15 PM		
4:30 PM		
4:45 PM		
5:00 PM	**Panel Discussion** *Featuring a variety of speakers* 5:00pm - 6:30pm	Session 5 **Adversity and Brain Development** *Featuring Kathryn Humphreys* 5:00pm - 6:30pm
5:15 PM		
5:30 PM		
5:40 PM		
5:45 PM		
6:00 PM		
6:15 PM		
6:30 PM		**FIT'NG Society Updates**
6:45 PM	**President's Reception** 6:30pm - 7:30pm	
7:00 PM		
7:15 PM		
7:30 PM		
7:45 PM		
8:00 PM		
8:15 PM	**Trainee Committee Social Event** 8:30pm Hotel Terrace	
8:30 PM		
8:45 PM		
9:00 PM		
9:15 PM		
9:30 PM		

Registration/Information Desk Open

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.

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Welcome!

To our growing FIT'NG Community,

Welcome to the 3rd Annual Conference for The Fetal, Infant, and Toddler Neuroimaging Group (FIT'NG)! We are thrilled to have you join us in the vibrant city of Baltimore, Maryland for this exciting event to share your science and passion for this rapidly growing field.

Having launched in 2018, we are very proud of the enormous gains we have made towards fulfilling our mission of bringing together the interdisciplinary community to understand early brain development and behavior. We have hosted multiple successful workshops, trainings, and events, and have been overwhelmed by the enthusiasm and support from you all for our offerings. We are also particularly proud of how trainees have fueled our efforts and facilitated connections between people at all career levels. We see more clearly now than ever that our society has a critical role to fill amongst those committed to advancing the understanding of early brain development. You are all integral to the success of the FIT'NG community, and we cannot thank you enough!

Our inaugural 2022 meeting in Paris, France marked a significant time in the development of FIT'NG, and the 2023 meeting in Santa Rosa, CA demonstrated significantly increased interest in attendance. Society membership in 2024 spans 24 countries, with broad representation across all the modalities and backgrounds that make up our exciting and progressive community. This year, we have expanded our executive board and elected Tomoki Arichi and Lindsay Bowman to join our founders and existing board, consisting of Marisa Spann, Dustin Scheinost, Lilla Zollei, and Brittany Howell.

FIT'NG has been changing the face of our field within a few short years, as demonstrated by our multiple papers and commentaries. These have included the history of FIT MRI (Pollatou et al., 2022), answers to common concerns of grant and manuscript reviewers (Korom et al., 2022), commentaries related to the art of FIT scanning (Spann, et al., 2023) and collaborative science opportunities (FIT'NG et al., 2023), a recent "hot topics" piece outlining the field's key principles (Spann & Scheinost 2024), and a book chapter about early exposures and risk of neurodevelopmental disorders. We are excited to announce a special FIT'NG issue themed around last year's conference for Developmental Cognitive Neuroscience. These achievements are all of ours to share. We hope to continue as a prolific, collaborative society

OUR KEYNOTE

We are honored and excited to have **Professor Ellen Grant** as our keynote speaker at this year's conference. She is the Käthe Beutler Harvard Professor of Pediatrics and Radiology at Harvard Medical School, where she has been at the forefront of the field, developing novel tools for detecting and understanding normal and abnormal brain physiology and development. Professor Grant obtained a bachelor's and a master's in Physics before attaining her medical degree and qualifications in neuroradiology. This has enabled her to seamlessly marry cutting-edge technological advancements with clinical need and neuroscience insight, pioneering numerous methodologies, including fetal and placental MRI, bedside quantitative and frequency-domain NIRS for neonates, and pediatric MEG.

OUR AWARDEES

We highlight the *Young Investigator Award Winners*, listed later in this brochure. The Program Committee again received many amazing applications, having the difficult decision to select the awardees. We provided 16 awards. The awardees represent a microcosm of FIT'NG, spanning various techniques, methods, and biological and clinical topics. Congratulations to you all!

OUR COMMITTEES

Our society's commitment and collaborative nature shines brightly from our committee members. Many volunteered their time from the beginning, as the first FIT'NG workshop mobilized our community. We wanted more scientific content for us and by us. Over the past few years, your efforts have made this idea a reality.

We sincerely thank our wonderful *Program Co-Chairs*, Nadege Roche-Labarbe and Tomoki Arichi. Nadege and Tom worked closely with the scientific program committee of Lorenzo Fabrizi, Lindsey Powell, Ka Ip, Emma Margolis, and Paige Nelson (the wonderful

and enthusiastic trainee committee liaisons). Together with Marisa Spann (representing the board) and Tori Lunden (Podium), they crafted a program that spans methodologies, age ranges, and scope. The content aims to represent all the amazing work being done. We are also indebted to the more comprehensive Scientific Program Committee, listed later in this brochure. They worked tirelessly to review abstracts and to select posters and oral presentations.

The *Communications Committee*, led by Kelly Vaughn and Claudia Lugo-Candelas (Co-chairs), has continued to expand our membership and reach this year. As some of our members left Twitter/X for other platforms, we have expanded our social media presence to include Mastodon, Bluesky, and LinkedIn. Our handles are **@FIT_NGIn** on Twitter/X, **@FIT_NGIn** on Mastodon.social, **@fitngin.bsky.social** on Bluesky and https://www.linkedin.com/company/fitng on LinkedIn. Please follow us and engage with us on your preferred platform using **#fitng2024**. We are currently planning new initiatives to connect our society members and promote FIT'NG research. Sign up for our mailing list https://groups.io/g/fitng to further communicate 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

We are so proud of our exceptional *Trainee Committee* led by co-Chairs Halie Olson and Áine Travers Dineen with active members María José Castro Gómez, Claudia Adelita Carreno, Juliette Champaud, Abigail Fiske, Marta Korom, Emma Margolis and Paige Nelson, and board member Dustin Scheinost. This year, they expanded the success of FIT'NG Together, a publicly available and free virtual programming series for FIT researchers, by continuing events focused on prevalent methodological and conceptual challenges in FIT imaging and introducing the various modalities at the core of FIT neuroimaging to new audiences ("Modality Introduction Series"). They hosted 6 FIT'NG Together events, reaching over 250 attendees. The Trainee Committee also contributed to society publications, including an upcoming paper, 'Modality-Level Obstacles and Initiatives to Improve Representation in Fetal, Infant, and Toddler Neuroimaging Research Samples'.

Last year's 'Elephants in the Room' Think Tank conference discussions organized by the Trainee Committee led to 5 papers for an upcoming special issue in Developmental Cognitive Neuroscience involving trainee and senior authors across more than 30 institutions. Building on efforts to foster mentorship networks and promote trainee-focused conference programming, this year's conference will feature three events organized by the Trainee Committee and initiatives designed to advance the professional development of FIT'NG trainees. FIT'NG thanks the many experts who presented at FIT'NG Together events this year: Parvaneh Adibpour, Claire Kabdebon, Genesis Flores, Slava Karolis, Siân Wilson, Jonathan O'Muircheartaigh, Laurel Gabard-Durnam, Madeleine K. Wyburd, Isabel Benavente-Fernández, Chiara Bulgarelli, Nwabisa Mlandu and Sonya Troller-Renfree. 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 *Vision & Visibility (V&V) Committee* was established in 2022 as a presidential initiative 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 & Jerod Rasmussen. It includes exceptional EEG and fNIRS faculty from across the globe, including Lindsay Bowman, Sam Wass, Sobana Wijeakumar, Sam McCann, Laura Pirazzoli, and Joscelin Rocha Hidalgo. Brittany Howell and Lindsay Bowman serve as the committee's board representatives. In February 2023, the V&V committee hosted EEG and fNIRS workshops attended by hundreds of researchers across Asia, Europe, the Middle East, and North and South America. Attendees represented various career stages, from students and research assistants to full-time faculty. These workshops and other engagement initiatives illustrate FIT'NG's deep commitment to supporting and training researchers studying the developing brain. We are currently planning additional workshops to share data collection strategies with fetal/infant/toddler populations. 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 if you want to join us and have ideas for initiatives that further support diversity and visibility in society!

The *Sustainability and Advancement Committee* was established a few months after the annual meeting in 2023 with the primary goal of securing funding to ensure the society's long-term financial stability. The committee is led by Marisa Spann as Chair and

Kathrine Skak Madsen as Co-Chair, with committee members Brittany Howell, Áine Travers Dineen, and Courtney Filippi actively contributing to its efforts. In its first year, the committee has focused on identifying and pursuing various funding opportunities, such as grants and sponsorships, to support the society's future initiatives. Recently, the committee secured crucial support for the society for the next three years. While this is a significant milestone, it marks the beginning of building a robust financial foundation for our society. Looking ahead, the committee aims to expand its efforts to secure further funding and explore new avenues for promoting economic sustainability, ensuring the society's continued growth and success. We encourage all members to share ideas or join us in building a sustainable future for our community!

The *Scholarly Works Committee* was established this year to facilitate and spearhead the realization and dissemination of scholarly works, including coordinating the grant submission efforts for the society. The committee is led by Dustin Scheinost, Sarah Shultz, and Cat Camacho, with active members Brittany Howell, Marisa Spann, Marta Korom, and Johanna Bick. They assisted with and led the submission of 3 grants and 3 publications and oversee the first FIT'NG meeting special issue to be published in Developmental Cognitive Neuroscience. The committee is excited to expand further in the coming year to support more scholarly initiatives from FIT'NG members!

OUR SPONSORS AND PARTNERS

FIT'NG continues to grow in a supportive incubator! To our universities and their affiliates: Yale University School of Medicine (Magnetic Resonance Research Center and BioImage Suite), Virginia Tech (Fralin Biomedical Research Institute at VTC), Mass General Brigham (Radiology Department), A.A. Martinos Center for Biomedical Imaging, Columbia University (Department of Psychiatry), and the Nathaniel Wharton Fund, your belief in us and provision of support necessary to move our vision forward is invaluable! To our new and ongoing sponsors, thank you for ensuring our meeting this year was possible. Bringing together young brain researchers indeed provides a better future for humankind. They are listed above and on our website, but we want to acknowledge them here: ***NIRx, BrainVision, MindWare Technologies, TracInnovations, Noldus, ANTNeuro North America,*** and ***Mangold***. We will continue to grow and are so glad to have you with us from the beginning!

For this society to flourish, ongoing and continued support of our scientific mission is essential. The National Institutes of Health provides multi-year support through the NIH Support for Conferences and Scientific Meetings grant mechanism. Our funded grant is titled "Fetal, Infant, Toddler Neuroimaging Group (FIT'NG): Uniting Clinical, Computational, Engineering, and Neuroscience to advance discoveries for the young child" (R13 HD108938). We are primarily supported by the ***Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD)*** and co-supported by the ***National Institute of Drug Abuse (NIDA)***. We also thank the ***Burroughs Wellcome Fund*** for multi-year grant support. These grants provide a forum for investigators to disseminate novel methods to support better understanding of neural mechanisms disrupted due to prenatal and early childhood traumas, present the most cutting-edge science that will shift and shape our understanding of the developing brain, sensitive periods of prevention and intervention, and novel mechanism integral for healthy brain development. They also support travel awards for young and underrepresented minority investigators and trainee activities.

We are so grateful to our sponsor and partner, **Podium Conference**. From the beginning, Podium believed in our mission and ensured we had the skills to grow and develop into a viable and sustainable society. Their encouragement and advanced knowledge of society's development are invaluable. We thank Marischal De Armond, the president and founder, for the continued resources to grow. To Tori Lunden, thank you for all the patience, tireless support, and fantastic organization you have put into preparing for this year's meeting. You are the wind in our sails! Looking forward to seeing you at the harborside.

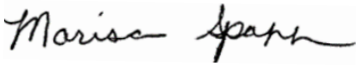
OUR MEMBERS

No person can build a society and a conference home without a strong foundation. It is YOU, our members and partners in forming this society, that turned this idea into a reality. Year after year you have demonstrated the importance of FIT'NG through your engagement and contributions. Your voices will continue to fuel the intellectual, social-community, and fiscal success of our society. You are sharing more of your work focused on the early developing brain! From 45 poster submissions at our first meeting 2022 to twice that amount at this meeting. There is a role

and opportunity for everyone in this community, all you have to do is reach out! Join a committee, propose a new white paper or commentary, and be an active member of this society so we can ensure our voices are heard in the sea of neuroimaging technologies that were not originally designed for, but that we are ensuring are reimagined for the small brain. Still in our infancy, we cannot wait to see where we take FIT'NG together.

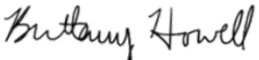
Sincerely,

Executive Board and Founders



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

Alice Graham, PhD
Founding Member
Assistant Professor, Oregon Health & Sciences University

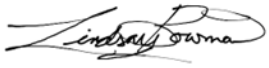


Brittany Howell, PhD
Secretary
Assistant Professor, Virginia Technical Institute

Dustin Scheinost, PhD
Treasurer and Founding Member
Associate Professor, Yale University School of Medicine

Lilla Zollei, PhD
Bylaws Officer and Founding Member
Associate Professor,
Massachusetts General Hospital/Harvard University

Tomoki Arichi MBChB FRCPCH FHEA PhD
Board Member
Reader in Perinatal Imaging, King's College London



Lindsay Bowman, PhD
Board Member
Assistant Professor, University of California, Davis

Program Committee

Nadege Roche-Labarbe, PhD
Program Committee Co-Chair
Associate Professor of Psychology, University of Caen Normandy

Tomoki Arichi MBChB FRCPCH FHEA PhD
Program Committee Co-Chair
Reader in Perinatal Imaging, King's College London

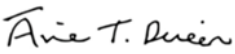
Communications Committee

Kelly Vaughn, PhD
Communications Committee Co-Chair
Assistant Professor,
University of Texas Health Science Center at Houston

Claudia Lugo-Candelas, PhD
Communications Committee Co-Chair
Assistant Professor, Columbia University Irving Medical Center

Trainee Committee

Halie A. Olson, PhD
Trainee Committee Chair
Postdoctoral Associate, Massachusetts Institute of Technology



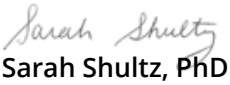
Áine Travers Dineen
Trainee Committee Co-Chair
PhD Candidate, Trinity College Dublin

Sustainability and Advancement Committee

Kathrine Skak Madsen
Sustainability and Advancement Committee Co-Chair
Senior Researcher, Danish Research Centre for Magnetic Resonance

Scholarly Works Committee

M. Catalina Camacho, PhD
Scholarly Works Committee Co-Chair
Assistant Professor,
Washington University in St. Louis School of Medicine



Sarah Shultz, PhD
Scholarly Works Committee Co-Chair
Assistant Professor, Emory University School of Medicine

FIT'NG Leadership & Committees

FIT'NG BOARD

Marisa N. Spann	President & Founding member, Columbia University
Alice Graham	Incoming President & Founding member, Oregon Health & Science University
Brittany Howell	Secretary, Virginia Tech
Dustin Scheinost	Treasurer & Founding member, Yale University
Lilla Zöllei	Bylaws Officer & Founding member, Massachusetts General Hospital / Harvard Medical School
Tomoki Arichi	Board Member, King's College London
Lindsay Bowman	Board Member, University of California, Davis

2024 SCIENTIFIC PROGRAM COMMITTEE

Tomoki Arichi	(Chair), King's College London
Nadege Roch-Labarbe	(Co-chair), University of Caen Normandy
Marisa N. Spann	(Board liaison), Columbia University
Paige Nelson	(Trainee liaison), University of Iowa
Emma Margolis	(Trainee liaison), Northeastern University
Lorenzo Fabrizi	University College London
Lindsey Powell	University of California, San Diego
Ka I Ip	University of Minnesota

VISION & VISIBILITY COMMITTEE

Courtney Filippi	(Chair), University of Maryland
Jerod M. Rasmussen	(Co-chair), University of California, Irvine, School Of Medicine
Lindsay Bowman	University of California, Davis
Sam Wass	University of East London
Sobana Wijeakumar	University of Nottingham
Sam McCann	King's College London
Joscelin Rocha Hidalgo	Pennsylvania State University

COMMUNICATIONS COMMITTEE

Kelly Vaughn	(Chair), Children's Learning Institute, University of Texas Health Science Center at Houston
Claudia Lugo-Candelas	(Co-chair), Columbia University Irving Medical Center/New York State Psychiatric Institute
Roxane Licandro	Massachusetts General Hospital, Harvard Medical School and Medical University of Vienna
Tara Rutter	Oregon Health & Science University
Gavkhar Abdurokhmonova	University of Maryland
Claudia Adelita Carreno	Virginia Tech
Ogy Nwana	The University of Texas Health Science Center at Houston
Sahar Ahmad	University of North Carolina at Chapel Hill

TRAINEE COMMITTEE

Áine Travers Dineen	(Co-chair), Trinity College Dublin
Halie Olson	(Co-chair), Massachusetts Institute of Technology
Juliette Champaud	University College London
Claudia Adelita Carreno	Virginia Tech
Paige Nelson	University of Iowa
Emma Margolis	Northeastern University
Abigail Fiske	University of Oxford
Genesis Flores	University of Southern California
María José C Gómez	McGill University
Marta Korom	University of Delaware

SCHOLARLY WORKS COMMITTEE

M Catalina Camucho	(Co-chair), Washington University, St Louis
Sarah Shultz	(Co-chair), Emory University
Dustin Scheinost	Yale University
Brittany Howell	Virginia Tech

SUSTAINABILITY AND ADVANCEMENT COMMITTEE

Marisa Spann	(Chair), Columbia University
Kathrine Skak Madsen	(Co-chair), Danish Research Centre for Magnetic Resonance
Brittany Howell	Virginia Tech
Áine Travers Dineen	Trinity College Dublin
Courtney Filippi	New York University

ASSOCIATION SECRETARIAT & CONFERENCE MANAGEMENT

(fitng@podiumconferences.com)

Podium Conference Specialists
Michelle Smith
Marischal De Armond
Tori Lunden

2024 FIT'NG Young Investigator Award Winners

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.

Armen Bagdasarov	Duke University
Brian Rivera	University of Nebraska Lincoln
Chiara Casella	King's College London
Diego Derman	Indiana University
Guy Perkins	University of Padova
Halle Miller	University of Virginia
Jucha Willers Moore	King's College London
Kayla Delapenha	Columbia University
Madeleine Wyburd	University of Oxford
Michal Zieff	University of Cape Town
Rebecca Naur Barbosa	University of São Paulo
Ruohan Xia	University of California, Davis
Sahar Ahmad	University of North Carolina at Chapel Hill
Tristan Yates	Columbia University
Valentina Gomes	Mackenzie Presbyterian University
Yanbin Niu	Vanderbilt University

General Conference Information

Venue

The Royal Sonesta Harbor Court Baltimore
550 Light Street
Baltimore, MD, 21202
United States of America

All conference sessions will take place at this location.

Registration

Conference registration fees include access to all sessions including, speaker presentations, coffee breaks, and poster sessions.

Name Badges

Your name badge is your admission ticket to the conference sessions, coffee breaks, 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 that will be set out or leave it at the Registration Desk.

Registration & Information Desk Hours

The FIT'NG Registration and Information Desk, located on the mezzanine area on the main conference floor, will be open during the following dates and times:

- Wednesday, September 25, 2024: 8:00am – 6:45pm
- Thursday, September 26, 2024: 8:00am – 6:00pm

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 anyone of our staff for assistance. For immediate assistance please visit us at the Registration Desk.

Internet Services

Wireless Internet is available to delegates for no charge. Simply choose the WiFi Network: **Sonesta Meeting** Password: **RSHC4615**, select Complimentary and agree to the terms and conditions, then select Connect Me. No password is required. Kindly note, the WiFi strength is ideal for checking emails and websites but is not strong enough for streaming videos or heavy social media use.

If you are active on social media, make sure to hashtag #FITNG2024 @FIT_NGIn when referring to the meeting. We ask all FIT'NG delegates to respect no live tweeting of presentations without prior approval from the speakers/authors. We encourage social tweets about the conference and look forward to growing our online community.

If you require assistance, please visit the registration desk and we will endeavour to assist you.

Poster Information

- **Annual Meeting**

There are two Poster Sessions during the conference and posters have been allocated to either one of the sessions based on poster themes. Poster presenters must set-up and remove their posters during the following times.

- **Poster Session 1**

Set-up:	Wednesday, September 25 between 8:30am and 10:30am
Poster Hours:	Wednesday, September 25 3:10pm – 4:45pm
Remove:	Wednesday, September 25 no later than 6:45pm

- **Poster Session 2**

Set-up:	Thursday, September 26 between 8:30am and 10:30am
Poster Hours:	Thursday, September 26 3:25pm – 5:00pm
Remove:	Thursday, September 26 immediately following the poster session

Any posters that are not taken down by the removal deadline will be held at the registration desk until the end of the Meeting. Any posters that remain 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.

The Royal Sonesta Harbor Court Baltimore

Conference BINGO

Ask a question during a session	Find (at least) 1 person each who studies fetuses, infants, and toddlers	Connect over lunch with a fellow conference- goer	Post a group photo spelling out "FITNG" and tag the FIT'NG social media account	Engage with 5+ poster presenters in conversation
Post about a talk you attended	Take pictures of items matching each of the 7 colors on the FIT'NG brain logo	Attend a session outside your research field	Tell a Trainee Committee member about an idea for a future FIT'NG Together session	Chat with someone who uses a different modality than you
Give a high-five to a FIT'NG board member	Exchange contacts with an attendee from another institution		Contribute to a Think Tank Discussion	Compliment a speaker on their talk
Take notes during a session	Come up with a FIT'NG pun and use it in conversation	Take a picture of a poster that inspired you	Tag an exhibitor in a post	Plan to fill out the post-conference survey (and actually do it later!)
Introduce two people you know at the conference (who don't know each other)	Talk to an exhibitor at a booth	Post about your conference plans	Introduce yourself to a new colleague	Add a new paper to your to-read list

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 2024: Annual Conference Detailed Daily Schedule

All sessions will be held in the Whitehall Ballroom, The Royal Sonesta Harbour Court.

WEDNESDAY SEPTEMBER 25, 2024

08:30 – 08:45 **FIT'NG Welcome & Introduction**

08:45 – 10:15 **Session 1: Brain and Behavioral States**

Chairs: Lindsey Powell, *University of California, San Diego*
Halie Olson, *Massachusetts Institute of Technology*

Developing the sensorimotor system in our sleep: Implications for typical and atypical development
Mark Blumberg, *The University of Iowa*

Normative EEG growth curves of infant visual neurodevelopment generalize across global cohorts and predict cognitive outcomes
Emma Margolis, *Northeastern University* and Chris Camp, *Yale University*

Multimodal techniques: synchronizing doppler ultrasound and fnirs to understand signals of fetal well-being
Xuejun Hao, *Columbia University*

Neuromonitoring cortical hemodynamics in neonates during cardiopulmonary bypass surgery using high-density diffuse optical tomography
Adam Eggebrecht, *Washington University*

10:15 – 10:45 **Break**

10:45 – 12:15 **Session 2 - Early Cognitive Development**

Chairs: Nadege Roche-Labarbe, *University of Caen Normandy*
Paige Nelson, *University of Iowa*

Dynamics of learning and prediction in the infant brain
Lauren Emberson, *University of British Columbia*

Neural indicators of visual attention in toddlers born prematurely
Haley Marie Laughlin, *University of Houston*

Foundations of emotion development: Neural and caregiver mechanisms supporting real-world emotion-perception and emotion-related interactions in the first 2 years of life
Ruohan Xia, *University of California, Davis*

Neural indices of auditory statistical learning in infancy associated with concurrent language skills at 24-months in a sample of South African infants
Sarah Mccormick, *Northeastern University*

12:15 – 13:45 **Lunch on own**

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

Chair: Tomoki Arichi, *King's College London*

Can innovations in imaging enhance perinatal care?
Ellen Grant, *Harvard Medical School*

14:45 – 15:10 **Flash Talks #1**

Chairs: Nadege Roche-Labarbe, *University of Caen Normandy*
Paige Nelson, *University of Iowa*

Infants' resting state functional connectivity and ERPs: A multimodal approach to investigating the neural basis of infant novelty detection
Courtney Filippi, *New York University, Langone*

Dorso-medial prefrontal cortex responses to social smiles predict sociability in infancy
Olivia Allison, *University of Virginia*

Larger than life: Cartoons drive infant visual cortex more than realistic movies
Tristan Yates, *Columbia University*

Intrinsic functional neurocircuitry of the bed nucleus of the stria terminalis in early infancy
Yanbin Niu, *Vanderbilt University*

15:10 – 17:00 **Poster Session 1**

17:00 – 18:30 **Panel Discission - Large Cohorts in Fetal, Infant, and Toddler Neuroimaging Research**

Chairs: Brittany Howell, *Virginia Tech*
Emma Margolis, *Northeastern University*

Hear from an esteemed panel of presenters:

- Laurel Gabard-Durnam, *Northeastern University College of Science*
- Ellen Grant, *Harvard Medical School*
- Jonathan O'Muircheartaigh, *King's College London*
- Lindsay Powell, *University of California, San Diego*
- Katherine Cole, *National Institute on Drug Abuse*

18:30 – 19:30 **Presidential Reception**

20:30 – Onwards **FIT'NG Trainee Committee Social Event**

THURSDAY SEPTEMBER 26, 2024

08:30 – 10:00 **Session 3 - Methods Development**

Chairs: Lilla Zöllei, *Massachusetts General Hospital*
Áine Dineen, *Trinity College Dublin*

Bedside, dynamic and high spatial resolution assessment of neonatal brain connectivity using functional ultrasound imaging
Charlie Demene, *Institute Physics for Medicine Paris*

Surface-based Bayesian modeling improves individual-level functional network characterization during early brain development
Diego Derman, *Indiana University*

Normative fetal growth trajectories of eleven brain structures in the second trimester measured automatically from ultrasound volumes
Madeleine Wyburd, *University Oxford*

7T fMRI characterisation of depth dependent hemodynamics in the neonatal somatosensory cortex
Jucha Willers Moore, *King's College London*

10:00 – 10:30 **Break**

10:30 – 12:00 **Think Tank: Elephants in the room for developmental neuroimaging**

Join us for small group discussions led by faculty in the field!

- Harmonizing FIT Cohorts Across Different Contexts to Conduct Larger Scale Analyses (Laurel Gabard-Durnam & Emma Margolis)
- Studying Language Development from Different Neuroimaging Perspectives (Kelly Vaughn & Halie Olson)
- Deep Learning as a Model of Brain Development (Laurie Bayet & Áine Travers Dineen)
- Using FIT Neuroimaging to Investigate Neurodevelopmental Disorders (Nadege Roche-Labarbe & Haerin Chung)
- Multimodal imaging in FIT: What Works and What Doesn't? (Jerod Rasmussen & Juliette Champaud)
- Bridging the Gap: Translating Neuroimaging Insights into Medical Practice (Tomoki Arichi & Paige Nelson)

12:00 – 13:30 **Lunch on own**

13:30 – 15:00 **Session 4 - Sensitive periods & brain plasticity**

Chairs: Dustin Scheinost, *Yale University*
Marta Korom, *National Institute of Mental Health*

Developmental connectome from fetal stage to toddlerhood
Minhui Ouyang, *Children's Hospital of Philadelphia*

Prenatal environment is associated with the pace of cortical network development over the first three years of life
Ursula Tooley, *Washington University in St. Louis*

Relationship between microstructural and functional connectivity during the preterm period
Andrea Gondova, *Université Paris Cité*

The building blocks of vision: Cortical and subcortical organization of the newborn visual system
Vladislav Ayzenberg, *University of Pennsylvania*

15:00 – 15:25 **Flash Talks 2**

Chairs: Tomoki Arichi, *King's College London*
Juliette Champaud, *King's College London*

Exploring the relationship between Brain Functional and Structural Changes in Prematurity: an EEG-MRI study (WIP)
Aline Gonzalez, *INSERM*

Ultra-high field quantitative susceptibility mapping of the neonatal brain
Chiara Casella, *King's College London*

Aperiodic EEG activity in early childhood is associated with temperament, socioemotional functioning, and maternal psychopathology
Dashiell Sacks, *Harvard Medical School/Boston Children's Hospital*

Improving precision with ultra-high field functional MRI in infants
Julia Moser, *University of Minnesota*

Is tactile sensory processing regulation in preterm neonates an early determinant of neurodevelopmental outcomes at age 2 years (WIP)
Victoria Dumont, *University of Caen Normandy*

15:25 – 17:00 **Poster Session 2**

17:00 – 18:30 **Session 5 - Adversity and Brain Development**

Chairs: Ka I. Ip, *University of Minnesota*
Emma Margolis, *Northeastern University*

Assessing stress and adversity in early life
Kathryn Humphreys, *Vanderbilt University*

Abnormal fetal cortical areal expansion is predictive of 2-year neurodevelopmental outcome in Congenital Heart Disease
Sian Wilson, *Harvard Medical School*

Prenatal exposure to adversity and neonatal brain connectivity relate to emerging executive function at age 2 years
Rachel Lean, *Washington University*

Maternal childhood adversity and its association with offspring neonatal white matter development
Anna Constantino-Pettit, *Washington University in St. Louis*

18:30 – 18:45 **FIT'NG Society Updates**

Learn more about the society and the future.

FIT'NG Conference Oral Abstracts

WEDNESDAY, SEPTEMBER 25
SESSION #1: BRAIN AND BEHAVIORAL STATES

Chairs: Lindsey Powell, *University of California, San Diego*
Halie Olson, *Massachusetts Institute of Technology*

INVITED SPEAKER

Developing the sensorimotor system in our sleep: Implications for typical and atypical development

Mark Blumberg, *The University of Iowa*

During active (REM) sleep in mammals, skeletal muscles twitch throughout the body, causing jerky movements of limbs, eyes, and whiskers. These discrete movements are particularly prominent during the perinatal period when active sleep predominates. As demonstrated in newborn rats, the triggering of a twitch is followed by a cascade of sensory feedback (reafference) throughout the sensorimotor system. Twitch-related activity also results in coherent oscillatory activity in cortical and subcortical structures. In addition, the production of twitches by brainstem motor structures gives rise to motor copies that flow to the cerebellum, ultimately yielding predictive information about the sensory consequences of self-generated movement. We are also investigating human infants in the NICU and the lab with an eye toward understanding the links between sleep and neurodevelopmental disorders. Altogether, this work highlights the many ways that sleep provides a critical context for neural activity, ultimately producing a brain that is functionally integrated with its body.

CONTRIBUTED TALKS

O1.1 - Normative EEG growth curves of infant visual neurodevelopment generalize across global cohorts and predict cognitive outcomes

Emma Margolis[1], Chris Camp[2], Ana Sobrino[1], Kirsten Donald[3], Guilherme Polanczyk[4], Khula South Africa Team[3], Brainrise Team[4], 1Kd Eeg Working Group[5],1Kd Machine Learning Working Group[2], Charles Nelson[5], Elizabeth Shephard[4], Dustin Scheinost[2], Laurel Gabard-Durnam[1]

[1]Northeastern University, [2]Yale University, [3]University of Cape Town, [4]University of São Paulo Medical School, [5]Boston Children's Hospital, Harvard Medical School

Summary: We created brain-based growth curves that generalize across countries and predict later cognitive outcomes, demonstrating that tracking brain development with growth curves can help with the early identification of the risk of cognitive impairment and facilitate early intervention across global contexts.

Details: In early life, infants rapidly undergo foundational visual sensitive-period learning. This visual learning and plasticity can be indexed neurally using the visual-evoked potential (VEP) derived from the electroencephalography (EEG) signal. Here, we leverage generalized additive models for location, scale, and shape (GAMLSS) to create longitudinal growth curves of VEP features (i.e., latency and amplitude of the N1, P1, and N2 components) using repeated measures of the VEP (2-3 timepoints) from a multi-national sample (n=695 individuals, 1127 observations) of infants (58 to 518 days old) from South Africa and Brazil. The normative growth curves derived from the Brazil site were externally validated with high accuracy to the South Africa site (mean cross-validation RMSE=8.74 days, r=0.21) [Fig. 1]. The same was true when modeling data on the South Africa site and validating to the Brazil site (mean RMSE=9.33 days, r=0.48). This high external validity across sites from vastly different contexts demonstrates the robustness of this method. We also explore how these visual learning trajectories relate to later developmental and cognitive outcomes as measured by the Global Scales for Early Development (GSED). We derive z-scores for each VEP component latency and amplitude and each timepoint by projecting the data from the South Africa cohort onto the centile growth curves estimated from the Brazil cohort. We sum across these z-scores to create a composite deviation score for each participant. This deviation score was positively associated with GSED scores (r=0.26, p<.05, N=92) at the third timepoint (median age at timepoint=428 days, SD=36.5), demonstrating the VEP's remarkable robustness in predicting cognitive outcomes across disparate populations [Fig. 2A]. We conducted a series of post hoc analyses to determine the most influential features and periods for this association. Latency was a better predictor of GSED than amplitude (rlatency=0.25, ramplitude=0.11) [Fig. 2B]. As expected, the third timepoint was the most associated with GSED scores given these are concurrent measurements, though deviation scores from the first timepoint were better than the second (rT1=0.11, rT2=0.09, rT3=0.19) [Fig. 2C]. We believe that the robustness of the VEP brain growth curves across highly different global contexts and the ability to predict later cognitive outcomes will be useful in global public health contexts to identify infants who may benefit from early intervention.

O1.2 - Multimodal techniques: synchronizing doppler ultrasound and fnirs to understand signals of fetal well-being

Marisa Spann[1], Cristin Holland[1], Xuejun Hao[2], Dustin Scheinost[3], Bin Cheng[4], Saloni Mehta[3], Sanjana Inala[5], Vinus Mahmoodi[1], Vincenzo Lauriola[2], Shely Khaikin[2], Eric Morgan[6]

[1]Columbia University, [2]Columbia University, Vagelos College of Physicians and Surgeons, [3]Yale School of Medicine, [4]Columbia University Irving Medical Center, [5]Columbia University, Vagelos College of Physicians and Surgeons, New York, NY, [6]MindWare Technologies

Summary: This study explored associations between fetal-maternal synchrony in regard to recognition of movement patterns from the fetus.

Details: Introduction: Fetal neurobehavior (indexed by fetal motion) has been linked to development of the central nervous system and sleep regulation. Observations of fetal movements, quality and quantity, has provided insights into environmental influences and pregnancy complications such as preterm labor and stillbirth. Therefore, early dyadic interactions between mother and fetus may be

essential to predict birth outcomes. We propose a neurobiological hyperscanning approach to evaluate the dynamic interaction between the maternal-fetal dyad to understand the interrelationship between fetal activity and maternal neural response.

Method: We collected longitudinal assessments of dyadic development and responses in the mother and fetus to determine preliminary associations between fetal neurobehavior and maternal neural response. Seven healthy pregnant women underwent longitudinal fetal ultrasound and maternal functional near-infrared spectroscopy (fNIRS) in the third trimester (n=21 sessions). Fetal motion was acquired using Toitu MT-610 Doppler ultrasound. fNIRS data was acquired using NIRSport2/2.10 comprising 8 sources and 7 detectors (Fig. 1). Analysis of the fNIRS data was conducted using Homer3 and after processing data was converted into oxy- and deoxygenated hemoglobin concentrations. A paired T-test was conducted comparing baseline (no motion) to fetal motion epochs in relation to maternal prefrontal brain activity.

Results/Conclusions: We found a positive correlation between fetal neurobehavioral activity and maternal bilateral prefrontal cortex activity observed within dorso-lateral and -medial regions ($p<0.05$; Fig. 2). Our results suggest that fetal movement is correlated with maternal brain circuitry in the prefrontal region. Heightened prefrontal cortex activation in mothers is positively associated with parenting behaviors, such as maternal sensitivity, care, and responsiveness, as shown in prior postnatal fMRI studies. The preliminary dyadic hyperscanning data may suggest there are patterns of recognition in the maternal brain that could potentially help interpret fetal well-being. This line of research suggests the need for more dyadic research in the fetal period.

O1.3 - Neuromonitoring Cortical Hemodynamics in neonates during Cardiopulmonary bypass surgery using high-density diffuse optical tomography

Sophia Mcmorrow[1], Kelsey King[2], Tessa George[3], Dani Tallchief[3], Abigail Magee[1], Jordan John[1], Neal Joshi[1], Anshuman Sharma[4], Adam Eggebrecht[5]

[1]Washington University in St. Louis, [2]Roosevelt University, [3]Washington University School of Medicine in St. Louis, [4]University of California, San Francisco, [5]Washington University

Summary: Congenital heart disease is associated with brain injuries and neurodevelopmental deficits. Reparative surgery with cardiopulmonary bypass is a potentially risky period of altered cerebral perfusion, and current bedside neuromonitoring tools face limitations. Thus, there is a need for novel neuroimaging tools with high sensitivity and specificity.

Details: Congenital heart disease (CHD) is associated with neurologic injuries and long-term neurodevelopmental deficits, and it often requires reparative surgery using cardiopulmonary bypass. The perioperative period is a potentially risky period of altered cerebral perfusion due to anesthesia, cardiopulmonary bypass, or other surgical factors. Despite these risks, current neuroimaging tools (e.g., near-infrared spectroscopy, electroencephalography) lack sensitivity and specificity to detect early signs of brain injury during surgery. Therefore, it is crucial to develop novel bedside neuromonitoring tools with high sensitivity and specificity for early detection of brain injury, with the ultimate goal of promoting early interventions and improving neurodevelopmental outcomes. Herein, we present high-density diffuse optical tomography (HD-DOT) for safe, non-invasive bedside neuroimaging with image quality comparable to functional magnetic resonance imaging. Specifically, we assess the feasibility of HD-DOT for bedside assessment of functional connectivity during cardiopulmonary bypass surgery.

Data were collected during surgical procedures using an HD-DOT system optimized for infants. High-quality data were identified for further analyses, and patient-specific facial landmarks and an age-appropriate anatomical atlas were used to model light propagation and depth sensitivity of the HD-DOT array. The HD-DOT field of view was intersected with the Gordon parcellation, and HD-DOT data was bandpass filtered (0.009-0.08 Hz) for functional connectivity analysis.

We present example results for one neonatal patient that underwent cardiopulmonary bypass surgery to repair the aortic arch, a septal defect, and a ventricular defect. Preliminary functional connectivity analysis relative to a parcel in the motor cortex and visual cortex reveal disruptions in spatial correlation during cardiopulmonary bypass.

We establish the feasibility of HD-DOT for bedside neuromonitoring during cardiopulmonary bypass, a valuable step towards understanding brain health in the perioperative period and promoting early identification of potential brain injury. Future analyses will quantify changes in functional connectivity across the surgery period, investigate spatial-temporal variation in cerebral oxygenation, and relate HD-DOT data to physiological parameters and outcomes.

SESSION 2: EARLY COGNITIVE DEVELOPMENT

Chairs: Nadege Roche-Labarbe, *University of Caen Normand*
Paige Nelson, *University of Iowa*

INVITED SPEAKER

Dynamics of learning and prediction in the infant brain

Lauren Emberson, *University of British Columbia*

In the mid-20th century, researchers reported that infants reduce their responses to repeated stimuli. This simple type of learning, habituation, revolutionized our understanding of early development. Today, we have a long list of types of learning that infants can do, and infants not only learn but they also use what they have learned to predict upcoming stimuli. Moreover, learning and prediction are very important in how an infant's early experiences shape their neural and behavioural development. Yet, we still know very little about the neural basis of learning in infancy. In this talk, Professor Emberson will present a series of studies investigating the dynamics of learning and prediction in the infant brain. These studies use functional near-infrared spectroscopy (fNIRS) which allows for both localized recordings of hemodynamic responses while infants are comfortably seated with a parent and engaging with learning experiences. Findings of infants at both low and high-likelihood of experiencing developmental challenges due to premature birth and

families with a range of socioeconomic status will be included. This series of studies will show that, when experiencing simple learning paradigms, infants rapidly and dynamically change their neural responses. These studies will also show that learning and prediction are not one thing in the infant brain with many regions working together to support learning and prediction. Research also shows that infants at high-likelihood of experiencing developmental challenges due to premature birth exhibit strong resilience in their learning abilities yet differences in the neural mechanisms engaged.

CONTRIBUTED TALKS

O2.1 - Neural indicators of visual attention in toddlers born prematurely

Haley Laughlin[1], Livia Merrill[1], Johanna Bick[1], Kelly Barry[1]

[1]*University of Houston*

Summary: More children than ever are surviving premature birth, however, that means a larger number of children are at risk for cognitive delays. Thus, this study aims to examine brain activation patterns of visual attention in premature toddlers to elucidate potential neural developmental mechanisms that may contribute to future cognitive risk.

Details: Each year, approximately 14 million babies are born prematurely worldwide, putting them at risk for a variety of developmental delays across the lifespan. Premature children commonly experience cognitive deficits, which have been associated with future academic delays and socioemotional problems. Recent technological advances have increased premature infant survival rates, resulting in a larger number of children developing neurocognitive delays (Ohuma et al., 2023; Perin et al., 2022). However, little is known about how prematurity disrupts the neural networks subserving foundational attentional processes that support higher-level functioning. Thus, the primary goal of this study will be to investigate the neural basis of visual attention development in toddlers born prematurely to better understand behavioral risk. We will assess the brain activity of premature toddlers, aged 15 to 30 months, while they engage in a visual attention task. Specifically, we will measure alpha and theta frequency bands using EEG. Previous research has shown these frequencies are linked to attention (Xie et al., 2018). Furthermore, we'll employ source localization techniques to map EEG signals to precise cortical regions. This approach enhances understanding of the premature brain's visual attention system offering both temporal and spatial precision. This study has two aims: 1) examine the variability of neural activity of sustained attention as a function of prematurity, 2) determine whether neural signatures of sustained attention predict behavioral risk. We hypothesize that toddlers with the earliest gestational ages will show more immature neural patterns of attention, as indicated by less effective modulation across visual attention and baseline conditions and have less cortical localization, indicating less developed spatial organization.
We hypothesize that effects from aim 1 will map on to behavioral risk. We have a current sample of 65 toddlers. Our plan for data analysis will be as follows: Aim 1: we will use ANCOVA models to examine theta and alpha power with GA as the predictor. Aim 2: we will use linear regression models to test whether alpha and theta power can predict behavioral risk. Risk will be indicated by measures of vigilance during free play, and sustained attention abilities reported by the parent in the BRIEF. This study has potential to identify early neural abnormalities of visual attention in premature toddlers, informing intervention strategies to mitigate future delays.

O2.2 - Foundations of emotion development: Neural and caregiver mechanisms supporting real-world emotion-perception and emotion-related interactions in the first 2 years of life

Ruohan Xia[1], Zoe Pestana[1], Aditi Hosangadi[1], Serena Mon[2], Olufemi Shakuur Nyabingi[3], Lindsay Bowman[1], Tahl Frenkel[4]

[1]*University of California, Davis,* [2]*Northwestern University,* [3]*University of California - Davis,* [4]*Reichman University*

Summary: Emotion perception is key to successful social interactions, and existing methods examining infants' emotion perception neural correlates lack ecological validity. We use event-related EEG to explore infants' neural responses to emotional events during naturalistic mother-infant dyadic interactions in a large-scale longitudinal study.

Details: The ability to perceive and interpret emotions is central to healthy human functioning. However, there is a gap in our understanding of how foundational emotion-perception abilities develop, and what contributes to critical individual differences in emotion perception and interpretation. There are changes in the neural circuitry supporting infants' emotion perception over the first year of life (Leppanen & Nelson, 2009), and theory states this neural circuitry may be 'wired up' during interactions with caregivers (Tan et al., 2020), and influenced by caregivers' own emotional characteristics (Morris et al., 2007). However, the role of caregivers and their emotional characteristics in shaping infants' neural correlates of emotion perception is little explored or understood. Moreover, no study has examined how the brain supports infants' perception of different emotions within the naturalistic, real-world interactions in which it occurs. Existing research therefore lacks ecological validity, and the interactive role of brain and caregiving experience in influencing the development of infants' emotion perception remain unclear. The current project addresses these limitations in a large-scale longitudinal study of mothers and their infants at ages 4, 12, and 24 months (current N = 68 4-months; 45 12-months; 12 24-months; data collection ongoing). Preliminary findings demonstrate: 1) infants have distinct neural responses to emotional signals conveyed within naturalistic caregiver-infant interactions (Figure 1); 2) infants and young children's neural responses to emotional signals are influenced by caregivers' own emotional characteristics (Figure 2 ; Xia et al., 2024); and 3) infants neural responses to emotional signals longitudinally predict how they perceive, interpret, and respond to emotional information including as manifest in prosocial, empathic, and anxious tendencies in childhood (Figure 3). These novel findings provide important initial support for our hypotheses that critical individual differences in emotion development are predicted by neural activity patterns supporting foundational emotion-perception abilities in the first year of life, which are themselves wired up in the early caregiver-infant interactions in which different emotional signals are conveyed.

O2.3 - Neural indices of auditory statistical learning in infancy associated with concurrent language skills at 24-months in a sample of South African infants

Sarah Mccormick[1], Tess Allegra Forest[2], Lauren Davel[3], Michal Zieff[3], Khula South Africa Data Collection Team[3], Kirsten Donald[3], Laurel Gabard-Durnam[1]

[1]*Northeastern University,* [2]*Columbia University,* [3]*University of Cape Town*

Summary: The goal of the current study is to examine whether infants' show neural sensitivity to predictable information during

auditory statistical learning, and if these neural indices relate to future or concurrent language development measures at 24-months of age.

Details: Statistical learning is a robust mechanism that allows infants to find structure and meaning within complex sensory input (Saffran & Kirkham, 2018), and is thought to support many aspects of language development (e.g., word segmentation). Previous work has demonstrated that 24-month-old children show neural signatures of tracking statistical probabilities in continuous auditory input (Pierce et al., 2021), but we know little about how this process is reflected in the brain longitudinally, or how it relates to emerging language skills.

Study participants are infants (N = 198) drawn from a larger longitudinal study on infant development in Cape Town, South Africa. At 6-months and 24-months of age, event-related potentials (ERPs) from high-density EEG data were recorded while infants listened to a continuous stream of tri-tone "words" in which, for each word, Tone 1 always predicted Tone 2 which always predicted Tone 3, but in which different tri-tone words appeared randomly. At 24-months, infants also heard a testing condition while ERPs were still recorded where the tones were shuffled to present new tri-tone words with the same transitional probability. At 24-months of age, children completed the Bayley Scales of Infant Development IV to assess receptive and expressive language skills.

Consistent with prior work, we find that at 24-months of age, the amplitude of the P2 component of the ERP waveform is larger in response to word final tones (M = 4.32 uV) compared to word onset tones (M = 4.04 uV), ($F(1,197) = 6.58$, $p = .011$). The latency of the P2 at 24-months to word final tones in the testing condition was correlated with receptive language scores on the Bayley ($r = .218$, $p = .007$), suggesting that faster processing of predictable tones when the task structure changes might indicate more efficient tracking of statistical probabilities in stimuli that are in turn associated with higher receptive language skills. No associations between 6-month ERP scores and 24-month Bayley scores were observed. Results suggest that infant tracking of auditory statistical regularities is evident on a neural level and that neural indices of statistical learning in infancy are associated with concurrent language skills. Additional results will be discussed.

KEYNOTE TALK

Can Innovations in Imaging Enhance Perinatal Care?

Ellen Grant, *Harvard Medical School*

This talk will discuss strategies for image acquisition and analysis that could potentially enhance the clinical management of fetuses and infants. Discussions will delve into the interplay between placental function and fetal brain development alongside the repercussions of hypoxic stress. Moreover, the talk will highlight the burgeoning role of artificial intelligence (AI) in advancing fetal anomaly detection and characterizing fetal neuromotor development. Illustrations will be provided on how multimodal approaches can refine neonatal outcome prediction in hypoxic-ischemic encephalopathy (HIE), as well as the complexities encountered in AI applications for neonatal MRI-based outcome prediction in HIE. Additionally, the significance of large public datasets will be underscored, showcasing how AI-driven brain age estimation, developed using such datasets, holds promise in identifying potential modifiable risk factors for disease.

THURSDAY SEPTEMBER 26, 2024

SESSION 3: METHODS DEVELOPMENT

Chairs: Lilla Zöllei, *Massachusetts General Hospital*
Áine Dineen, *Trinity College Dublin*

INVITED SPEAKER

Bedside, Dynamic and High Spatial Resolution Assessment of Neonatal Brain Connectivity Using Functional Ultrasound Imaging

Charlie Demene, *Institute Physics for Medicine Paris*

Neonatologists have long been interested in functional brain monitoring, as reversible functional losses often precedes the observable irreversible structural insults. The lack of currently available clinical tools prevents both early diagnostic and prognostic, but also brain status monitoring during treatment. By characterizing neonatal functional cerebral networks, resting-state functional connectivity is envisioned to provide early markers of cognitive impairments and achieve this role. Here we present a pioneering deep brain resting-state functional connectivity imaging on human neonates using functional ultrasound (fUS). fUS is based on ultrafast Doppler, an ultrasound imaging technique acquiring thousands of images per second and extremely sensitive to small blood flows, the contrast being proportional to CBV. It offers in depth imaging, portability, a 250µm spatial resolution and <1s temporal resolution, making it unique in the landscape of neonatal brain imaging. Using a micro-motorized and miniaturized probe facing the anterior fontanel, it enables to acquire 3D images of the neonate's brain that can be co-registered with an MRI neonate atlas.

Connectivity analysis using signal correlation between cerebral regions enabled to assess interhemispheric connectivity in very preterm newborns at an early stage where only few connectivity data exist. Furthermore, fUS high spatial resolution enabled to build fine-grain homotopic connectivity maps, based on correlations between mirror pixels, which revealed underlying structures, such as the white/grey matter boundary in the cortex. It also revealed thalamic substructures that correlate either with ipsi-lateral cortex or contralateral thalamic nuclei, when those data are generally concealed by other functional imaging modalities (fMRI). Finally, resting-state connectivity could be assessed dynamically showing a significant occurrence decrease of thalamo-cortical networks for very preterm neonates (N=6) as compared to control term newborns (N=4), a subtle difference that would have staid concealed with a more classical static connectivity analysis. The same method also showed abnormal patterns in a congenital seizure disorder case compared with the control group.

We are now taking this research to another level with a small clinical trial including >70 neonates (term and preterm) starting summer 2024, to prove feasibility at more diverse gestational ages and post-natal ages and to study the emergence of functional networks in the early days of life. We hope that in the future fUS will help to quickly identify in a quantitative manner atypical connectivity patterns at bedside, to manage patients with abnormal neuro-developmental trajectories better and earlier

CONTRIBUTED TALKS

O3.1 - Surface-based Bayesian modeling improves individual-level functional network characterization during early brain development

Diego Derman[1], Silvina Ferradal[1]

[1]*Indiana University*

Summary: It is essential to develop precision imaging strategies for accurately mapping the individual functional connectome in neonates to better understand typical and atypical trajectories during early brain development.

Details: Introduction 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: fMRI data from 391 neonates (age at scan: 29.3 – 44.9 weeks PMA) was used for this analysis. Using fMRI data from the minimally preprocessed dHCP pipeline, additional preprocessing involved frame censoring to reduce motion, fMRI projection onto an individual cortical surface, and registration to a cohort-specific surface atlas. Eight RSNs were identified after performing group Independent Component Analysis (ICA) on a subset of 24 subjects. The proposed Bayesian framework requires an empirical population prior, which was built from dual regression estimates using a subset of 36 subjects sampled uniformly across the entire cohort. Finally, individual RSN maps were obtained using the Bayesian approach as a compromise between individual fMRI data and the population priors. After defining individual masks of significant activity for each RSN, connectivity strength was calculated for each subject.

Results: We estimated individual-level maps for eight networks and individual functional parcellation maps that revealed topographical differences across subjects (Fig. 1). We found a significant relationship between age and mean connectivity strength in all RSNs, including significant differences between preterm and term-born infants. The development of the DMN is particularly noteworthy, as the frontal and temporal clusters are seen developing within this time frame. This is quantitatively reinforced by the steeper slope of the DMN maturation curve (Fig. 2).

Conclusion: This work details the maturation trajectories of RSNs profiles during early brain development. It demonstrates the potential advantages of surface-based methods and statistical approaches in uncovering individual variability within very young populations.

O3.2 - Normative fetal growth trajectories of eleven brain structures in the second trimester measured automatically from ultrasound volumes

Madeleine Wyburd[1], The Intergrowth Consortium[2], Ana Namburete[1]

[1]*University of Oxford,* [2]*Nuffield Department of Women's & Reproductive Health, University of Oxford*

Summary: Regional brain volume provides crucial insight into fetal development; however, current analysis pipelines are isolated to MRI. In this abstract, we propose a fully automated method to segment 11 brain structures from ultrasound and apply it to a large cohort to produce the first normative growth trajectories derived from ultrasound.

Details: With recent advances in fetal Magnetic Resonance Imaging (MRI), abnormal regional fetal brain volume is commonly associated with at-risk pregnancies, suggesting that structural volume could serve as a biomarker. Current methods for studying the 3D growth of brain tissues are limited to MRI and are not directly applicable to ultrasound, the modality of choice in prenatal care, due to significant domain differences. In this abstract, we propose a fully automated method to segment 11 brain structures from ultrasound volumes and apply it to a large cohort to produce the first normative fetal brain growth trajectories derived from ultrasound.

Eleven brain regions were labelled on 9 weekly ultrasound atlases between 18 and 26 gestational weeks (GW), as illustrated in Fig 1. The labels were then registered to 643 transabdominal ultrasound volumes that were used to create the atlas through previously learned registration fields. As only the distal hemisphere (the hemisphere furthest from the US probe) is clearly visible in ultrasound, we labelled only this hemisphere in each scan. These labelled volumes were used to train a deep-learning segmentation method, which was then applied to 4,349 unseen volumes, from 2,906 typically developing fetuses collected as part of the INTERGROWTH-21st study. An example segmentation is depicted in Fig. 2. The volume measurement of each structure from each scan was then computed.

The trained network segmented each volume into 11 tissues in less than 1 second. Figure 3 displays the growth trajectories of each structure across the second trimester, with a fitted polynomial estimated through polynomial regression. The volume of each structure notably increases with gestational age, except for the choroid plexus. The volume measurements were found to be in a comparable range to previous MRI studies (Studholme, 2020; Uus, 2023).

In summary, we have developed an automated segmentation method that parcellates ultrasound scans into 11 anatomical regions in less than 1 second per scan. By applying this method to a large dataset, we generated normative growth curves for each structure across the second trimester. The development of this automatic pipeline, paired with the reference growth trajectories, could enable future studies to use ultrasound to investigate differences in cohorts and identify potential biomarkers for at-risk pregnancies.

O3.3 - 7T fMRI characterisation of depth dependent hemodynamics in the neonatal somatosensory cortex

Jucha Willers Moore[1], Elisabeth Pickles[1], Philippa Bridgen[1], Pierluigi Di Cio[1], Alena Uus[1], Ines Tomazinho[1], Beya Bonse[1], Maria Deprez[1], Sharon L Giles[1], A David Edwards[1], Jo V Hajnal[1], Shaihan Malik[1], Tomoki Arichi[1], Jonathan Polimeni[2]

[1]King's College London, [2]Harvard Medical School

Summary: Brain activity is often studied by sampling the associated hemodynamic response. Using 7T fMRI, the cortical depth-specific features of responses can be studied, adding insight into circuitry and physiology. Here we use this approach to understand how these depth features vary and evolve in neonates, at a time when the cortex is rapidly maturing.

Details: Neuronal activity, neurovascular coupling (NVC) and vascular dynamics undergo rapid maturation in the perinatal period [1, 2, 3], resulting in different hemodynamic responses to neuronal activity from the adult response [4]. It is thus unclear if depth-dependent hemodynamic response features, seen with 7T fMRI in the mature cortex relating to the intracortical vascular hierarchy [5], can be generalised to neonates. To address this, we developed a platform for high-resolution 7T fMRI studies in neonates and performed a cortical-depth dependent analysis of BOLD responses in primary somatosensory cortex (S1).

Ethics committee approval and parental consent was provided for data collection. GRE-EPI BOLD fMRI data (Table 1) were acquired from 11 infants in natural sleep and 2 adults (Table 2) using a Siemens 7T system. Sensorimotor stimulation (on/off blocks of 26.6 s) was elicited with a custom robotic device [6] (Fig. 1). The hand area in S1 was split into three depths (Fig. 2C) using LAYNII [7], and depth-specific BOLD timeseries extracted.

Significant activation was identified in the contralateral hand area of S1 in response to sensorimotor stimulation (Fig. 2A, B). Cortical depth dependent differences in BOLD amplitude were evident in both adults and neonates, with the largest differences across depths seen in early term infants (Fig. 2D). The neonatal BOLD trial-averaged response has delayed onset and was temporally dispersed compared with the adults (Fig. 2E). Peak amplitude in the middle and deep cortical depths increased with development and the BOLD post-stimulus undershoot emerged in term aged infants. The latter was associated with a prominent downward response slope following the positive peak.

We present the first evidence of differing hemodynamic responses across cortical depths in the neonatal brain, which differ markedly than those in adults. This may reflect developmental differences in the vasculature, physiology, NVC and cortical circuitry. Increased functional contrast-to-noise ratio at 7T [8] provides a unique opportunity for detailed in vivo studies of activity related hemodynamics in the critical perinatal period. These results have implications for understanding the aforementioned factors, their relationship to the BOLD signal, and how the human cortex first develops.

1 Harris et al 2011; 2 Kozberg et al 2016; 3 Norman et al 1986; 4 Arichi et al 2012; 5 Siero et al 2013; 6 Allievi et al 2013; 7 Huber et al 2021; 8 Viessmann et al 2021

SESSION 4: EARLY NETWORK DEVELOPMENT

Chairs: Dustin Scheinost, *Yale University*
Marta Korom, *National Institute of Mental Health*

INVITED SPEAKER

Developmental connectome from fetal stage to toddlerhood

Minhui Ouyang, *Children's Hospital of Philadelphia*

The human brain undergoes rapid structural and functional growth from fetal stage to toddlerhood. Local properties of brain growth have been studied extensively using histological, macro-, micro-structural and functional measures. Studying brain development from a connectomic viewpoint can link the local properties to a brain system or network level. The recent improvements in magnetic resonance imaging (MRI) techniques, especially resting-state functional MRI (rs-fMRI) and diffusion MRI (dMRI) have provided unprecedented opportunities to non-invasively quantify and map the early developmental connectome at whole brain and regional levels. In the functional connectome, maturational gradients are seen from primary to higher-order cognitive functional brain regions with strengthened balances between topological integration and segregation. The structural connectome is generally considered to be coupled with the functional connectome, with maturation in infancy proceeding from a relatively random network to a well-organized network. Despite exciting progress, several challenges remain, such as consistency of network construction across studies. Characterization of the developmental connectome in the healthy brain is crucial as it sets the stage for understanding aberrant connectome in pathological populations.

CONTRIBUTED TALKS

O4.1 - Prenatal environment is associated with the pace of cortical network development over the first three years of life

Ursula Tooley[1], Aidan Latham[1], Jeanette Kenley[1], Dimitrios Alexopoulos[1], Tara Smyser[1], Ashley Nielsen[1], Lisa Gorham[1], Barbara Warner[1], Joshua Shimony[1], Jeffrey Neil[1], Joan Luby[1], Deanna Barch[1], Cynthia Rogers[1], Christopher Smyser[1]

[1]Washington University in St. Louis

Summary: Environmental influences on brain structure and function have been well characterized, but whether the early environment affects the pace of brain development is not clear. In pre-registered analyses, we investigated associations between prenatal environment and the pace of brain network development, with implications for language and cognition.

Details: Introduction: As children mature, intrinsic cortical networks become more segregated, with sets of brain regions displaying more densely interconnected connectivity and large-scale systems becoming increasingly distinct. Some theoretical models posit that environmental influences on brain development might arise by way of effects on the pace of brain development, such that brain development proceeds faster in neonates and toddlers from lower-SES backgrounds.

Methods: In pre-registered analyses (#128836|AsPredicted), we test whether early socioeconomic status (SES) is associated with differences in the pace of cortical network segregation during the first three years of life. We capitalize on a cohort of neonates and toddlers (n=261, M=41.3 weeks at first scan) with longitudinal fMRI data and extensively characterized early environments, using generalized additive mixed models to examine moderating effects of prenatal SES on development of cortical network segregation. We take a hierarchical approach, first examining measures of network segregation (Fig. 1a-c) at whole brain resolution, then at the level of functional brain systems, and finally in individual brain regions. Lastly, we examine whether differences in cortical network segregation at age two years are associated with language and cognitive abilities.

Results: Cortical network segregation increases with age (Fig. 1d-f), and prenatal SES significantly moderates trajectories of cortical network segregation across scales (Fig. 1g-i). Neonates and toddlers from lower-SES backgrounds show a steeper increase in cortical network segregation with age, consistent with accelerated network development. Effects of prenatal SES are strongest in the somatomotor and dorsal attention systems (Fig. 2a-b) and conform to a sensorimotor-association hierarchy of cortical organization (Fig. 2c). Importantly, SES-associated differences in cortical network segregation are associated with language abilities at age two years, even when controlling for prenatal SES (Fig. 2d-f).

Conclusions: The development of cortical brain networks during the first three years of life is associated with features of the early environment. Being born into a more advantaged (higher SES) environment is associated with a more protracted trajectory of cortical functional network development in early childhood. Importantly, environmental influences on development of cortical network segregation might underlie SES-associated differences in language abilities observed later in development.

O4.2 - Relationship between microstructural and functional connectivity during the preterm period

Andrea Gondova[1], Sara Neumane[2], Tomoki Arichi[3], Jessica Dubois[4]

[1]Université Paris Cité, Inserm, NeuroDiderot; UNIACT, NeuroSpin, CEA, Université Paris-Saclay, [2]Université Paris-Saclay; Centre for Developing Brain, King's College London, [3]King's College London, [4]Université Paris Cité, Inserm, NeuroDiderot; UNIACT, NeuroSpin, CEA, Université Paris-Saclay

Summary: Microstructural measures can inform about cortical cytoarchitecture and maturation. Whilst regional microstructural covariations likely reflect synchronized development[1], their relationships to functional connectivity are little understood. We explore this interplay and highlight specific connection maturational stages in the preterm period.

Details: We studied early microstructural and functional connectivity (MC, FC) using longitudinal anatomical, diffusion, and resting-state functional MRI from the developing Human Connectome Project[2]. 45 preterm (PT) infants without brain lesions (26 males, median gestational age at birth 32.3 weeks, range [25.6w–36.0w]) were scanned: in the preterm period (PT:ses1, median postmenstrual age at scan 34.9 weeks [28.3w–36.9w]) and near term-equivalent age (PT:ses2, 41.3 weeks [38.4w–44.9w]). Covariation of median MC across cortical and subcortical grey matter (GM) regions (Fig1a) was evaluated with metrics from diffusion tensor imaging (DTI)[3] and neurite orientation dispersion and density imaging (NODDI)[4] models. FC was derived as the Pearson's correlation between the mean BOLD timeseries across the same regions.

Our results showed significant MC-FC relationships at both sessions, which decreased with age (Fig1b). We further categorized connections into 4 groups, based on their theoretical maturation progression pattern (from the most to the least mature): cortico-subcortical, inter-hemispheric homotopic and non-homotopic, and intra-hemispheric connections[5,6]. Different subgroups revealed different patterns of MC-FC relationships: while inter-hemispheric non-homotopic and intra-hemispheric groups maintained significant MC-FC relationships across the two sessions, both cortico-subcortical and inter-hemispheric homotopic groups showed decreasing relationships (Fig1c). We hypothesize that these developmental changes in MC-FC relationship reflect relatively mature tissue microstructure contrasting with the still progressing functional specialisation of GM regions and networks[7].

Our work offers a novel perspective on structure-function relationships during early brain development, complementing prior work focusing on white matter and functional connectivity[8]. Further exploration and comparison with white matter connectivity, genetic or evolutionary patterns, extrinsic environmental influences will be needed to further our understanding of microstructural connectivity development and its potential as a biomarker of subsequent neurodevelopmental acquisitions.

[1]Alexander-Bloch, et al., 2013, Nat. Reviews Neurosc. [2]Edwards et al., 2022, Front Neurosc. [3]Basser et al., 1994, J. of MR [4]Zhang et al., 2012, Neuroimage, [5]Kulikova et al., 2015, Brain struc. & funct. [6]Neumane et al., 2022, Front Neurosc. [7]Allievi et al., 2016, Cereb. Cortex [8]van den Heuvel et al., 2015, Cereb. Cortex

O4.3 - The building blocks of vision: Cortical and subcortical organization of the newborn visual system

Vladislav Ayzenberg[1], Michael Arcaro[1]

[1]University of Pennsylvania

Summary: From face perception to visuospatial processing, infants demonstrate sophisticated perceptual abilities from the first days of life. By understanding the anatomical and functional organization of the brain at birth we can gain insights into the mechanisms underlying early developing perceptual and cognitive abilities.

Details By understanding the anatomical and functional organization of the visual system at birth we can gain critical insights into the mechanisms that support early developing perceptual and cognitive abilities. Using resting-state fMRI and diffusion tensor imaging, we examined the cortical and subcortical organization of the visual system in neonates (37-42 weeks gestation). We used an adult probabilistic atlas of retinotopic maps (Wang et al. 2015) to identify putative visual areas in neonates. To achieve this, each neonate's cortical surface was registered to an adult cortical surface template and the adult probabilistic atlas was projected onto each neonate's cortical surface. Functional correlations between cortical areas revealed that the infant visual system exhibits an adult-like hierarchical organization, with distinct clusters for regions of the occipital cortex, as well as ventral, lateral, and dorsal visual pathways. Direct comparisons between neonates and adults revealed that correlation patterns within occipital and dorsal areas were more adult-like than ventral and lateral areas. We then examined the extent to which this cortical organization was mirrored in the maturity of structural

connections between each cortical area and the pulvinar – a subcortical structure that is extensively interconnected with the entire visual cortex in adults and plays a crucial role in visual processing. Probabilistic tractography analyses reliably identified white matter pathways between the pulvinar and each cortical visual area. These connections showed region-level specificity and overlapped with homologous pathways of adults. However, we found developmental differences within the fine-grained connectivity pattern of the pulvinar. Although the coarse connectivity organization for all neonate networks were qualitatively similar to those of adults, the connectivity maps for ventral visual areas were immature and did not show strong specificity within the pulvinar. Altogether, our findings indicate that the large-scale anatomical and functional organization of the visual system is established by birth, but there are developmental differences in the maturity of different pathways with the dorsal pathway maturing earlier than the ventral pathway.

SESSION 5: ADVERSITY AND BRAIN DEVELOPMENT

Chairs: **Ka I. Ip,** ***University of Minnesota***
Emma Margolis, ***Northeastern University***

INVITED SPEAKER

Assessing Stress and Adversity in Early Life

Kathryn Humphreys, *Vanderbilt University*

Understanding the impact of adversity on brain development is a critical area of research in developmental neuroscience. Despite significant advancements, methodological challenges persist, including on how to define and assess adversity in early life. This talk will explore the current state of knowledge regarding adversity's influence on brain development, emphasizing several key methodological issues. These include the reliance on external informants, retrospective reports, lumping together different types of adversity, and consideration of the timing of exposure. Further, approaches to counter prior limitations will be discussed. This includes work from my lab, the Stress and Early Adversity (SEA) lab, which has embarked on a longitudinal project aimed at refining our approach to studying adversity and brain development. This project involves scanning infants at 1, 6, and 12 months of age to capture the dynamic nature of brain development in response to early adversity. By focusing on these early developmental stages, we hope to overcome some of the limitations associated with retrospective reporting and better account for the timing and type of adversity. This presentation will provide progress on this ongoing study, sharing preliminary findings from our first three years of data collection. We will discuss how these findings inform our understanding of the neurobiological impacts of different types of adversity and propose potential paths forward for the field.

CONTRIBUTED TALKS

O5.1 - Abnormal fetal cortical areal expansion is predictive of 2-year neurodevelopmental outcome in Congenital Heart Disease

Sian Wilson[1], Hyukjin Yun[2], Anjali Sadhwani[1], Henry Feldman[3], Seungyoon Jong[3], Kaysi Herrera Pujols[1], Jane Newburger[3], P. Ellen Grant[1], Caitlin K. Rollins[1], Kiho Im[1]

[1]Harvard Medical School, [2]Harvard University, [3]Boston Children's Hospital

Summary: Neurodevelopmental deficits rank among the most common complications faced by individuals with Congenital Heart Disease (CHD). The neurodevelopmental impairment observed in children with CHD is thought to have in utero origins.

Details: Introduction: Volumetric brain abnormalities have been observed in CHD in utero, but fetal cortical development in CHD is not well characterised. We use longitudinal fetal MRI to normatively model growth trajectories of surface features in 30 gyral regions over the late second to third trimester, estimating the deviance of each CHD fetus on the growth curve at two time points. We use linear regression to show that greater deviations from normative growth in utero are associated with worse neurodevelopmental (ND) outcome at 2 years old.

Methods: 292 in utero 3T T2-weighted brain MRI scans (20 – 39 weeks Gestational Age (GA)) were obtained (CHD = 135, Controls = 157). 76 participants were scanned twice, before and after 30 weeks GA. We segmented the brain, extracting the inner cortical plate boundary to reconstruct the surface. We aligned meshes to a 31 GA template, then parcellated the surface into 30 gyral regions, calculating the average sulcal depth, mean curvature and surface area in each region. We use Gaussian Process Regression to normatively model surface metrics in the Controls, estimating a continuous standard error of the mean with GA. We calculated Z-scores for each fetus, representing the deviation from the mean for a given metric, accounting for GA and sex. We compared z-score distributions between Scan 1 and Scan 2, and between CHD and Controls using a Kruskal-Wallis test (Figure 1E), subtracting the difference between z-score means (Figure 1F). We fit general linear models to examine the effect of CHD and fetal GA on the relationship between z-scores and ND outcome at 2 years old.

Results: Prior to 30 GA, CHD fetuses follow the normal growth trajectory. Cortical areal expansion in fetuses with CHD deviates from the normative trajectory in the late third trimester, after 30 GA: 13 cortical regions were significantly reduced for surface area (Figure 1); 2 for sulcal depth and 0 for curvature. Similarly, lower z-scores after 30 GW are correlated with worse Bayley standard scores in CHD fetuses, but not in healthy controls (Figure 2).

Conclusion: Areal expansion is reduced in certain regions in CHD, but depth and curvature largely follow the normative growth trajectory, suggesting that despite cardiovascular impairment, the mechanisms governing gyrification are operational. Our results support that increased metabolic demands of the third trimester perturb structural brain growth in CHD, manifesting as neurodevelopmental abnormalities at 2 years old.

O5.2 - Maternal childhood adversity and it's association with offspring neonatal white matter development

Anna Constantino-Pettit[1], Berenice Anaya[1], George Slavich[2], Rachel Lean[3], Barbara Warner[1], Joan Luby[1], Christopher Smyser[1], Deanna Barch[3], Cynthia Rogers[1]

[1]Washington University in St. Louis, [2]University of California, Los Angeles, [3]Washington University

Summary: Adversity can "get under the skin" and span generations; evidence of this intergenerational transfer has relied on studies of observable characteristics (e.g., psychopathology) rather than biological mechanisms. This project examined differences in neonatal structural connectivity associated with their mothers' childhood adversity.

Details: Objective: Many studies have identified associations between maternal childhood adversity (MCA) and offspring early childhood psychopathology; however, few have examined the potential biological pathways underlying these effects. Prior studies have found associations with other significant prenatal environmental exposures - namely, social disadvantage - with differences in neonatal structural connectivity serving structures implicated in emotion development. However, these findings have not assessed significant early environmental exposures, such as MCA, that may affect the prenatal environment. We investigated whether MCA is related to differences in neonatal structural connectivity while accounting for concurrent prenatal environmental influences (in this case, social disadvantage).

Methods: Data (N = 272 mother-child dyads) were derived from the Early Life Adversity, Biological Embedding, and Risk for Developmental Precursors of Mental Disorders (eLABE) study. MCT was measured using the early childhood adversity derived variable from the Stress and Adversity Inventory (STRAIN), administered during the prenatal period. Structural connectivity among term-born, healthy neonates was interrogated using probabilistic tractography of tracts of interest (uncinate, cingulum bundle, and fornix; corups callossum and corticospinal tract control tracts). Covariates included: infant postmenstrual age at scan, prenatal social disadvantage, and maternal adulthood adversity. Prenatal depression was considered as a covariate but was not correlated with the neonatal tracts, so was not included in the final models. Generalized additive models (GAMs) were used to accommodate non-linear relationships, with each tract serving as its own dependent variable in a separate model.

Results: MCA was positively related to differences in neonatal right and left uncinate mean diffusivity (edf=1, F=11.13, p<.001 and edf=1.92, F=3.57, p=.02, respectively) and negatively related to differences in right fornix mean diffusivity (edf=1, F=5.49, p=.02). All results were subjected Bonferroni correction for multiple comparisons and cross-validated via bootstrapping.

Conclusions: MCA was associated with variation in multiple neonatal white matter tracts that support the development of emotion regulation and processing. Differences may represent a substrate by which MCA is biologically embedded and transgenerationally transmitted in offspring

O5.3 - Prenatal exposure to adversity and neonatal brain connectivity relate to emerging executive function at age 2 years

Rachel Lean[1], Jeanette Kenley[2], Aidan Latham[2], Tara Smyser[2], Jeffrey Neil[2], Ashley Nielsen[2], Chad Sylvester[1], J. Philip Miller[3], Joshua Shimony[2], Joan Luby[1], Deanna Barch[1], Barbara Warner[2], Christopher Smyser[2], Cynthia Rogers[2]

[1]Washington University, [2]Washington University in St. Louis, [3]Washington University School of Medicine

Summary: The prenatal period is a window of vulnerability when the fetal brain is highly sensitive to adversity. The implications for developmental outcome, including transdiagnostic risk factors for psychopathology, are less clear. Findings may inform the neural mechanisms of adversity and identify infants who may benefit the most from early intervention.

Details: Childhood exposure to adversity alters brain connectivity in higher-order networks that subserve executive function (EF), impairments in which are a major risk factor for psychopathology. The extent that alterations in neonatal structural and functional brain connectivity represent a putative neurobiological pathway by which prenatal adversity relates to delays in emerging EF is unclear. This longitudinal study focuses on 164 infants who were recruited prenatally and over-sampled for low socio-economic background. Maternal Social Disadvantage (SD; family and neighborhood socio-economic factors) and Psychosocial Stress (PS; depression, anxiety, life stress) was assessed throughout pregnancy. Offspring then underwent diffusion and resting state functional connectivity MRI scans in the first weeks of life. Published work in this cohort has related prenatal adversity to altered neonatal white matter microstructure. At age 2 years, children completed the Minnesota Executive Function Scale task, a dimensional sorting task measuring shifting/flexibility. Results showed that prenatal exposure to SD (PSD) but not maternal PS, related to delays in emerging EF at age 2. Lower neonatal fractional anisotropy and higher mean diffusivity in the corpus callosum, inferior fronto-occipital fasciculus, uncinate and corticospinal tract also related to poorer EF outcome. White matter results persisted after adjustment for PSD and maternal and child intellectual ability, and multiple comparison correction. Moderation analysis showed that there was no interaction between PSD and neonatal white matter microstructure on EF outcome. Additionally, neonatal white matter did not mediate the association between PSD and EF. Although stronger cingulo-opercular--fronto-parietal and weaker (more anti-correlated) ventral attention--somatomotor network functional connectivity correlated with poorer EF outcome, these results did not pass multiple comparison correction. Findings highlight that in this socially-diverse cohort of infants enriched for adversity, aberrant neonatal white matter microstructure was associated with early delays in emerging EF regardless of the level of PSD. While PSD relates to both neonatal white matter microstructure and EF outcome, aberrant white matter microstructure did not attenuate PSD-EF associations. Ongoing PSD-related alterations in postnatal white matter development may emerge as a more salient mechanism linking PSD with EF problems later in development.

FIT'NG Flash Talk Abstracts

FLASH TALK SESSION 1

WEDNESDAY SEPTEMBER 25, 2024

P1-D-15 - Dorso-medial prefrontal cortex responses to social smiles predict sociability in infancy

Olivia Allison[1], Tobias Grossmann[1]

[1]University of Virginia

Summary: How is variability in brain function linked to individual differences in social behavior? Using functional near-infrared spectroscopy (fNIRS), we examined whether brain responses in the dorso-medial prefrontal cortex (dmPFC) to viewing social smiles at 11 months predict sociability at 18 months.

Details: The dorso-medial prefrontal cortex (dmPFC) plays a vital role in social cognition and behavior among humans. However, to date, little is known about what role the dmPFC plays in guiding overt social behavior during early development. The current longitudinal study examined the association between dmPFC responses and sociability in early development. Based on prior work with adults, linking dmPFC to sociability (Powers et al., 2016) and with infants, linking dmPFC to sensitivity to social gaze (Grossmann, 2017), we hypothesized that dmPFC responses longitudinally predict sociability levels, with greater dmPFC responses to direct gaze-social smiles (friendly individuals) being positively predictive of heightened levels of sociability. Brain responses were measured in response to social smiles (direct gaze smile minus averted gaze smile) and frowns (direct gaze frown minus averted gaze frown) using functional near-infrared spectroscopy (fNIRS) at 11 months (N= 76 typically developing infants; n= 38 female sex assigned at birth; Mage = 339.94 days, SE = 0.744). Individual differences in sociability were operationalized as behaviors indexing the seeking out of and taking pleasure in social interaction measured by using the Early Childhood Behavior Questionnaire (ECBQ; Putnam et al., 2006) at 18 months (Mage = 555.07 days, SE = 1.448). Our longitudinal results show that greater engagement of the dmPFC when processing social smiles (ß = 0.237, t = 1.999, p = 0.050), but not frowns (ß = 0.031, t = 0.263, p = 0.793), at 11 months predict higher levels of sociability at 18 months. This demonstrates that early variability in dmPFC responses during positive social interactions are linked to later individual differences in overtly displayed social behavior. The current findings further suggest that enhanced dmPFC engagement during social smiles is associated with higher levels of social motivation and reward, considering that higher levels of sociability at 18 months were characterized by greater seeking out of and taking pleasure in interactions with others. Future research should include direct measures of social motivation and reward to better understand the role of dmPFC in the development of sociability.

P1-C-7 - Infants' resting state functional connectivity and ERPs: A multimodal approach to investigating the neural basis of infant novelty detection

Courtney Filippi[1], Dana Kanel[2], Santiago Morales[3], Kathryn Altman[2], John Richards[4], Anderson Winkler[5], Daniel S. Pine[6], Nathan Fox[7]

[1]New York University, Langone, [2]National Institute of Mental Health, [3]University of Southern California, [4]University of South Carolina, [5]The University of Texas Rio Grande Valley, [6]Section on Development and Affective Neuroscience, Emotion and Development Branch, NIMH, [7]University of Maryland, College Park

Summary: By integrating EEG and MRI data, this report provides new insight into the neural generators of infant novelty-detection ERPs and provide new evidence that individual differences in moment-to-moment processing of novelty are related to intrinsic network architecture in infancy. This work has implications for infant learning and development.

Details: Individual differences in how the brain responds to novelty emerge in infancy. Event-related potentials (ERPs) are among the best ways for measuring novelty processing in infancy. However, this method has limited spatial resolution. This study aimed to evaluate the neural basis of novelty detection by combining ERP data with magnetic resonance imaging (MRI) data.

Twenty-nine infants completed both resting-state functional MRI (Mage= 4.73 months) and EEG during a three-stimulus auditory oddball task (Mage= 5.19 months). Resting-state functional connectivity (rs-FC) was computed from functional MRI data. The mismatch response (MMR) and P3 were computed using the MADE pipeline for developmental EEG data (Debnath et al., 2020). Figure 1 depicts standard ERP response. Source localization was conducted by combining EEG and structural MRI data as outlined in Conte & Richards, 2022. Source localized MMR and P3 responses were extracted from five regions-of-interest.

In line with prior work, EEG source localization showed that the bilateral auditory cortices, posterior cingulate cortex, and superior parietal cortex were involved in the generation of MMR and P3 responses (See Figure 2). We next explored the association between source-localized ERP responses and intrinsic network architecture using whole-brain network level analyses of rs-FC (See Wheelock et al, 2021 for methods description). Results demonstrated that a larger MMR (localized to the superior parietal lobule) was associated with greater connectivity within the Somatomotor network and greater Somatomotor - Dorsal Attention Network (DAN) connectivity (See Figure 3). A larger P3 response (localized to the superior parietal lobule) was associated with greater Somatomotor network connectivity and Somatomotor- Ventral Attention Network (VAN) connectivity (See Figure 4).

These results provide new insight into sensory processing and novelty detection. This is the first report of source generators of P3 responses to novel complex auditory stimuli in infancy. This work additionally implicates coordinated activity with the DAN, known for its role in reorienting attention, in the MMR. In contrast, coordinated activity with the VAN, known for its support of later-stage, complex adjustments in attention, related to the later P3.

P1-C-9 - Larger than life: Cartoons drive infant visual cortex more than realistic movies

Tristan Yates[1], Ariadne Letrou[2], Juliana Trach[3], Lillian Behm[3], Sheri Dawoon Choi[3], Cameron Ellis[4], Nicholas Turk-Browne[3]

[1]Columbia University, [2]Princeton University, [3]Yale University, [4]Stanford University

Summary: Infants must make sense of rich and dynamic sensory input. In the auditory domain, they prefer to listen to, and learn better from, exaggerated, infant-directed speech. We explore this sensory exaggeration effect in the visual domain by testing how cartoons enhance the reliability and representational content of activity in infant visual cortex.

Details: The human visual system exhibits sophisticated structure and function even in infancy, including retinotopic organization in early visual areas and category-selective responses in late visual areas. Yet, there is also dramatic perceptual learning early in development and it is unclear how this plasticity alters the selectivity and tuning of infant visual cortex. Infant visual cortex may be optimized to process realistic input, given the structure of the sensory environments in which the human brain evolved and the types of visual input infants experience early in life. Alternatively, developing sensory systems may be especially receptive to exaggerated or simplified features that emphasize diagnostic information, as in the case of infant-directed speech. Here, we evaluate this sensory exaggeration hypothesis by testing whether cartoons elicit stronger and more consistent representations in the human infant visual cortex than realistic movies. We collected fMRI data from 24 infants (4-15 months) while they watched (in a random order) two versions of the same 3-minute movie: 2-D animated cartoon and 3-D realistic computer-generated imagery. These movie formats differed in certain visual features (i.e., color, texture), but were otherwise perfectly matched in semantic content on a frame-by-frame basis, which we verified with a computer vision model. As a baseline, we also collected data from 12 adults for whom we did not expect a benefit for cartoons. We performed intersubject correlation analyses in both infants and adults to assess the reliability of BOLD activity evoked by the two movies. In adults, the visual cortex responded similarly to both cartoon and realistic movies. In contrast, the visual cortex of infants showed stronger and broader intersubject correlation for the cartoon than the realistic movie. Using multivariate pattern similarity, cartoons allowed for better decoding of high-level visual features than realistic movies, including whether a face was present and the spatial scale of the scene. Crucially, these neural differences emerged despite no significant differences across movies in infant behavioral preferences (i.e., the amount of infant data excluded for head motion or looking away). These results suggest that the visual system may be attuned to diagnostic visual features in early development and that cartoons may (unknowingly) capitalize on this neural preference.

P1-E-23 - Intrinsic functional neurocircuitry of the bed nucleus of the stria terminalis in early infancy

Yanbin Niu[1], M. Catalina Camacho[2], Sanjana Ravi[1], Joshua Hageman, Jennifer Blackford[3], Kathryn Humphreys[1]

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

Summary: To address a critical gap in the developmental neuroscience of the BNST, we aimed to characterize: 1) BNST circuitry in early infancy and 2) associations between prenatal stress, BNST connectivity, and infant negative affect (an anxiety risk factor).

Details: Background: Cross-species research has identified the bed nucleus of the stria terminalis (BNST) as a critical neural substrate for anxiety phenotypes. In rodents, the BNST has extensive connections to other limbic regions—including the amygdala, hypothalamus, and hippocampus, playing a critical role in sustained fear states and stress responses. Imaging studies in human adults reveal similar anatomical and functional connectivity, as well as integrative and regulatory functions in emotional and stress-related processes. However, we know little about the BNST's development in early human life.

Method: We collected approximately 10 minutes of low-motion fMRI data from 79 infants aged 2.29-6.86 weeks and aimed to map the whole-brain resting-state connectivity of the BNST. Data were processed using Nibabies and XCP-D, with a framewise displacement (FD) threshold of 0.2 mm and bandpass filtering 0.01-0.1 Hz. Data from 35 infants were excluded due to excessive motion or less than 5 minutes of low-motion data, leaving 44 infants with high quality (mean FD after censoring=0.11 mm) for analysis. Participant level seed-to-voxel correlation maps and the group-level analysis (family-wise error rate<.05) were conducted using Nilearn. For aim 2, maternal levels of stress during pregnancy was obtained using the Perceived Stress Scale. infant negative affect was measured at age 6 months using the Infant Behavior Questionnaire-Short Form and minutes of crying from 32 hours of home recordings. Covariates in analyses included sex, infant age at scan, maternal age, and FD.

Results: We found significant connectivity between the BNST and bilateral amygdala (extent=325 voxels, peak location=[58, 72, 30], FWER p<.05). Greater maternal stress in pregnancy was associated with lower BNST–amygdala connectivity in infants (=-0.48, 95%CI[-0.85, -0.11], p=.013). Higher BNST–amygdala connectivity was associated with less 6-month infant crying (=-0.38 95%CI[-0.74, -0.02], p=.041), but not associated with 6-month parent-reported negative affectivity (=-0.02 95%CI[-0.39, 0.43], p=.920).

Discussion: We found evidence, for the first time, that functional connectivity between the BNST and amygdala is present in early infancy. Our exploratory analyses indicated a potential link between prenatal perceived stress and BNST–amygdala connectivity, and suggests BNST–amygdala connectivity may be relevant for negative affect in later infancy.

FLASH TALK SESSION 2
THURSDAY SEPTEMBER 26, 2024

P2-H-27 - Improving precision with ultra-high field functional MRI in infants

Julia Moser[1], Kimberly Weldon[1], Sooyeon Sung[1], Alireza Sadeghi-Tarakameh[1], Thomas Madison[1], Hannah Pham[1], Jacob Lundquist[1], Edward Auerbach[1], Gregor Adriany[1], Yigitcan Eryaman[1], Steven Nelson[1], Jed Elison[1], Essa Yacoub[1], Damien Fair[1]

[1]University of Minnesota

Summary: Infant brains are small compared to commonly used voxel sizes which leads to a lack of spatial precision in functional MRI data. Ultra-high field imaging (7T) allows for up to 4 times smaller voxels compared to 3T, due to the almost quadratic SNR gains. This opens up new possibilities for precision functional imaging in infants.

Details: Important insight into brain function during early development can be gained from fMRI in infants. However, working with infants faces a number of methodological challenges. Typical voxel sizes encompass larger proportions of brain volume, resulting in reduced spatial specificity of connectivity patterns. Characterization of individual specific functional brain organization requires large amounts of low motion data, which is difficult to acquire in a single session with an infant.

Ultra-high field (7T) imaging can help overcome these challenges, by achieving a level of spatial precision that allows us to uncover details of connectivity patterns that are difficult to resolve with 3T acquisitions, and - as seen in adults - by decreasing the amount of data needed for precision functional mapping. Despite the availability of FDA approved 7T MRI scanners, they are rarely used with infants because the increased field strength requires additional safety considerations. To make 7T acquisition with infants feasible, we developed an in-house system to assess individualized safe operating power limits based on each infant's head volume derived from their anatomical scans at 3T. Here we show initial results from a 7T ME-fMRI acquisition in three healthy full-term infants (seven, five and ten weeks old).

Functional data at 3T was acquired using a four-echo sequence (14ms, 39ms, 64ms, 88ms, TR=1.761s, 2mm3 res) together with T2w and T1w anatomical references. Functional data at 7T was acquired using a three-echo sequence (14ms, 35ms, 57ms, TR=1.768s, 1.6mm3 res). All data acquisitions were performed during natural sleep. We preprocessed data using NORDIC for thermal denoising and an infant specific preprocessing workflow for functional connectivity processing (BIBSnet, Nibabies and XCP-D). Functional connectivity matrices were calculated using low motion data (framewise displacement < 0.3mm) only.

All datasets showed high functional tissue contrast, and direct (within infant) comparison of spatial resolutions at 3T and 7T emphasized the gain in spatial precision and reduced partial voluming. Functional connectivity matrices showed similar correlation patterns between brain regions for data acquired at 3T and 7T with an increase of the absolute magnitude of functional connections in 7T data. Our initial results show that ME-fMRI in infants at 7T is not only feasible but feasible with much higher voxel resolutions, resulting in data with high specificity and sensitivity.

P2-H-30 - Ultra-high field quantitative susceptibility mapping of the neonatal brain

Chiara Casella[1], Katy Vecchiato[1], Ayse Sila Dokumaci[1], Philippa Bridgen[1], Pierluigi Di Cio[1], Beya Bonse[1], Jucha Willers Moore[1], Joseph V Hajnal[1], Sharon L Giles[1], Jan Sedlacik[2], Tom Wilkinson[1], Raphael Tomi-Tricot[1], David W Carmichael[1], Jonathan O'Muircheartaigh[1], Shaihan Malik[1], Tomoki Arichi[1]

[1]King's College London, [2]Great Ormond Street Hospital for Children

Summary: Iron is essential for neurodevelopment yet measuring it non-invasively in infancy is challenging due to low brain iron levels. Because of enhanced SNR, resolution, and susceptibility effects, 7T quantitative susceptibility mapping (QSM) affords high sensitivity to iron variations, but has never been applied to the new-born brain.

Details: We explored the feasibility and sensitivity of 7T QSM for assessing brain iron in neonates.

Methods: 5 neonates (median age: 39.7 weeks postmenstrual age (PMA)) were imaged in natural sleep at 7T with a T2w acquisition and a 3D T2*w GRE sequence for QSM. For comparison, 11 children (mean age: 11.9 years) were imaged on the same scanner with 3D MP2RAGE, 3D FLAIR, and 3D T2*w GRE sequences.

Combination of complex data and QSM computation were carried out using the approach outlined in Chari et al. (2023).

Neonates' T2w images were registered to a 37-week PMA template. Magnitude images were registered to the corresponding T2w volume. QSM normalisation to the template was achieved through composition of the above transformations. Tissue segmentations and surfaces were generated using the dHCP pipeline.

Children's magnitude images were registered to the corresponding MP2RAGE volume, and QSM normalisation was achieved through the composition of the above transformations. FLAIR and MP2RAGE images were analysed with the HCP pipeline to perform tissue segmentation and surface reconstruction.

Susceptibility (χ) was examined in caudate, lentiform nucleus, corpus callosum (CC) and lateral ventricles. Additionally, χ was sampled along the grey/white matter (GM/WM) boundary.

Results: χ in GM nuclei is negative in neonates and positive in children, where clearer structural boundaries are observed, reflecting greater iron deposition. In children, χ in the CC is more negative, reflecting increased myelination. Positive χ values are observed in posterior cortical areas in neonates, while in children positive χ values are more widespread, corresponding to the underlying myeloarchitecture, and consistent with a posterior to anterior pattern of myelination in neurodevelopment.

Discussion: We demonstrate the feasibility of QSM of the neonatal brain at 7T and its ability to detect regional variations in tissue composition through different stages of brain development.

P2-B-1 - Is tactile sensory processing regulation in preterm neonates an early determinant of neurodevelopmental outcomes at age 2 years (WIP)

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

[1]University of Caen Normandy

Summary: Years of research on neurodevelopmental disorders have yielded limited understanding. Our innovative approach merges recent findings on neonatal perception & attention, emphazing tactile perception's role in cognitive development. Using EEG, our study on high-risk preterm babies seeks early predictors of neurodevelopmental outcomes at age 2.

Details: Background: Premature birth heightens the risk of later Neurodevelopmental Disorders (NDD). However, this link remains to be fully explained, and we lack reliable vulnerability markers that would allow us to propose early screening and effective interventions. Exploring sensory processing regulation holds promise: a core process in cognitive development is sensory prediction (SP), which modulates sensory processing via repetition suppression (RS) during irrelevant stimuli or amplification during relevant ones. NDDs often entail sensory deficits, especially tactile. Altered tactile SP and RS may constitute early mechanisms of cognitive deficits seen in autism and attention disorders. This study assesses tactile SP and RS in preterm babies and their link with neurodevelopment at 2 years.

Methods: At 35 weeks of corrected Gestational Age (GA), we measured EEG evoked potentials in 62 preterm infants born between 26 and 34 weeks GA, during a tactile oddball-omission paradigm (290 vibrations on the forearm). The first and last 40 stimuli served as standards for assessing RS. Interspersed were blocks of stimuli (5 standards, 1 deviant, and an omission in pseudo-random order). All patients take part in an ongoing 2-year follow-up with NDD screening, cognitive and social milestone assessments (BRIEF-P/ESSENCE 2-5, ASQ), neurosensory evaluation (Dunn Sensory Profiles), and sleep quantity/quality analysis. Neonatal somatosensory processing measures will be compared with these outcome measures.

Results: Prematurity significantly influences somatosensory processing measures: lower GA at birth is associated with greater RS ($r=0.38$, $p=.002$), increased EEG amplitude during stimulation omission ($r=0.33$, $p=.007$), but lower amplitude of the mismatch response to deviants ($r=0.49$, $p<.001$). Preliminary findings from the first 25 patients with outcome measures at age 2 will be discussed, emphasizing the link between the three neonatal measures and attention/executive functions assessments.

Discussion: Sensory processing is modulated in premature infants at term equivalent age, potentially compromising subsequent sensory development and impacting neurodevelopment. Our cohort's 2-year follow-up, including NDD screening and cognitive assessments, will elucidate whether neonatal somatosensory processing predicts cognitive development at 2 years. If so, these measures could act as early predictors for neurodevelopmental outcomes in at-risk patients, guiding preventive strategies.

P2-E-24 - Aperiodic EEG activity in early childhood is associated with temperament, socioemotional functioning, and maternal psychopathology

Dashiell Sacks[1], April Levin[2], Charles Nelson[2], Michelle Bosquet Enlow[3]

[1]Harvard Medical School/Boston Children's Hospital, [2]Boston Children's Hospital, Harvard Medical School, [3]Boston Children's Hospital

Summary: Aperiodic EEG activity was historically dismissed as 'background noise', but more recent research demonstrates associations with brain function and mental health outcomes in older children and adults. The present study sought to investigate whether aperiodic EEG, measured in infants and toddlers, is associated with behavior and mental health.

Details: Background: Recent research has investigated aperiodic EEG power, characterized by a variable 1/f distribution in which power decreases as frequency increases. This distribution can vary in 'slope' (i.e., rate at which power decreases as frequency increases) and 'offset' (i.e., uniform shift of power across frequencies). The slope and offset are hypothesized to index the synaptic excitatory-inhibitory balance (flattened/reduced slope=increased excitation over inhibition) and broadband neuronal firing, respectively. Studies in adults and older children suggest changes in aperiodic EEG may characterize various psychopathology. Studies are needed to determine whether aperiodic EEG is associated with socioemotional functioning in early childhood and whether associations are affected by adverse exposures (e.g., maternal psychopathology).

Methods: Data were analyzed from N=401 infants and caregivers, with follow-up at age 3 years (N=226). At both assessments, children completed baseline EEG; aperiodic activity was calculated using the "specparam" (spectral parameterization) algorithm, modified for use in infants and toddlers. Mothers completed the State-Trait Anxiety Inventory and Beck Depression Inventory at both timepoints to measure maternal anxiety and depressive symptoms; the Infant Behavior Questionnaire-Revised at infancy to measure child temperament (surgency, negative affectivity, orienting/regulation); and the Infant-Toddler Social and Emotional Assessment at 3 years to assess child socioemotional problems (internalizing, externalizing).

Results: In linear regression analyses, offset and maternal anxiety symptoms were additively associated with infant surgency and orienting/regulation. Greater offset was associated with greater surgency and lower orienting/regulation. Greater slope (increased inhibition) was additionally associated with greater orienting/regulation; an interaction effect further showed that the observed negative association between maternal anxiety and orienting/regulation was more robust in infants with greater slope. At 3 years, greater offset and maternal anxiety symptoms were additively associated with greater child externalizing symptoms.

Conclusions: These findings provide evidence for associations between aperiodic EEG and socioemotional functioning in early childhood, including interaction effects with adversity exposures. Aperiodic EEG may index early development in excitatory-inhibitory networks associated with socioemotional outcomes.

P2-K-41 - Exploring the relationship between Brain Functional and Structural Changes in Prematurity: an EEG-MRI study (WIP)

Aline Gonzalez[1], Amandine Pedoux[2], Laurie Devisscher[3], Nicolas Elbaz[2], Chloé Ghozland[2], Sara Neumane[4], Aline Lefebvre[2], Lucie Hertz-Pannier[3], Alice Heneau[5], Marianne Alison [2], Richard Delorme[2], Marianne Barbu-Roth [6], Valérie Biran[2], Parvaneh Adibpour[7], Jessica Dubois[7]

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Summary: Prematurity is linked to various neurodevelopmental disorders, but early brain alterations are poorly understood. Characterizing early impairments at structural and functional levels is crucial to propose diagnostic and prognostic markers for evaluating rehabilitation programs aimed at improving neurodevelopmental outcomes.

Details: Objective: Our goal was to investigate the relationships between functional and structural markers of brain development in premature-born infants by integrating EEG and MRI information at term equivalent age. Through this, we aimed to better understand associations with perinatal risk factors, including gestational age at birth and sex.

Methods: Forty-one preterm infants with a mean gestational age (GA) at birth of 27.1±1.7 weeks underwent MRI and EEG exams on the same day (post-menstrual age PMA: from to 39 to 42w). 3T-MRI T2-weighted images were acquired in three slice planes and reconstructed with a super-resolution of 0.8mm (NiftyMIC tool). Images were segmented into different compartments (iBEAT and DrawEM tools: Fig 1a; [1]), and White Matter volume was considered for further analysis. Resting-state EEG data were collected using a 128-channel net (EGI) at a sampling rate of 1kHz and were analyzed within active sleep for all infants (average duration ~ 6 minutes). The temporal dynamics of EEG activity were characterized by parsing it into 7 "microstates" (Figure 1c) [2,3]. We selected three microstates, based on their duration sensitivity in capturing aspects of brain dysmaturation when comparing premature-born and full-term infants [3]. Using a regression linear model, we related the interindividual variability in microstate duration and WM volume, while accounting for some perinatal risk factors (i.e. GA at birth, sex; [3]) and PMA at MRI/EEG

Results: In addition to a significant effect of GA at birth and to a lesser extent sex on the duration of all 3 microstates [3] (Figure 1d) and on WM volume (Figure 1b), we observed some association between these functional and structural measures: longer duration residuals (after correcting for PMA) were related to higher WM volume residuals (Figure 1e)

Conclusion: These preliminary findings suggest a relationship between the development of resting state EEG microstate activity and MRI measures of WM growth. Specifically, higher WM volume correlated with extended microstate duration, suggesting a slower neuronal impulse conduction. This highlights the potential of multimodal investigations to characterize the interindividual variability of brain development in premature-born infants. To gain a deeper insight into WM development and its implications for functional brain maturation, further analyses are planned to include complementary measures of WM maturation, provided by diffusion MRI.

FIT'NG Conference Poster Sessions

Poster Session 1
Wednesday, September 25 15:10–16:45

Poster Session 2
Thursday, September 26 15:25–17:00

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 the Brightons Room.

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
WEDNESDAY, SEPTEMBER 25, 2024 15:10 – 16:45

A – Big Data

P1-A-1 Infant cerebellar cytoarchitecture influences subsequent language and motor development

Katie Jobson[1], Ingrid Olson[1]

[1]*Temple University*

Summary: The cerebellum may play a significant role in the crucial neural groundwork is laid that influences future motor and cognitive abilities (Yi et al., 2022). Investigations into its role in development have yet to examine the neural architecture of the cerebellum at birth, which is the aim of this study.

Details: Cerebellar damage from stroke or tumor in infancy and early childhood can result in lasting motor, cognitive, and social deficits (Olson et al., 2023; Stoodley et al., 2016). Even in neurologically intact children, differences in cerebellar white matter and/or gray matter volume, are associated with altered language and cognition (Choi et al., 2021; D'Mello et al., 2016). Here we go a step further by asking whether cerebellar microstructure at birth predicts differences in language and motor behavior at approximately 18 months of age. To examine this, we analyzed the developing Human Connectome Project (dHCP) dataset (Edwards et al., 2023). Our sample included 255 infants who were scanned at birth (M = 7.4 days old, range 0 to 55, and later brought in for behavioral testing (M = 19 months old)). The primary neural measure of interest came from analyzing the diffusion-weighted MRI scans with an advanced technique called NODDI (Zhang et al., 2012). NODDI, for our study's purpose, describes the underlying neural microstructure by quantifying dendritic complexity. Here we focused on the metric orientation dispersion index (ODI), in gray matter, allowing us to extend prior findings relating cerebellar grey matter volume to language in older infants and children. Behavioral measures were from the BSID-III (Balasundaram & Avulakinta, 2023). We found that ODI measurements of grey matter at birth predict 4-6% of receptive and expressive language ability at 18-months. The implicated regions of the cerebellum for our language measures include left lobule V (a motor region), Crus II (a social/language region), and right lobule VIIIa (a working memory region). The location of findings is consistent with prior work in older samples (D'Mello et al.,2015; More et al.; 2017). These findings indicate that dendritic complexity within cerebellar gray matter at birth can shape the later development of language and motor skills. More generally, these findings indicate that a subcortical region often neglected by researchers, the cerebellum, plays an important role in shaping early developmental milestones.

B – Clinical Populations

P1-B-2 Characterizing functional brain networks in children with or without ASD (WIP)

Haerin Chung[1], Wenkang An[1], Carol Wilkinson[1], Charles Nelson[2]

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

Summary: Autism Spectrum Disorder is a complex disorder, affecting 1 in 36 individuals. Early biomarkers are needed for timely diagnosis. While sub-optimal brain network organization have been suggested as potential biomarkers of ASD, most studies are from older children, thus missing the age-related changes that occur in early development.

Details: Objectives: Building on previous research demonstrating sub-optimal networks among older children and adults with autism, this study aims to: 1) characterize EEG graph-theory-based functional network trajectories in children with and without ASD in the first three years of life and 2) to assess whether measures that quantify network specialization (e.g. modularity) and efficiency (e.g. path-length) are predictive of an autism diagnosis.

Methods: High density resting-state EEG data was collected from 243 participants (63 ASD; 180 no-ASD) from two prospective longitudinal projects spanning 3-to-36 months. Whole-brain functional connectivity (e.g. coherence) and graph theory metrics (e.g. local efficiency - clustering coefficient; global efficiency - path length) were computed. Standardized assessments (i.e., Autism Diagnostic Observation Schedule, Mullen Scales of Early Learning) were administered to assess autism outcomes at 24 or 36 months.

Results: Preliminary analyses indicate that the frequency of peak alpha (4 - 11Hz) connectivity increases with age from 3-to-36 months, across both children with and without autism (Figure 1A). At 36 months, the autism group showed reduced global alpha connectivity (Figure 1B, C) relative to those without autism, particularly between frontal-temporal and central-posterior pairs. In addition, toddlers with autism had reduced local network efficiency (e.g. reduced clustering coefficient; Figure 1D) compared to those without autism.

Conclusion: These preliminary findings characterize age-related changes in peak alpha connectivity frequency, as well as group-level network differentiation at 36 months. Next, to understand how functional networks change across time (i.e., 3-to-36 months), two additional analyses will be conducted. First, we plan to explore within-individual network trajectories in both ASD and no-ASD groups. Second, we plan to map topographical changes in functional networks to specify regional alterations associated with (sub)-optimal network development in ASD. Identifying such age-related differences in functional networks early on in development will yield important insights into the neurobiological mechanisms linked to ASD.

P1-B-3 Neuroimaging of babies during natural sleep to assess typical development and Cerebral Palsy (NIBS-CP)

Line Johnsen[1], Emilie Kristine Waage Nielsen[1], Henrik Lundell[1], Karen Kettless[2], Camilla Gøbel Madsen[3], Franchesca Andre Edwards[1], Christina Engel Høi-Hansen[4], Thomas Quaade Bandholm[5], Tea Nørgaard Hansen[5], Annika Wollenberg Juul[6], Anne Mette Plomgaard[6], Helle Cecilie Viekilde Pfeiffer[6], Melanie Ganz[7], Kathrine Skak Madsen

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Summary: Cerebral Palsy (CP) is a common severe motor disability in children, often due to early brain injuries. Early diagnosis is vital for prompt intervention. We will study 200 infants, perform advanced MRI, and conduct motor assessments to evaluate early brain and motor development in infants at risk of CP and typically developing infants.

Details: Background: Cerebral Palsy (CP) is the most common severe motor disability in children, often resulting from non-progressive brain injuries or malformations that occur during early brain development. Early diagnosis of CP is vital for prompt initiation of targeted interventions. The median age for diagnosing CP in Denmark is 11 months, delaying early intervention for many children (1). The three diagnostic tools that best predict CP before the age of 5 months are cerebral MRI, the Hammersmith Infant Neurological Examination (HINE), and General Movements Assessments (2). In the Danish healthcare system, diagnostic MRI of infants with suspected brain damage is conducted under general anesthesia (GA) and utilizes conventional structural MRI techniques designed to detect major structural brain abnormalities. However, there are growing concerns about the potential neurotoxic effects of GA. Moreover, advanced MRI sequences, like advanced diffusion MRI, may offer additional insights into the neuropathology of CP.

Aims and Objectives: The project encompasses several goals and objectives that benefit infants with CP and other neurological disorders necessitating cerebral MRI. We aim to establish a cohort of 200 infants to:

1) Develop protocols for conducting clinical MRI scans on infants and toddlers while they are naturally asleep at Hvidovre Hospital and the forthcoming Mary Elizabeth's Child Hospital.

2) Investigate how early brain development differs in infants at risk for CP from typically developing infants. We will create 'normative' models of early brain development, like growth charts, to identify deviations in brain development in children with CP.

3) Map the relationship between early brain development, motor function, and cognitive development. These features may enhance predictions regarding motor function and developmental prospects in children. Ultimately, the objective is to reduce the diagnostic age of CP in Denmark.

Methods: We plan to follow 200 infants categorized into two groups: infants at risk for CP (n=50-60) and typically developing (n=140-150). The at-risk group is recruited from the Danish The Cerebral Palsy: Early Diagnosis and Intervention Trial (4). MRI is performed on a 3T MR scanner (MAGNETOM Vida, Siemens Healthcare) using a 64-channel head and neck coil. The project consists of three waves over a 2-year period, covering the age span of 3-24 months (see Figure 1 for study outline and included assessments). Enrollment commenced in June 2024.

P1-B-4 Listening to mom in the Neonatal Intensive Care Unit: A randomized trial of increased maternal speech exposure on neural connectivity in infants born preterm

Katherine Travis[1], Cory Dodson[2], Molly Lazarus[3], Lisa Bruckert[2], Rocio Poblaciones[2], Virginia Marchman[2], Melissa Scala[2], Kristen Yeom[2], Heidi Feldman[2]

[1]Weill Cornell Pediatrics and Burke Neurological Institute, [2]Stanford University, [3]Stanford University and Weill Cornell Medicine

Summary: The present research aims to demonstrate that a language intervention, which involves playing recordings of a mother's voice to the infant while s/he is in the hospital nursery, will be effective for promoting healthy brain development in support of long-term language outcomes in preterm babies.

Details: Background: Among preterm neonates, limited speech exposure in the neonatal intensive care unit may alter brain development, which may ultimately delay development of language. This study used a randomized controlled trial to examine the impact of maternal speech exposure during hospitalization on structural white matter connectivity in a sample of healthy preterm newborns.

Methods: Participants (N=44) were PT newborns (24-31 weeks gestational age at birth), recruited when they were medically stable. Exclusion criteria included complications of PT birth known to affect brain structure. Newborns were randomly assigned to treatment (T: n=21) or standard of care (C: n=23) groups. The treatment was enhanced maternal speech exposure. Mothers of all participants were recorded reading a children's book. All infants had iPods placed in their crib/incubator. The T group heard the audio recordings for a total of 160 minutes/day. The C group were not played the recordings. Two high-angular resolution diffusion MRI sequences (scan 1 b=700 and scan 2 b=1500) and quantitative R1 relaxometry scans were collected as part of routine MRI imaging at near term age. Treatment effects were assessed using mean diffusivity (MD) as the pre-registered primary outcome metric (NCT02847689) from the left and right arcuate fasciculus. Secondary analysis, performed to confirm treatment effects, assessed fractional anisotropy FA from dMRI scans and R1 (1/T1) from qR1 scans.

Results: T and C groups were matched on all medical, demographic, and experimental variables. Compared to the C group, the T group demonstrated significantly lower MD in the left arcuate (scan 1: t=2.9, p=0.01; scan 2: t=3.26, p=0.005) but not right arcuate (scan 1: t=1.5, p=0.14; scan 2: t=0.84, p=0.42). Secondary analyses confirmed that compared to the C group, in the left arcuate, newborns in the T group demonstrated significantly higher FA (scan 1: t= -2.6, p=0.01; scan 2: t= -3.0, p=0.01) and significantly higher R1 (t= - 3.8, p= 0.001). In the right arcuate, T-C group differences were not significant for FA (scan 1: t= -1.3, p=0.19; scan 2: t=0.15, p=0.88) or R1 (t= -1.2, p =0.25).

Conclusions: The direction of group differences suggested that increased exposure to maternal speech led to increased white matter maturation in the left arcuate, a neural pathway known to be important in language. Preterm children may benefit from interventions that directly increase amount of speech exposure in the NICU.

P1-B-5 Investigating the haemodynamic response to hypo-glycaemia in preterm infants using diffuse optical tomography (WIP)

Guy Perkins[1], Silvia Guiducci[1], Giulia Res[1], Federica Savio[1], Elena Priante[1], Alfonso Galderisi[2], Eugenio Baraldi[1], Sabrina Brigadoi[1]

[1]University of Padova, [2]University of Yale

Summary: Very preterm neonates are prone to experience hyper and hypo-glycaemia. This study uses continuous glucose monitoring and diffuse optical tomography to investigate the haemodynamic response to these events, which is not currently understood, nor how this effects cognitive development.

Details: Introduction: Very preterm neonates (< 32 weeks gestational age (GA)) are prone to experience hyper and hypo-glycaemia. Current clinical practice means that preterms blood glucose concentrations (BGC) are sampled approximately twice a day, with the aim to regulate BGC to maintain a euglycemic state. This practice doesn't consider any individual differences in the preterm such as the variability in thresholds for glycaemic events, which currently lacks consensus (Hay WW, 2009). This study aims to investigate the relationship between glycaemic episodes and brain haemodynamics in preterms, using diffuse optical tomography (DOT).

Methods: Very preterm infants were enrolled from March 2020 in the Neonatal Intensive Care Unit of the University Hospital of Padova. 60 patients were recruited with a median GA of 30 weeks. Continuous glucose monitoring (CGM) was carried out on all patients using a Medtronic CGM system inserted in the thigh. Glucose data was sampled every 5 minutes and four different glycaemic episodes were classified, severe hyper (> 180 mg/Dl), mild hyper (> 144 mg/Dl), mild hypo (< 72 mg/Dl) and severe hypo (< 47 mg/Dl). Events were synchronized with NIRS data, which were acquired using an NTS device (Gowerlabs), consisting of 8 sources and 8 detectors (10 Hz, 64 channels at 780 nm and 850 nm respectively), distributed evenly across the scalp. NIRS data were split into 10 minute segments based upon features of the BGC curve, and changes in total haemoglobin concentration (HbT) calculated using DOT. These were then compared to the peak of the BGC curve for each glycaemic event.

Results: Glucose data from 41 preterms have been classified, of which 15 exhibited majority hypo glycemic events (mean 5 events & STD = 9, mean 114 minutes & σ = 78 minutes). In the first two preterms analysed, spatial correlations were found in the cortex between the peak change in HbT and glucose (figure 1). Further analysis of the remaining 13 hypo majority preterms are planned.

Conclusion: So far we have identified 15 preterms as majority hypo-glycaemic. A technique for correction of motion artefact 'trains' was developed and spatial correlations between peak changes in HbT and glucose concentrations has been observed.

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C – Cognitive Development

P1-C-6 Correlation between maternal affectionate touch and temporal activation in response to social touch in 6-month-old infants

Valentina Gomes[1], Lívia Campos[1], Sérgio Novi Jr[2], Rogério Oliveira[1], Isabella Francischelli [1], Camila Ribeiro[1], Beatriz Pacheco[1], Borja Blanco[3], Sarah Lloyd-Fox[3], Rickson Mesquita[4], Ana Osório[1]

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Summary: The study aimed to correlate the frequency of maternal affectionate touch on a mother-infant interactionand activation on temporao-parietal cortices in 6 month infants in response to social touch. Infants were evaluated with fNIRS while receiving soft touch on the right shoulder blade. Maternal touch was coded using a scheme developed by our team.

Details: Touch is an essential part of maternal care and mother-infant bonding, with studies demonstrating its importance to positive outcomes in infant development, like emotion regulation (Linhares & Martins, 2015). However, investigations about the neural correlates of touch among infants are still scarce. This study aimed to evaluate the correlation between the frequency of maternal affectionate touch and temporoparietal activation in response to maternal touch in 6-month-old infants. N = 16 infants were assessed using functional near-infrared spectroscopy (fNIRS) with the following procedure: Gentle hand strokes were administered by a trained researcher (concealed behind a curtain) on the children's right shoulder blade at the approximate speed of 3 cm/s. A total of 16 trials were applied (3 seconds of baseline + 15 seconds of stimuli + 10 seconds of baseline) and, in half of the trials, the mother was sitting

next to the infant (in the other half, a non-familiar woman sat next to the child). This layout would lead the child to perceive the person sitting next to them as the source of touch. For this study, only the mother trials were analyzed using a minimum of 3 valid trials on the condition. NIRS channels over the temporal and parietal cortices (bilaterally) were considered based on previous studies' findings (Croy et al., 2022; Miguel et al., 2018). Maternal affectionate touch (characterized by soft, gentle stroking that aims to convey positive affection to the child) was assessed through recordings of 9-minute mother-infant interactions. The frequency of affectionate touch was coded by two trained researchers (blind to the study hypotheses) on a second-by-second basis using a coding protocol previously developed by our team. Since all variables had a normal distribution, a Pearson correlation coefficient was performed to quantify oxy-hemoglobin (HbO) on activated channels (mean of HbO concentration on the valid trials) and frequency of maternal affectionate touch. Channels 21 (over the superior temporal sulcus and middle temporal gyrus) and 25 (over the middle temporal gyrus) were significantly activated (versus baseline). A higher frequency of maternal affectionate touch was associated with higher HbO levels on channel 25 in response to maternal touch rho=.52, p=.038 This study highlights a link between behavioral aspects of the mother-child tactile interaction – namely maternal affectionate touch during everyday interactions – and infants' neural responses to social touch.

P1-C-7 Infants' resting state functional connectivity and ERPs: A multimodal approach to investigating the neural basis of infant novelty detection

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Summary: By integrating EEG and MRI data, this report provides new insight into the neural generators of infant novelty-detection ERPs and provide new evidence that individual differences in moment-to-moment processing of novelty are related to intrinsic network architecture in infancy. This work has implications for infant learning and development.

Details: Individual differences in how the brain responds to novelty emerge in infancy. Event-related potentials (ERPs) are among the best ways for measuring novelty processing in infancy. However, this method has limited spatial resolution. This study aimed to evaluate the neural basis of novelty detection by combining ERP data with magnetic resonance imaging (MRI) data.

Twenty-nine infants completed both resting-state functional MRI (Mage= 4.73 months) and EEG during a three-stimulus auditory oddball task (Mage= 5.19 months). Resting-state functional connectivity (rs-FC) was computed from functional MRI data. The mismatch response (MMR) and P3 were computed using the MADE pipeline for developmental EEG data (Debnath et al., 2020). Figure 1 depicts standard ERP response. Source localization was conducted by combining EEG and structural MRI data as outlined in Conte & Richards, 2022. Source localized MMR and P3 responses were extracted from five regions-of-interest.

In line with prior work, EEG source localization showed that the bilateral auditory cortices, posterior cingulate cortex, and superior parietal cortex were involved in the generation of MMR and P3 responses (See Figure 2). We next explored the association between source-localized ERP responses and intrinsic network architecture using whole-brain network level analyses of rs-FC (See Wheelock et al, 2021 for methods description). Results demonstrated that a larger MMR (localized to the superior parietal lobule) was associated with greater connectivity within the Somatomotor network and greater Somatomotor - Dorsal Attention Network (DAN) connectivity (See Figure 3). A larger P3 response (localized to the superior parietal lobule) was associated with greater Somatomotor network connectivity and Somatomotor- Ventral Attention Network (VAN) connectivity (See Figure 4).

These results provide new insight into sensory processing and novelty detection. This is the first report of source generators of P3 responses to novel complex auditory stimuli in infancy. This work additionally implicates coordinated activity with the DAN, known for its role in reorienting attention, in the MMR. In contrast, coordinated activity with the VAN, known for its support of later-stage, complex adjustments in attention, related to the later P3.

P1-C-8 Asymmetries in structure and connectivity precede functional specialization for language in the infant brain

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Summary: How does the brain specialize for language? The "language-ready" brain hypothesis suggests infant brains are prewired for language acquisition due to the asymmetries in anatomical regions associated with language processing. We test this by examining the structural asymmetries, functional connectivity, and activation to a language task in infants.

Details: During the first few years of life children acquire language skills and develop a left-lateralized frontotemporal language network. How does this arise? Do structural asymmetries exist early and drive specialization for linguistic content? We examine the relationship between structural asymmetries, functional connectivity, and task-based language activation in infants.

All infants (N=20, ages 0-35 months) completed high-resolution structural scans and multiple runs of a language task (forward sentences, reverse sentences, and texturized noise conditions). 15 infants completed at least one five-minute resting state. Rigorous motion thresholds (80% timepoints with <0.5mm framewise displacement) were applied to the task and resting data, leaving a final sample of 11 infants. We leverage publicly available software to segment (BIBSnet) and parcellate (NiBabies; Infant FreeSurfer) each infant's brain. After visual examination of segmentation, structural properties (sulcal depth, grey matter volume, and surface area) were estimated within Desikan-Killiany (DK) atlas regions associated with language and auditory processing. For regions with a structural asymmetry (paired samples t-test) we examined language activation and functional connectivity.

We found that the superior temporal sulcus (STS) had a significant leftward asymmetry of maximum sulcal depth. We compared asymmetries in connectivity of an STS ROI (top 10% deepest section per hemisphere) to the DK regions. The left sulcal pit ROI was significantly more connected to the left auditory cortex (AC, transverse temporal lobe) than right STS sulcal pit—right AC connectivity. Examining the functional properties of the AC shows that the left, but not right, AC significantly responds to all auditory task conditions, and is also more structurally developed (significant leftward structural asymmetries in surface area and grey matter volume). Finally, canonical language regions (including the sulcal pit ROIs) did not show reliable language activation.

Overall, we find strong anatomical asymmetries in the STS and AC. Left putative language areas are more structurally developed and functionally connected, and these asymmetries precede functional specialization to language. Functional connectivity of left STS to functionally active left AC may not only precede but also drive functional selectivity to language that will emerge in left STS. Ongoing longitudinal investigation will further test this theory.

P1-C-9 Larger than life: Cartoons drive infant visual cortex more than realistic movies

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Summary: Infants must make sense of rich and dynamic sensory input. In the auditory domain, they prefer to listen to, and learn better from, exaggerated, infant-directed speech. We explore this sensory exaggeration effect in the visual domain by testing how cartoons enhance the reliability and representational content of activity in infant visual cortex.

Details: The human visual system exhibits sophisticated structure and function even in infancy, including retinotopic organization in early visual areas and category-selective responses in late visual areas. Yet, there is also dramatic perceptual learning early in development and it is unclear how this plasticity alters the selectivity and tuning of infant visual cortex. Infant visual cortex may be optimized to process realistic input, given the structure of the sensory environments in which the human brain evolved and the types of visual input infants experience early in life. Alternatively, developing sensory systems may be especially receptive to exaggerated or simplified features that emphasize diagnostic information, as in the case of infant-directed speech. Here, we evaluate this sensory exaggeration hypothesis by testing whether cartoons elicit stronger and more consistent representations in the human infant visual cortex than realistic movies. We collected fMRI data from 24 infants (4-15 months) while they watched (in a random order) two versions of the same 3-minute movie: 2-D animated cartoon and 3-D realistic computer-generated imagery. These movie formats differed in certain visual features (i.e., color, texture), but were otherwise perfectly matched in semantic content on a frame-by-frame basis, which we verified with a computer vision model. As a baseline, we also collected data from 12 adults for whom we did not expect a benefit for cartoons. We performed intersubject correlation analyses in both infants and adults to assess the reliability of BOLD activity evoked by the two movies. In adults, the visual cortex responded similarly to both cartoon and realistic movies. In contrast, the visual cortex of infants showed stronger and broader intersubject correlation for the cartoon than the realistic movie. Using multivariate pattern similarity, cartoons allowed for better decoding of high-level visual features than realistic movies, including whether a face was present and the spatial scale of the scene. Crucially, these neural differences emerged despite no significant differences across movies in infant behavioral preferences (i.e., the amount of infant data excluded for head motion or looking away). These results suggest that the visual system may be attuned to diagnostic visual features in early development and that cartoons may (unknowingly) capitalize on this neural preference.

P1-C-10 Characterizing neural habituation to deviant sounds in sleeping neonates (WIP)

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Summary: Anxiety is associated with poorer habituation to deviant stimuli. Recent work found that neural alterations associated with anxiety are present near birth, suggesting that early detection of altered habituation may be possible. This project will characterize neural habituation to deviant sounds in a sample of infants at high risk for anxiety.

Details: Anxiety is associated with less habituation to deviant stimuli. Recent work found that neural alterations associated with anxiety are present near birth, suggesting that early detection of altered habituation may be possible.

In this project we will 1) characterize neural habituation to deviant sounds in neonates and 2) in relation to maternal anxiety diagnosis.

Our final sample will include approximately 125 neonates (ages 39-43 weeks) imaged during natural sleep while undergoing an auditory oddball task. Each 6.7-minute run of the task includes 56.4s of pure scanner noise, 24 white noise bursts (deviant sound) at jittered intervals (9.6-14.4s) over the sound of the scanner (habituated sound), and then 77s of pure scanner noise. Activation to the deviant sounds will be characterized using finite impulse response modeling (FIR) then summarized (dot product) to account for individual variation in the hemodynamic response. To measure habituation across the task run, subject level activation maps will be produced separately for the early, middle, and late deviant sounds (8 trials each). To measure habituation across the session, FIR modelling will be conducted separately for the first two runs versus the second two runs of the task. The resulting six subject level activation maps ([early, middle, late] x [runs 1&2, runs 3&4]) will then be entered into a hierarchical model to characterize effect of trial and run order on activation, with subject entered as a random intercept, and sex, age at scan, and mean motion entered as covariates. For aim 2, maternal anxiety lifetime diagnosis will be added to this model as a main effect and an interaction with trial and run time variables.

In a preliminary analysis of 63 neonates, we found increased activation of the dorsolateral prefrontal cortex and decreased activation of the lateral parietal cortex in later runs compared to earlier runs. Across trials within each run, we found decreasing activation over time in the superior temporal gyrus and increasing activation over time in the dorsal cingulate and posterior insula. Maternal anxiety disorder diagnosis was associated with greater decreases in the pre and postcentral gyri and insula activation from early to late runs of the task and greater increases in posterior cingulate and dorsolateral prefrontal cortex activation from early to late trials.

The results of this study will provide key insights into the pathophysiology of anxiety and infant cognitive processing.

P1-C-11 Gestational diabetes is associated with decreased structural connectivity in the neonatal brain

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Summary: The purpose of our study is to compare brain structural connectivity of neonates born to mothers with gestational diabetes compared to neonates born to mothers without gestational diabetes.

Details: Objective: Gestational diabetes (GD) has been associated with adverse perinatal outcomes, such as preterm birth, and adverse outcomes for the fetus, such as atypical cardiac development. Prior literature suggests that children of mothers with GD are more likely to experience deficits in language, attention, and motor skills. Previous research has investigated the potential link between GD and brain development using animal models. Thus, little is known about the influence of GD on offspring's connectomes in humans. The current study assesses the relationship between GD and neonatal structural brain connectivity.

Methods: We investigated the brain structural connectomes of 611 neonates, including 437 term infants (203 female, 234 male) and 174 preterm infants (74 female, 100 male) from the developing Human Connectome Project. All mothers were screened for GD during their pregnancy, and 37 were diagnosed. Standard diffusion weighting imaging was performed and processed to construct brain structural connectomes with the 90-node infant atlas. To test the influence of GD on offspring's brain structure, we used a multivariate analysis of variance (MANOVA), controlling for the influence of preterm birth.

Results: Our analysis found 18 significant ($p<0.05$) structural edges. All had positive associations, indicating weaker structural connections in the GD group compared to controls. Eleven edges involved regions associated with the somatomotor network, 10 edges involved the subcortical network, 6 edges involved the limbic network, 2 edges involved the frontoparietal network, and 2 edges involved the dorsal attention network.

Conclusions: Overall, our results suggest that GD is associated with decreased neonatal brain structural connectivity in comparison to neonates born to mothers without GD. This decreased connectivity, particularly between the attentional, somatomotor, and frontoparietal networks, could benefit from further investigation to understand whether there is a neurobiological connection to postnatal attentional and motor deficits detailed in the prior literature on children born to mothers with GD.

D – Developmental Psychology

P1-D-12 Early neural predictors for communicative development from infancy to toddlerhood

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Summary: The current study aims to answer the question: can the neural response to novel stimuli in infancy predict communicative development? Identifying early indicators of communication skills is critical in recognizing which children may need early intervention services. This study investigates the brain's response to novelty as one potential predictor.

Details: Background: Communicative development includes linguistic (e.g., words) and non-verbal (e.g., gestures) features (Landa, 2007). Infants' neural responses to novel linguistic stimuli (native versus non-native sounds) predicts toddlers' ability to learn linguistic features of language (Kuhl et al., 2007, Wong et al., 2021)). It is unknown whether novelty detection is related to other aspects of communicative development.

Some studies of autistic individuals indicate that event-related potential (ERP) responses to novel sounds correlate with social skills impairment (Chien et al., 2018). It is unknown if these patterns are present in neurotypical samples and whether they emerge in infancy. The current study aims to investigate associations between neural novelty responses at 5 months and various domains of communicative development at 2 years.

Methods: Electroencephalogram (EEG) data were collected from 44 infants (20 male, Mage=5.24 months) during a 3-stimulus auditory oddball task of standard, novel, and deviant tones. Two ERP responses were calculated: mismatch response (MMR; ERP response to deviant – standard stimuli) and P3 (ERP response to novel – standard stimuli).

Communication was measured at 24 months via the parent-reported Infant-Toddler Checklist (ITC) speech, symbolic, and social subscales. Regression analyses were conducted to examine associations between MMR and P3 responses and ITC subscale scores. Bonferroni correction controlled for multiple comparisons (adjusted p threshold=0.05/6=0.0083)

Results: Higher social communication scores at age 2 were associated with larger P3 responses ($r(42)=0.35$, $p=0.0146$; Figure 1) and MMR ($r(42)=0.44$, $p=0.0024$; Figure 2). After controlling for multiple comparisons, the MMR–Social Subscale association remained significant. No significant associations were found between ERP responses and speech or symbolic subscale scores.

Discussion: This is the first study to investigate longitudinal associations between infants' novelty ERP responses and communicative development. The results indicate heightened MMR at 5 months predicts stronger social communication skills at 2 years. This complements previous findings indicating associations between larger responses to novel linguistic stimuli and faster vocabulary growth (Kuhl et al., 2007). Future research should examine this association in youth with communication delays, to determine whether reduced neural novelty responses can predict social communication impairments.

P1-D-13 Sleep and twitches in the premature infant and what they tell us about the brain "waking up" early

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Summary: We sleep the most when we are young, but it is known that premature infants sleep less throughout the day than predicted by previous behavioral state studies during fetal development. This goal of this study is to understand the impact of reduced sleep in this vulnerable population.

Details: We sleep the most when we are young, including as fetuses. But when fetuses are born prematurely, they experience an abrupt change in the environment that results in reduced sleep. This reduction in sleep is further compounded by the premature infant's often profound health challenges and need for care. Also, because the third trimester is a period of rapid brain growth, it is unclear how premature birth impacts brain development. Previous work from our lab using infant rats has shown that spontaneous activity in sensorimotor cortex, in the form of brief oscillations called spindle bursts, predominates during sleep. Spindle bursts are not only state dependent, but they are also reliably elicited in response to spontaneous movements called myoclonic twitches, a hallmark of active,

or (or REM) sleep; indeed, twitches trigger neural activity in all sensorimotor structures we have studied to date. Our findings strongly suggest that sleep and twitching should be protected in premature infants to promote brain development and sensorimotor integration. Our current study addresses sleep, twitching, and associated brain activity in premature infants in the neonatal intensive care unit (NICU). We aim to determine whether these measures can predict risk for atypical development in extremely (<32 weeks postmenstrual age (PMA)) and mildly (>32 to <37 weeks PMA) premature infants. Preliminary data indicate that extremely premature infants are awake, on average, more than 30% of the time. This amount of wakefulness persists at 34-36 weeks PMA; a similar level of wake is also observed in mildly preterm infants at these ages. When asleep, infants exhibit increased EEG power in the spindle-burst range (8-25 Hz), and power was further increased during periods of twitching. These findings suggest that reductions in sleep and/or twitches impact the amount of spontaneous activity produced by the developing brain. Ultimately, the goal of our work is to understand both short- and long-term outcomes when sleep and twitching are disrupted in preterm infants.

P1-D-14 The developmental origins of processing third-party social interactions in the human brain (WIP)

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Summary: Recent work shows that infants preferentially engage brain regions in the dorsomedial prefrontal cortex and the superior temporal cortex when viewing third-party social interactions. We are extending this line of work by investigating timing of brain process involved in third-party social interaction processing using event-related brain potentials.

Details: Our understanding of developing social brain functions during infancy primarily relies on research that has focused on studying how infants engage in first-person social interactions or view individual agents and their actions. Behavioral research suggests that observing and learning from third-party social interactions plays a foundational role in early social and moral development. However, we are only beginning to understand the developmental origins of the brain bases for processing third-party social interactions. In a recent study (Farris et al., 2022), we tested the hypothesis that brain systems in the prefrontal and temporal cortex, previously identified in adults and children, begin to specialize in third-party social interaction processing during infancy. We measured brain responses in infants (N = 62), ranging from 6-13 months in age, using functional near-infrared spectroscopy (fNIRS) while viewing third-party social interactions and compared this to two control conditions: infants viewing two individual actions and infants viewing inverted social interactions. Our results showed that infants preferentially engage brain regions localized within the dorsomedial prefrontal cortex and to a lesser degree in superior temporal cortex when viewing third-party social interactions. We are currently extending this line of work by investigating the timing of the brain process involved in third-party social interaction processing using event-related brain potentials (ERPs) in adults, children and infants. We have started data collection from a sample of young adults (currently at n =26; 17M, 9F; Mage=20.64, planned full sample of N=50). By the time of the conference, we will have completed data collection with adults and might be able to present preliminary data from children.

P1-D-15 Dorso-medial prefrontal cortex responses to social smiles predict sociability in infancy

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Summary: How is variability in brain function linked to individual differences in social behavior? Using functional near-infrared spectroscopy (fNIRS), we examined whether brain responses in the dorso-medial prefrontal cortex (dmPFC) to viewing social smiles at 11 months predict sociability at 18 months.

Details: The dorso-medial prefrontal cortex (dmPFC) plays a vital role in social cognition and behavior among humans. However, to date, little is known about what role the dmPFC plays in guiding overt social behavior during early development. The current longitudinal study examined the association between dmPFC responses and sociability in early development. Based on prior work with adults, linking dmPFC to sociability (Powers et al., 2016) and with infants, linking dmPFC to sensitivity to social gaze (Grossmann, 2017), we hypothesized that dmPFC responses longitudinally predict sociability levels, with greater dmPFC responses to direct gaze-social smiles (friendly individuals) being positively predictive of heightened levels of sociability. Brain responses were measured in response to social smiles (direct gaze smile minus averted gaze smile) and frowns (direct gaze frown minus averted gaze frown) using functional near-infrared spectroscopy (fNIRS) at 11 months (N= 76 typically developing infants; n= 38 female sex assigned at birth; Mage = 339.94 days, SE = 0.744). Individual differences in sociability were operationalized as behaviors indexing the seeking out of and taking pleasure in social interaction measured by using the Early Childhood Behavior Questionnaire (ECBQ; Putnam et al., 2006) at 18 months (Mage = 555.07 days, SE = 1.448). Our longitudinal results show that greater engagement of the dmPFC when processing social smiles (ß = 0.237, t = 1.999, p = 0.050), but not frowns (ß = 0.031, t = 0.263, p = 0.793), at 11 months predict higher levels of sociability at 18 months. This demonstrates that early variability in dmPFC responses during positive social interactions are linked to later individual differences in overtly displayed social behavior. The current findings further suggest that enhanced dmPFC engagement during social smiles is associated with higher levels of social motivation and reward, considering that higher levels of sociability at 18 months were characterized by greater seeking out of and taking pleasure in interactions with others. Future research should include direct measures of social motivation and reward to better understand the role of dmPFC in the development of sociability.

P1-D-17 Exploring the utility of toddler ERP MMN and language for predicting school-age early reading skills

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Summary: This study aims to shift the current "wait to fail" model of dyslexia identification by examining indicators of early reading abilities. We investigate whether combining ERP mismatch negativity (MMN) with early language assessments and family history can improve early detection of reading impairment.

Details: Early identification of reading impairments has become a prominent area of focus in research, with the goal of shifting the "wait to fail" diagnostic model. It is thus crucial to find the earliest indicators that effectively predict established early reading skills, such

as phonological awareness (PA), rapid automatized naming (RAN), and letter knowledge. Children with lower expressive and/or receptive language in toddlerhood or with familial history of reading impairments are at higher risk for reading problems, but both are inaccurate predictors and there are no reliable ways to detect risk for reading difficulty in toddlerhood. Previous studies have identified ERP mismatch negativity (MMN) in infancy as relating to school-age reading ability within samples in high rates of familial risk and in orthographically transparent languages (Dutch, van Zuijen et al. 2013; Finnish, Lohvansuu et al., 2021). Our study aims to develop a predictive model of core early reading abilities which form the foundation of later reading ability and are commonly included in school-based literacy screening, first possible at age 4. We recruited children at age 1-2 years, oversampling for language delays. We assessed family history of reading difficulties and expressive and receptive language skills in toddlerhood. Toddlers also completed an MMN paradigm, a measure of auditory processing, associated with reading skills, as noted by Norton et al. (2021). ERPs to 1300 speech syllable stimuli (15% deviants) were collected with a 32-channel BioSemi EEG system and measured in a priori regions and time windows of interest. We have followed these children until age 5+ years and continue to gather data on their early reading skills. We anticipate ~80 participants with complete usable data for analysis after preprocessing in the HAPPE pipeline and ensuring >50 usable deviant trials per child. We will conduct a multiple linear regression to examine whether including measures of MMN amplitude at age 2 significantly improves the prediction of early reading abilities, beyond the contribution of toddler expressive and receptive language measures. Additionally, we will investigate whether family history of reading impairment moderates the relationship between MMN and early reading skills. This study will further clarify the longitudinal relationship of early language and MMN to later reading with the goal of including the most useful biomarkers in early screening.

P1-D-18 Exploring how burstiness of caregiver language input is associated with language-related brain activation in young children (WIP)

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Summary: This work will investigate how exposure-consolidation way of thinking about caregiver speech input relates to language-related brain activation above and beyond sheer measure of quantity of language input.

Details: Extensive body of research shows evidence for strong positive associations between early caregiver linguistic input and language outcomes in children (Huttenlocher et al., 2010; Rowe, 2018). More specifically, higher number of overheard adult words (Hart & Risley, 1995), greater diversity and sophistication of caregiver lexicon (Weizman & Snow, 2001) and higher number of caregiver-child conversational turns (Romeo et al., 2018) have been linked to children's vocabulary growth both on behavioral and neurocognitive levels. Although this "more equals more" way of thinking provides support for encouraging linguistically rich early language environments for "optimal" child development, it also creates a highly biased and deficit-based approach that places the blame on lower-income families for their inability to dedicate more time and resources for their children providing constant "high-level" linguistic input. Given that children's vocabulary size, measured in the lab-based environments, has been used as an ultimate indicator of language development, and that the automated algorithms of the majority of naturalistic measures of language exposure (i.e., LENA) have been normed on mostly White higher-income families, we are still left with the need for more objective and unbiased measures of mechanisms that might be driving children's early language development.

Cychosz et al. (2024) found that the distribution (burstiness) of speech input positively related to language outcomes (vocabulary) in 2-7 year-olds. This proposed study will be the first known study to explore the language-related brain mechanisms of this burstiness hypothesis in a sample of n= 44 4-7 year old children from diverse socioeconomic, racial/ethnic, and linguistic backgrounds using fMRI and daylong LENA home recordings.

We hypothesize that LENA-derived measures of speech burstiness will be associated with children's language skills and languages-related brain activation (i.e., in inferior frontal, superior temporal, and supramarginal gyri), above and beyond socioeconomic status (SES) and number of adult words. We also expect to see correlations between duration of bursty speech and caregiver-child turn count.

Results have implications for reducing SES disparities in language development, especially for children and families from demographically and linguistically diverse backgrounds.

P1-D-19 Neural correlates of mother-infant attachment (WIP)

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Summary: Infant development is increasingly acknowledged to occur in a transactional manner with the parenting environment. However, there is little knowledge of neural processes occurring in both infants and mothers that associate with the dyadic infant-mother relationship. We examined whether infant and mother neural reactivity related to attachment.

Details: Mother-infant attachment reflects the history of maternal responses to infant distress, highlighting a role for both maternal and infant characteristics in attachment dimensions (Cassidy, 1994). Greater reactivity across the dyad likely contributes to the development of attachment. Rejecting or inconsistent responses predicting insecure attachment may indicate mothers' high reactivity to negative emotion (Martorelli & Bugental, 2006). Highly reactive infants may be more difficult to parent sensitively. Yet, whether these reflect the same physiological processes of reactivity within the dyad is unknown. Establishing these associations would support a transactional model of developmental processes. The Late Positive Potential (LPP) provides a neural indicator of reactivity (Cuthbert et al., 2000) that, in mothers, is associated with parenting behaviors (Rutherford et al., 2021). Infant LPP in response to the mother's face may reflect infant reactivity (Brooker & Kiel, 2023). We hypothesized that maternal and infant LPP should relate to infant behaviors that characterize insecure attachment.

At two sites, 170 dyads recruited for ethnic and socioeconomic diversity have participated in an ongoing study of transactional emotion development between infants (12-15 mo at Time 1, 23-25 mo at Time 2) and mothers. Analyses are completed for 20 dyads with dimensional composites of infant avoidance and resistance (Fraley & Spieker, 2003) from the reunions of the Strange Situation Procedure (Ainsworth et al., 1978) and cleaned maternal and/or infant LPPs. Maternal LPP was scored as mean amplitude at electrode

Pz from 600-800 ms (middle) and 800-1000 ms (late) following passive viewing of negative images (Lang et al., 2005). Infant LPP was scored as mean amplitude at electrodes Pz and Cz, 300-600 ms following passive viewing of pictures of the infant's own mother.

Avoidance, but not resistance, related to middle (r=.64, p=.002) and late (r=.59, p=.006) maternal LPP (see Figure 1). Infant LPP similarly related to avoidance, but not resistance, with a (non-significant) medium effect size at both Cz (r=.34, p=.093) and Pz (r=.27, p=.205). Unique correlations with the avoidance dimension suggest specific, rather than general, relevance of LPP to attachment behaviors. Similarity across mothers and infants supports a transactional model of emotion in early development. With the full sample, infant and mother LPP will be analyzed together in regression models.

E – Early Life Stress

P1-E-20 Physical touch rescues preterm brain function

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Summary: As preterm infant survival rates improve, there is a growing need to examine modifiable factors affecting post-hospitalization outcomes, especially considering the heightened neurodevelopmental risk in this population. This study examines the neural mechanisms behind the positive effect of supportive touch experiences on infant brain development.

Details: Touch, as the earliest sense to develop, establishes a fundamental building block for the development of sensory systems and subsequent cognitive, behavioral, and communication skills. For preterm infants in the Neonatal Intensive Care Unit (NICU), their early transition to the extrauterine environment and separation from caregivers disrupt development during a critical period of neuronal growth and organization. In the NICU, infants often experience procedural touch rather than supportive or comforting touch. While touch interventions are increasingly recognized in developmental care, few studies investigate the neurological mechanism behind the role of early touch experiences on neurological development. Here, we examine the role of supportive physical touch on brain signal variability in neonates. Study participants include preterm (n= 25) and term (n = 17) infants who underwent an EEG paradigm with two resting conditions – held by a caregiver and swaddled in a bassinet. Data were subjected to multiscale entropy analysis to quantify brain signal variability. We found a significant interaction between resting condition and birth term. Preterm, relative to term, infants displayed significantly lower brain signal entropy during the non-held resting state condition at all temporal scales; however entropy levels were equivalent for the two groups during the held resting condition within low delta temporal scales – the predominant frequency for neonates. Our results contribute a potential mechanism for the positive effects of touch interventions on preterm infants, demonstrating a rescue effect of physical touch on preterm brain function. Infants most vulnerable to disrupted neurodevelopment may exhibit heightened receptivity to intervention. Such analyses of preterm brain maturation can help support the advancement of neuroprotective practices against developmental delay.

P1-E-21 Effects of maternal anxiety on infant probabilistic learning

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Summary: Maternal anxiety can influence the anxiety levels of infants. This anxiety, in turn, can disrupt learning in unpredictable environments. A key aspect of cognitive development is probabilistic association learning (PLA), and this skill is variable within the infant population. Our study delves into how maternal anxiety influences PLA.

Details: A hallmark feature of anxiety is the altered processing of uncertainty. Our study investigates how maternal anxiety influences infant development, focusing particularly on their ability to learn in volatile situations. PLA abilities have large differences across the infant population, particularly in the 6–8-month age range. To examine probabilistic association learning (PLA), we adapted an 80:20 ERP-style oddball paradigm (Emberson et al., 2015), for both gaze-tracking (Tobii Ltd.) and HD-DOT (LUMO, Gowerlabs Ltd.). By integrating gaze-tracking and HD-DOT, we can account for the varying levels of engagement with the paradigm at the trial level. Our findings reveal adult-like medial prefrontal responses linked to PLA, with unexpected events triggering stronger hemodynamic responses than expected events (Fig. 1 a,b). Importantly, infants of mothers with higher trait anxiety exhibit heightened surprise or 'prediction error' responses to unexpected events in the right mPFC ($p = 0.019$). Furthermore, an infant's response to unexpected stimuli in the right mPFC predicts the likelihood of their mothers having clinically diagnosable anxiety levels ($p = 0.02$). These results underscore the significant role of maternal mental health in shaping early cognitive development.

P1-E-22 Maternal experience of childhood neglect is linked to increased infant cortisol levels and volumes of stress-regulatory brain regions

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Summary: Children of maltreated parents show increased risk for adverse physical and psychological health. Identifying the neurobiological mechanisms underlying intergenerational transmission of CM effects is essential to mitigate these adverse outcomes.

Details: Background: Evidence supports the impact of maternal childhood maltreatment on child psychosocial development. However, research is lacking on the impact of maternal childhood maltreatment on infant neurodevelopment, including the role of infant cortisol as a transmission mechanism. This study examined whether a) maternal childhood abuse or neglect is associated with infant cortisol output, b) infant cortisol is associated with infant limbic brain volumes, and c) infant cortisol mediates any relation between maternal childhood maltreatment and infant limbic brain volumes.

Methods: 57 mother-infant dyads participated, stratified for maternal childhood maltreatment. Mothers completed the Maltreatment and Abuse Chronology of Exposure questionnaire. At 4 months, infant total cortisol output (AUCg) was assessed during a mild stressor.

Under natural sleep, infants completed a T1-weighted MRI scan (M age=12.28 months [SD=5.99], range=4-25 months), using a 3.0 T Siemens scanner. Whole brain, amygdala, hippocampus, thalamus, basal ganglia, and insular cortex volumes were extracted via automated segmentation.

Results: Maternal childhood neglect (β=0.361, CI =0.056, 0.666), but not abuse (β=0.246, CI=-0.084, 0.576), was associated with higher infant AUCg. Infant AUCg was related to increased volume of the amygdala (β = 0.455, CI=0.215, 0.645), hippocampus β = 0.484, CI= 0.206, 0.693), thalamus (β=0.388, CI=0.164, 0.611), and basal ganglia (β=0.569, CI=0.353, 0.784), but not insular cortex (β = 0.077, CI= -0.115, 0.270). Moreover, infant AUCg mediated indirect relations between maternal childhood neglect and infant amygdala, hippocampus, and thalamus.

Conclusions: Consistent with animal models, infant cortisol may be one mechanism associated with intergenerational effects of maternal childhood maltreatment on infant limbic volumes and may be particularly influenced by maternal childhood neglect.

P1-E-23 Intrinsic functional neurocircuitry of the bed nucleus of the stria terminalis in early infancy

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Summary: To address a critical gap in the developmental neuroscience of the BNST, we aimed to characterize: 1) BNST circuitry in early infancy and 2) associations between prenatal stress, BNST connectivity, and infant negative affect (an anxiety risk factor).

Details: Background: Cross-species research has identified the bed nucleus of the stria terminalis (BNST) as a critical neural substrate for anxiety phenotypes. In rodents, the BNST has extensive connections to other limbic regions—including the amygdala, hypothalamus, and hippocampus, playing a critical role in sustained fear states and stress responses. Imaging studies in human adults reveal similar anatomical and functional connectivity, as well as integrative and regulatory functions in emotional and stress-related processes. However, we know little about the BNST's development in early human life.

Method: We collected approximately 10 minutes of low-motion fMRI data from 79 infants aged 2.29-6.86 weeks and aimed to map the whole-brain resting-state connectivity of the BNST. Data were processed using Nibabies and XCP-D, with a framewise displacement (FD) threshold of 0.2 mm and bandpass filtering 0.01-0.1 Hz. Data from 35 infants were excluded due to excessive motion or less than 5 minutes of low-motion data, leaving 44 infants with high quality (mean FD after censoring=0.11 mm) for analysis. Participant level seed-to-voxel correlation maps and the group-level analysis (family-wise error rate<.05) were conducted using Nilearn. For aim 2, maternal levels of stress during pregnancy was obtained using the Perceived Stress Scale. infant negative affect was measured at age 6 months using the Infant Behavior Questionnaire-Short Form and minutes of crying from 32 hours of home recordings. Covariates in analyses included sex, infant age at scan, maternal age, and FD.

Results: We found significant connectivity between the BNST and bilateral amygdala (extent=325 voxels, peak location=[58, 72, 30], FWER p<.05). Greater maternal stress in pregnancy was associated with lower BNST–amygdala connectivity in infants (=-0.48, 95%CI[-0.85, -0.11], p=.013). Higher BNST–amygdala connectivity was associated with less 6-month infant crying (=-0.38 95%CI[-0.74, -0.02], p=.041), but not associated with 6-month parent-reported negative affectivity (=-0.02 95%CI[-0.39, 0.43], p=.920).

Discussion: We found evidence, for the first time, that functional connectivity between the BNST and amygdala is present in early unfancy. Our exploratory analyses indicated a potential link between prenatal perceived stress and BNST–amygdala connectivity, and suggests BNST–amygdala connectivity may be relevant for negative affect in later infancy.

P1-E-24 Hypoxic birth events in the preterm infant: Early identification of Autism spectrum disorder

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Summary: In 2020, 13.4 million infants were born early. Many preterm infants require intensive respiratory support which may increase the risk of developing autism spectrum disorder (ASD). Neurobiological markers may help identify infants at the highest risk of ASD early in order to intervene when the developing brain is maximally plastic.

Details: Premature infants experience unique neurodevelopmental outcomes including increased risk of autism spectrum disorder (ASD). This project utilizes neuroscience, neonatology, and inflammatory proteomics to identify infants at the highest risk of developing ASD. One of the most common risk factors for developing a neurological disorder following premature birth is hypoxic - ischemic injury, or a lack of oxygen in the blood. Hypoxia necessitates aggressive ventilation techniques such as positive pressure ventilation, which initiates systemic inflammatory responses that may damage developing white matter.

The present study used electroencephalography (EEG) and multiscale entropy (MSE) –a measure of brain signal variability– to identify preterm infants with increased neural variability at rest during two conditions - social (while the baby was held) and non-social (while the baby was swaddled in a bassinet). EEG data was collected from 91 preterm babies in the University of Virginia Neonatal Intensive Care Unit. MSE analyses revealed increased mean entropy in ventilated infants as compared to their non-ventilated peers during the social resting state condition. This effect was driven primarily by the male babies who had increased mean entropy in the social condition as compared to female babies. In addition, preliminary saliva samples collected from 13 infants showed that infants who received PPV at birth had trending higher mean levels of all inflammatory cytokines tested.

To date, 37 additional EEGs and 67 additional inflammatory saliva samples have been collected and 35 neonates have received clinical MRI including DTI. Additionally, 28 infants have received follow-up EEG testing and autism diagnostic testing at 24 months corrected age. Using conduction velocity, g-ratio, and extracellular water volumes we will analyze connections between white matter tractology, inflammation, and EEG signals. Together, this data will connect early neural signatures and inflammatory profiles with later developmental outcomes to better understand the long term impacts of ventilation on the developing brain. Identifying early, noninvasive biomarkers of ASD will enable researchers and clinicians to identify infants at the highest risk for neurodevelopmental disorders before discharge from the hospital. This early identification is exceptionally important given that many infants discharged from the UVA NICU go home to areas without a neurodevelopmental clinic within 100 miles.

F – Emotional Development

P1-F-25 P300 amplitude moderates the pathway from negative reactivity to behavioral inhibition

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Summary: It remains unknown why some infants exhibit both negative reactivity at 4 months and BI in toddlerhood. We tested the possibility that neural processing of novelty may inform trajectories from negative reactivity to BI.

Details: Behavioral inhibition (BI), a temperament characterized by fear and avoidance of novelty, is associated with elevated risk for developing anxiety later in life. One third of infants who exhibit BI also exhibit 'negative reactivity' (i.e., novelty-evoked distress) at 4-months of age. However, the factors that support the continuity of these temperamental phenotypes remain unknown. Prior work has shown how the brain responds to novelty moderates the pathway from BI to anxiety (Reeb-Sutherland et al., 2009). The current study explores whether this pattern can also be found in early infancy.

To do so, we used the Temperament Over Time Study (TOTS) dataset. TOTS participants were recruited at age 4 months and evaluated for negative reactivity via observational assessment (Fox et al., 2015). At 9 months, a 3-stimulus (i.e., Standard tone, Deviant tone, Novel sounds) auditory oddball task was administered while collecting simultaneous electroencephalography (EEG). Event-related potentials were calculated using an in-house, infant-specific pipeline. In line with prior work (Morales et al., 2023), the P300 response was isolated by taking the difference between Novel sounds and Standard tones. Analyses used the mean amplitude of the P300 response over Fz (See Marshall et al., 2009). At 24 and 36 months, BI in the presence of a stranger was evaluated using observational assessment (Fox et al., 2001). A composite score was computed by averaging BI across both timepoints. Analyses evaluated whether P300 moderated the association between negative reactivity and BI. To evaluate the specificity of these effects, we replicated the model using the mean amplitude of the neural response to deviant sounds (i.e., mismatch response [MMR]; Deviant sounds minus Standard) over Fz.

Results demonstrated that P300 amplitude at 9 months significantly moderated the association between negative reactivity and BI ($p<.039$, See Figure 1). Infants who exhibited negative reactivity and a larger P300 amplitude exhibited higher BI. Infants who exhibited negative reactivity and lower P300 amplitudes exhibited lower BI. No significant effects emerged with the MMR model, suggesting that this pattern was specific to P300 responses.

In conclusion, these results demonstrate that infant attention to novelty moderates the pathway from negative reactivity to BI. This work may elucidate the neural mechanisms that underlie behavioral inhibition and ultimately early-life risk for anxiety.

P1-F-26 Associations between infant resting-state functional connectivity, early childhood irritability, and emerging signs of psychopathology (WIP)

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Summary: While irritability (i.e., anger in response to a blocked goal) is normative in childhood, chronic elevated irritability predicts later psychopathology. The proposed work aims to examine neural correlates of irritability, a transdiagnostic risk factor, in early childhood to better understand the neurodevelopmental etiology of mental disorders.

Details: Increased irritability, characterized by anger in response to a blocked goal, predicts later disruptive mood dysregulation disorder, oppositional defiant disorder, anxiety, and depression. Given that irritability is transdiagnostic, the neural correlates of irritability may be characterized by the coordination, or lack thereof, of activity within or between multiple functional networks. Thus, investigating neural correlates of irritability at the level of functional networks may help inform precision psychiatry approaches aimed at addressing heterogeneity within and across disorders. However, very few studies have examined functional network connectivity in relation to irritability in early childhood. The proposed study aims to examine longitudinal associations between infant resting-state functional connectivity, early childhood irritability, and emerging signs of psychopathology using network enrichment analysis. As part of an ongoing longitudinal study, 103 infants (age ~1 month) underwent 12-18 minutes of resting state functional magnetic resonance imaging (fMRI) during natural sleep. At age 18 months, irritability was assessed using the Multidimensional Assessment of Preschool Disruptive Behavior–Temper Loss dimension (n=72), and internalizing and externalizing symptoms were assessed via the Child Behavior Checklist (n=74). Brain–behavior associations will be examined via network-level enrichment analysis, which involves first evaluating whole brain associations between connectivity and behavior and subsequently evaluating the density of associations within a given network–network pair. Longitudinal associations will be examined between functional connectivity, irritability, and internalizing and externalizing symptoms. We hypothesize that increased connectivity within and between default mode, cingulo-opercular, and sensorimotor networks would be associated with each increased irritability, internalizing, and externalizing symptoms. Given irritability is a salient early transdiagnostic marker of later psychopathology, examining these brain–behavior associations early in life could improve our understanding of the neurodevelopmental etiology of mental disorders with potential implications for identifying timing for interventions aimed at supporting emotion regulation in early childhood.

G – Methods: Analytics/Statistics

P1-G-27 Eye movements reveal pretend play mechanisms in toddlers and their effects on word-object learning

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Summary: In the literature of pretend play and related areas across cognition there is a gap between models theorizing on putative mechanisms and ways of empirically evaluating them. By capitalizing on cutting-edge, eye-tracking techniques, we design and tested a paradigm to study pretense mechanisms and its effects on learning as it emerges in infancy.

Details: Goals: Pretend play is a prevalent behavior in childhood where children create nonliteral meanings. Computational models

posit that pretense entails a decoupling process that allows disengaging from literality plus inferential mechanisms to make sense of people's mental states during play. Yet, empirical evaluations of these constructs in infants have proven difficult. Our first goal was to test a method to study them using advances in eye-tracking techniques. Our second goal was to evaluate if and how engaging in a pretense mode favors word learning.

Methods: A series of movies with an actress performing real actions (e.g. pouring juice into a glass and drinking it) and their pretense counterparts (e.g. pouring imaginary juice from an empty jar into a glass and pretending to drink it) were created and presented to a group of healthy 18-month-old infants (n = 24). We familiarized the infants with two videos of the same category (pretend or real) on each trial, while their gazes were recorded with an eye-tracker. Interleaved between the movie stimuli, two word-object pairs were shown followed by a testing phase (see figure).

Results: Results show that the temporal structure of infant's gaze steps exhibits fractal dynamics, similarly in pretense and real trials. Dynamic Area-of-Interest analyses reveal, on the other hand, that pretend scenarios yield more fixation time and less frequency of revisits to the face and active hand of the actress, suggesting that infants get more 'stuck' to these elements as pretense scenes unfold. Group-level analyses of learning outcomes show no boosting of word learning in pretense compared to real-action contexts. Ongoing predictive models evaluate if individual differences in gaze patterns of scene perception are linked to specific aspects of learning.

Discussion: The shared fractal metrics observed across real and pretense scenarios suggests that both trigger internal processes having long-range temporal correlations and complexity. Notably, the lack of resemblance between the scanning patterns of pretense and real actions suggests that the former does not merely rely on pattern completion mechanisms that 'fill in' missing information present in the latter; instead, it hinges upon attention mechanisms that weights on social cues, possibly supporting the on-line creation of metarepresentations in a decoupled state, as theorized for pretense. Future detailed analyses will help further clarify these mechanisms.

P1-G-28 Differences in the distribution of the BOLD signal in infants and toddlers and the impact on connectivity

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Summary: Resting-state fMRI analyses rely on correlation coefficients between spots on the cortex. We looked at the distribution of r values across the cortex for infants and toddlers.

We found less right-skew for infants and toddlers compared to adolescents, leading the fewer high r values. The pattern was regional.

Details: Underlying nearly all resting-state (RS) functional magnetic resonance imaging (fMRI) analysis are simple correlation coefficients between units. These values are manipulated in a variety of ways, including the creation of seedmaps, i.e., a map of the brain where each location has a value representing its correlation with a seed unit. In analyses of Baby Connectome Project (BCP) data of infants and toddlers between 8 and 30 months (n = 437), we noticed differences in the distribution of r values across the cortex, namely fewer higher values.

As a reference sample, we calculated all-to-all correlation coefficients across the brain using Adolescent Brain Cognitive Development (ABCD) data as a reference sample, n = 1,941. We compared the distribution of r values across the entire correlation matrix, calculating mean, SD, kurtosis, and skewness. Secondly, we examined regional distributions over development using the Glasser/HCP parcellation. Both analyses were conducted using 10 minutes of RS data with a framewise displacement threshold of < 0.2 mm.

Less right-skewness in BCP led to fewer high r values (BCP = 0.09; ABCD = 0.18; d = -1.35), rather than a reduced SD (BCP = 0.21; ABCD = 0.17; d = 1.21). In fact, the SD in BCP was higher, whereas kurtosis (3.5; 3.7; d = -0.69) and mean (0.0007; 0.0010; d = 0.52) were more similar. All tests were significant given the large sample size of ABCD, see Figure 1.

SD was persistently higher in BCP across the cortex, showing little regional variation. Likewise, the mean of the regional distributions were evenly low across the cortex. However, some regional changes emerged in skewness and kurtosis. Namely, the sensorimotor (sensorimotor) strip and superior temporal gyrus showed greater skew and kurtosis relative to the ABCD, with the extent and magnitude of the effect increasing between 8 and 30 months, see Figure 2.

Previous work on infant data identified increased anticorrelation between the SM strip and visual cortex and higher-order networks (Moore et al., 2023), affecting skew and SD. Likewise, we identified differences in correlations between primary cortices (SM, auditory cortex, although not visual cortex), which suggests a biological explanation for the observed differences, rather than attributing the differences to confounds such as head size or increased motion. This highlights the need for consideration of our methodology and assumptions when analyzing infant and toddler data.

P1-G-29 Spatial developmental trajectory of large-scale brain networks in infants

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Summary: Understanding early brain development is crucial for identifying neurodevelopmental disorders and promoting infant brain health. This study examines changes in spatial maps and voxel-level variations of brain networks in infants from birth to six months, offering insights into dynamic organization and activity not captured by connectome analysis.

Details: Objective: This study explores the development of large-scale brain networks over time using independent component analysis on resting-state fMRI data from 74 typically developing infants. Using a non-uniform longitudinal sampling design, each infant was scanned at up to 3 random time points between birth and 6 months, yielding a total of 137 scans.

Method: We identified brain networks in infants and measured spatial characteristics. Network-averaged spatial similarity (NASS) metric captures how well individual maps matched the group map. Network dynamic range (NDR) measures intensity range across voxels. Network strength and size represent the average intensity and the number of voxels with significant network contribution (Z = 1.96, p = 0.05). Network Center of Mass (NCM) is the average distance between all voxels and the voxel at the network's center of mass. Next, we identified the voxels that have a significant correlation with age in each network. We then performed modularity analysis on the average voxel intensity of those voxels in all networks to determine which networks belong to the same module.

Result: Our findings indicate a notable rise in NASS across age for all networks, while NDR decreased with age in all networks. Network strength increased in several networks, such as the frontal-mPFC and primary and secondary visual networks. Network size and center of mass varied; both metrics increased in the secondary visual network but decreased in the temporal network. Figure 1 illustrates changes in spatial measurements for the primary and secondary visual networks. Figure 2 demonstrates the similarity in the developmental patterns of each pair of networks.

Conclusion: These findings enhance our understanding of early brain development, providing valuable insights into potential markers of consolidation and spatial reorganization in large-scale brain networks during infancy.

P1-G-30 Mapping In-Utero human brain development from Macroscale to Microscale

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Summary: The availability of high-quality fetal MRI data provides an unprecedented opportunity to characterize in-utero human brain development. The aim of this abstract is to study the brain's morphological and microstructural changes in typically-developing fetuses from mid-gestation to full term.

Details: During gestation, a series of neurobiological processes transform a simple neural tube to a structurally complex and intricately folded brain. Disruptions in these processes give rise to prenatal brain defects that lead to adverse neurodevelopmental outcomes, cognitive impairments, or even neonatal deaths. Thus, it is critically important to characterize normal in-utero brain development that helps identify congenital brain malformations, providing opportunity for early intervention and management. Here, we chart growth trajectories of the fetal brain at the macroscopic and microscopic scales from mid-gestation to full term (21 - 38 gestational weeks (GWs)). We used structural and diffusion MRI data collected as part of the Developing Human Connectome Project (dHCP).
For macroscopic features, we computed volumes of the gray matter (GM) and the white matter (WM) in the frontal, temporal, parietal, and occipital lobes. For microscopic features, we computed DTI (fractional anisotropy (FA) and mean diffusivity (MD)) and NODDI (intracellular volume fraction (ICVF) and orientation dispersion index (ODI)) metrics. FA and MD were computed using MRtrix3 and ICVF and ODI were computed by modeling the orientation distribution function with a Watson distribution. Each feature was modeled as a smooth function of age using the generalized additive mixed model (GAMM). The volumes of the GM and WM for each lobe increase through the study period, though at different growth rates (Fig. 1). For GM, the parietal lobe grows the fastest with a percentage increase of ~998% over the study period; whereas, for WM, the frontal lobe grows the most (826% increase) between 21 and 38 GWs. FA and ICVF first decrease and then increase, with turning points located beyond 27 GWs for different lobes (Figs. 2a and 3a); MD exhibits an inverted U-shaped trajectory, with a change in trajectory occurring between 27 and 29 GWs (Fig. 2b); and ODI increases throughout the study period for all lobes (Fig. 3b). This growth analysis signifies dynamic in-utero alterations in brain morphology and tissue microarchitecture.

H – Methods: Data Acquisition

P1-H-31 Optimizing wearable OPM-MEG to explore mother-infant interactions (MInI-MEG)

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Summary: The lightweight and semi-mobile nature of OPM makes it an ideal neuroimaging method to explore interactions between infants and caregivers but remains largely unexplored. This poster presents the first-ever OPM hyperscan between mother and infant, supporting the feasibility of mother-infant hyperscanning using OPM-MEG.

Details: Magnetoencephalography (MEG) is a noninvasive neuroimaging modality with millisecond temporal resolution making it ideal for capturing neuronal activity while still having strong millimeter spatial resolution. Recent innovations in MEG using optically pumped magnetometers (OPM) allow for a wearable system to collect changes in magnetic fields generated by groups of neurons.

Participants included in this study are full-term, typically developing infants with no prior birth complications and between the ages of 3 to 8 months and their mothers. Infants are fitted with lightweight 3D-printed helmets designed and produced by the lab, while mothers are fitted with a bespoke helmet from Cerca Magnetics. Second generation diaxial QuSpin sensors are fitted into the helmet and data collection occurs within a magnetically shielded environment between two nulling coils to reduce environmental interference. Infants are positioned on their mom's lap facing a projector where the visual cue is displayed. During the flashing visual stimuli, using their right index finger and thumb, moms are asked to tap their infant's right hand and provide continuous tapping until the visual stimuli disappears. Each trial of the visual cue is presented for 2 s, followed by 5 s of rest before another trial begins, with 50 total trials.

To date, we have successfully collected OPM data from 2 mother-infant dyads. Six sensors were placed on each participant over the left sensorimotor cortex. Figure 1A shows the power spectral density of sensor-level data of both the infant (blue) and mom (red) during the visually cued tactile task. Figure 1B shows the average sensor-level data from a single sensor located on the infant which shows the response to sensory stimuli. Our findings demonstrate the feasibility of OPM-MEG to assess mother-infant interactions using a task-based paradigm. Future work will extend to explore dyadic social interactions during naturalistic behaviors.

P1-H-32 Characterizing the developmental trajectory of twitching during non-REM sleep in human infants (WIP)

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Summary: Recently we found that sleep movements, or twitches, occur during non-REM sleep in human infants up to 6 months of age. Non-REM twitches also co-occurred with sleep spindles. The present study will track the developmental trajectory between twitches and sleep spindles at older ages, which may provide insight into motor development.

Details: Twitches are brief discrete movements that are characteristic of rapid eye movement (REM) sleep. These movements are generated by the brainstem and provide sensory feedback to sensorimotor structures throughout the brain, thereby contributing to

the development of somatotopic maps and internal models. Recently, our lab made the surprising discovery that twitches also occur during non-REM sleep in human infants, beginning around 3 months of age, with the rate of non-REM twitching increasing over the next few months (Sokoloff et al., Current Biology, 2021). In addition, we found that the emergence of non-REM twitching occurs just after the emergence of sleep spindles over the sensorimotor strip and that individual twitches occur in synchrony with these sleep spindles. Spindles are associated with neural plasticity, suggesting that non-REM twitching may have a unique role in sensorimotor development. However, because we did not investigate infants over 6 months of age, we do not know the trajectory of non-REM twitching beyond that age. Specifically, does twitching continue to increase, level off, or decline? Understanding this trajectory and its timing could provide valuable insight into the neural substrates of motor control across early infancy. Preliminary data from our lab suggests that non-REM twitching is still present in children up to at least 30 months of age. However, data from this study did not use EEG to investigate the brain activity occurring during these twitches. In the present study, we will investigate twitching during daytime naps in the sleep lab in children 0.5 to 4 years of age. An infrared video camera records the child's sleep behavior. Videos are scored to identify limb twitches. EEG and EOG are used to characterize sleep states following AASM sleep scoring criteria. The twitch rate in 10-11-month-olds is similar to the twitch rate of 6-month-olds from our previous study and restricted to periods of N2 non-REM sleep. In this project, we will use a linear mixed-effects model with age as a continuous variable to quantify the developmental trajectory of twitch rate in different sleep states. Lastly, we will analyze the probability of sleep spindles occurring in relation a twitch. Investigating the typical developmental trajectory of spindles, twitching, and their coupling will help us better understand their role in sleep-dependent motor development.

P1-H-33 Better baselines: Optimizing contexts for measuring resting-state EEG in infants (pre-registered report)

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Summary: This study addresses the challenge of identifying developmentally appropriate resting-state EEG procedures for infants, critical for enhancing data quality and quantity. Systematically investigating different resting-state contexts will aid in establishing standard age-appropriate baseline protocols and ensuring meaningful cross-age comparisons.

Details: Resting-state (or baseline) EEG (RS-EEG) is a measure of neural oscillatory activity while an individual is awake and not engaged in a task or active cognitive/affective processing. The current pre-registered report is for BUBBLES (Babies: Understanding Brain & Baseline Longitudinal EEG Study), a systematic investigation of RS-EEG with the aims of identifying and comparing developmentally appropriate RS techniques from 6 to 48 months of age. An eyes-open and eyes-closed protocol is used with adults to capture resting-state alpha (8-13 Hz) activity and alpha desynchronization – a decrease in EEG power at occipital sites when eyes are open as compared to closed (Lehtonen & Lehtinen, 1972). There is some evidence that an analogous lights on/off procedure with 7- to 12-month-olds elicits similar patterns of change in a lower 5.2-9.6 Hz frequency band (Stroganova et al., 1999). However, this procedure has yet to be systemically tested and optimized for use throughout infancy and early childhood. Infants can exhibit negative affect during periods of complete darkness, so to determine the type of context that would be optimal for infant EEG acquisition we compared the lights on/off task to a screen-based task that has less abrupt lighting changes and still elicits alpha desynchronization (adapted from Perone et al., 2018). What is not yet understood is how different RS-EEG contexts affect the signal-to-noise ratio during infancy and whether they exhibit similar functional properties. To this end, two RS protocols were optimized and compared in the present study: lights on/off and screen bright/dark (see Fig. 1). Data collection is underway at 6, 12, and 18 months of age. Preliminary analyses with a subsample of 6-month-olds (n = 15) revealed that both RS protocols elicited similar levels of occipital alpha desynchronization in the 5-8 Hz and 6-9 Hz bands (Fig. 2). Further, there was no difference in the amount of usable EEG during dark conditions, providing initial evidence that both protocols are viable analogs for the eyes open-closed RS procedure at 6 months of age (Fig. 3). The presentation will include additional 6–12 month data as well as detailed rationale for infant RS-EEG methodology. The significance of this work lies in its initial contributions toward establishing standardized age-appropriate RS-EEG procedures, which will enhance the rigor and interpretability of cross-age and cross-study comparisons.

P1-H-34 FIT'NG in the scanner: Addressing the FIT issues in fetal MRI scanning (WIP)

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Summary: Limitations of MRI scanner bore size can result in inequities when scanning populations of pregnant women with higher BMI and larger hip size and/or bump proportions.

Details: Magnetic resonance imaging (MRI) is an important diagnostic tool that can provide high resolution images of organs and soft tissues. Despite the preference for MRI due to its non-invasiveness and versatility, there are limitations to imaging overweight patients. 1 Technical restrictions of the scanner, such as weight limits and bore diameter, can be especially challenging when imaging pregnant women. Limitations of MRI scanner bore size can result in difficulty scanning populations of pregnant women with higher body mass indexes (BMI) and larger hip size and/or bump proportions. This can result in inequities regarding who is able to participate in research that includes fetal scanning and who is not. Currently, there is no gold standard for predicting patient fit into the MRI scanner. Existing reports suggest a wide range of approaches to determine patient FIT. Patient fit is determined by using patient height, weight, girth, clinical experience, and trial and error, which can be unreliable methods. 2 The goal of this proposal is twofold. 1) We propose a literature review to understand existing tools that allow us to a priori predict FIT in the scanner. Currently there are no existing models for pregnant women only non-pregnant adults. 2) Using an existing sample of pregnant individuals that are part of an ongoing study, we propose to present preliminary evaluation of BMI, hip and bump proportions, as well as peripherals used for comfort during the scan to estimate FIT in the bore.

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I – Methods: Data Processing

P1-I-35 Edited MRS of the infant brain on 28 scanners

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Summary: HBCD is an NIH-funded multicenter study of brain development across the first decade of life. It is the largest ever study to incorporate magnetic resonance spectroscopy (MRS) to measure changes in the neurochemical profile. Here, we present in vivo data demonstrating MRS performance across vendor and site.

Details: Introduction: 1H MRS is a powerful technique for understanding normal neurometabolic development and establishing biomarkers for dysfunctional development1,2. HBCD study is the largest, long-term study of early brain and child development in the U.S. The prime MRS specification is to measure biomarkers of neurotransmitter dysfunction GABA, glutamate Glu and oxidative stress glutathione GSH and ascorbate Asc. MRS protocol employs HERCULES3,4 and PRESS to reliably measure brain chemicals at 3T. In a multi-vendor, multi-site study such as the HBCD study, it is essential to assess site differences in metabolite quantification. This abstract reports on data collected during the pilot phase (Nov 22 to Jul 23) in 100 0-12 months old infants on 28 scanners.

Methods: 28 scanners (25 sites) consist of 20 Siemens, 6 Philips, 2 GE. MRS data were acquired from a 30x23x23 mm3 voxel in the bilateral thalamus (Fig 1), using PRESS (TE/TR: 35/2000 ms, 32 NEX) and HERCULES (TE/TR: 80/2000 ms, 224 NEX). GE sites used HERMES5 in place of HERCULES, with acquisition parameters matched. 4 water reference transients were acquired at TE 35, 80 ms. 79 (from 24 scanners: Siemens S1-S18, Philips P1-P4, GE G1-G2) and 67 (from 22 scanners) PRESS and HERCULES/HERMES data respectively were considered for analysis, out of 82 PRESS and 72 HERCULES data exported correctly and passing QC (tCr linewidth < 7.5 Hz; acceptable lipid contamination). Spectra were modeled using Osprey 2.5.06. ANOVA testing, followed by multiple comparisons correction, was applied to concentrations, grouped according to scanner.

Results: MRS data were successfully acquired on 0-12 months old infants. Spectra grouped by vendor are plotted in Fig 2. A vendor comparison of tCr SNR and FWHM of the data is shown in Fig 3. Concentration plots are presented in Fig 4 and 5. Significant differences in concentrations between sites were observed for: tNAA (G2 from 3 sites), tCr (P4 from 9 sites), Glx (G2 from 3 sites), and mI (G2 and P4) from PRESS; NAA (G1 from 3 sites), tCr (S1 and G1), tCho (G1 and P1), and mI (G1 from 2 sites) from HERCULES sum; and Lac (P1 from 8 sites) from diff2.

Discussion: This dataset illustrates the successful completion of the pilot phase MRS acquisition for HBCD. Low-concentration metabolites were measured in a multicenter study of infants using HERCULES for the first time. Good levels of agreement between metabolite concentrations were seen across vendors and sites.

P1-I-36 3D Fetal brain imaging: a direct comparison between same day MRI and ultrasound volumetric measures in the second trimester

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Summary: Ultrasound (US) and MRI are the leading modalities in prenatal care, but, due to large differences in their image acquisition, it is unknown if the volume measurements computed from one can be directly compared to the other. Here, we compare the volume of 8 brain structures measured from 93 same-day US and MRI acquired during the second trimester.

Details: Advances in fetal 3D ultrasound (US) and Magnetic Resonance Imaging (MRI) have enabled us to study the 3D development of brain structures. As the two imaging modalities measure fundamentally different signals, it may not be appropriate to directly compare their volume measurements, which may be required to track growth when both scan types are used or if a growth reference chart is only available from a single modality. In this abstract, we explore whether there are systematic volume differences between the modalities by comparing the volume of eight brain structures derived from same-day US and MRI scans.

We used 110 same-day MRI and US scan pairs between 18+0 and 26+6 gestational weeks, from the iFIND2 study. Modality-specific deep-learning pipelines were used to segment each scan into 8 regions: intracranial volume (ICV), cortical plate (CP), white and deep grey matter (WDGM), cerebellum (C), thalamus (T), ventricular system (VS), cavum septum (CS) and the brain stem (BS). Poor quality segmentations were rejected through manual inspection, resulting in 93 paired scans. The volume of each structure was then calculated.

Figure 1 shows an example segmentation from a same-day MRI and US scan. The volume measurements, correlation curves, and Bland Altman plots between the two modalities are shown in Figs. 2-4. Excellent agreement between the two modalities, as measured using interclass correlation coefficient (ICC), was found for the C, CS and WDGM (ICC>0.75), with T showing good agreement (ICC>0.60). Volume measurements between the two modalities were found to correlate significantly ($p<0.001$) for all structures except the VS (Fig. 3). Fig 4 shows that for ICV and CP the US-derived volumes are greater than the paired MRI, which is consistent with size and, in turn, gestational age. Poor agreement and large mean absolute error (MAE) as a percentage of the volume is seen for the VS (ICC=0.13, MAE =23.3%) and BS (IC=0.22, MAE =42.1%).

Comparing the volume measurements of eight brain structures between same-day scans revealed three groups. The CS, T, C and WDGM

were found to have comparable volume measurements between the two modalities. ICV and CP volume had a strong correlation but a systematic shift in absolute volume and thus, when comparing the two groups this shift must be accounted for. Finally, in this study, the VS and BS were found not to be comparable, likely due to inconsistent delineation of the structures between the segmentation methods.

P1-I-37 fNIRS as an imaging modality in toddlers with neurodevelopmental conditions: A feasibility study

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Summary: While fNIRS has shown great success in studying preterm clinical populations, its effectiveness is less studied in neurodiverse toddlers. This study evaluates procedures for signal acquisition and processing, further discussing successful strategies to utilize fNIRS in toddlerhood, the earliest age to deliver a reliable diagnosis of ASD.

Details: fMRI studies report promising results on the brain-behavior relationship in attention processing in autism spectrum disorder (ASD) and other neurodevelopmental conditions (NDC). While fMRI is effective in understanding the neural bases of behavior in older children, it is often less feasible in young neurodiverse children. The functional near-infrared spectroscopy (fNIRS), a non-invasive tool with reduced sensitivity to motion artifacts, demonstrates great promise for effective assessments within ASD groups. However, few studies have examined feasibility of implementing fNIRS at the earliest time when autism can be diagnosed.

Participants included 12 toddlers with ASD (M age = 28.8 months, SD=5.8), 24 with NDC (e.g. language, motor delays) (M age = 23.9 months, SD=1.8), and 32 typically developing (TD) toddlers (M age = 26.5 months, SD=3.5). Cortical activity was recorded using the NIRx NIRSport2 system as participants viewed a series of 8-second videos of an actress in which the presence of gaze and speech was systematically manipulated. The data was preprocessed with an in-house pipeline combining python-based MNE-fNIRS packages, MATLAB-based global signal removal tool, R, as well as the channel-to-ROI specificity thresholds of the devFOLD toolbox for region of interest (ROI).

Feasibility measures included: 1) number of participants who were excluded due to fussiness or inattention and 2) the number of optodes above a scalp coupling index threshold of 0.5 for the full head and per ROI (left and right temporal cortex), respectively. Participant loss due to fussiness or inattention was relatively low (ASD: 17%, NDC: 21%, TD: 16%) compared to prior imaging studies with infants (Baek et.al, 2023). The remaining toddlers (ASD: n=10, NDC, n=17, TD, n=27) showed excellent attention to the screen, contributing an average of 26 trials (SD=8.1) across the entire experiment and an average of 6.24 trials (SD=3.6) per condition. The toddlers had an average of 92% (57/62) of valid optodes per subject (SD=6.7) for a full-head measurement and an average of 75% (24/32) of valid optodes in the ROI per subject (SD=5.3). After exclusions due to inattention and optode placement, participants contributed an average of 5.2 (SD=2.1) valid trials per condition, well-above the minimum recommended levels (n=3).

The study demonstrates excellent feasibility of fNIRS implementation in neurodiverse toddlers, which is crucial in establishing this technique's power for future studies.

P1-I-38 MAPSeg: Unified unsupervised domain adaptation for Heterogeneous infant medical image segmentation based on 3D Masked Autoencoding and Pseudo-Labeling

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Summary: This work addresses the challenge of efficiently segmenting rapidly changing infant brain structures without extensive labeled data. MAPSeg, our novel framework, reduces reliance on scarce expert annotations, making advanced neuroimaging more accessible and scalable across diverse research settings

Details: Accurate segmentation of developing infant brains in medical scans is crucial for neurodevelopmental research, presenting significant challenges due to rapid anatomical changes. Manual annotation, although precise, is costly and labor-intensive, making it impractical for large-scale, multi-center, and longitudinal studies. The limited availability of expert-annotated datasets further complicates robust segmentation in this domain.

This study introduces the Masked Autoencoding and Pseudo-Labeling Segmentation (MAPSeg), a novel Unsupervised Domain Adaptation (UDA) framework specifically designed to address these challenges. MAPSeg innovatively combines masked autoencoding with pseudo-labeling to enable effective feature capture and high-quality segmentation without the need for labeled data. This method is particularly advantageous for handling the heterogeneous and dynamic nature of infant brain images, accommodating variations across different imaging scanners, protocols, and developmental stages.

We systematically address these three types of domain shifts in medical image segmentation, demonstrating MAPSeg's adaptability in centralized, federated, and test-time UDA scenarios. Our evaluations on expert-annotated infant brain MRI datasets indicate that MAPSeg achieves a substantial 10.5 Dice improvement over existing methods. These results highlight MAPSeg's potential to revolutionize pediatric brain health by enabling more precise, scalable, and longitudinal neuroimaging studies.

P1-I-39 Comparing preprocessing methods for electroencephalography data to measure changes in relative power as infant reaching skill develops

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Summary: Optimization of infant EEG processing guidelines are crucial to extracting meaningful data and conclusions. This work describes key considerations for analyzing EEG from infants as they reach. Reaching movements are one of the first goal-oriented behaviors; our results will inform neuroscience and early intervention for atypical populations.

Details: Infant reaching movements are indicative of physiological and neurological development (Heineman, 2018). The neurologic changes during this period remain largely under-investigated. Electroencephalography (EEG) is one option but is susceptible to motion artifacts, resulting in low signal-to-noise ratios. In this study, we collected longitudinal data while infants with typical development

(N =14, age range: 2-7 months) engaged in a reaching task using 32-channel EEG recordings and synchronous video capture. Our goals were to 1) investigate whether we can improve the preprocessing pipeline to maximize the signal-to-noise ratio, and 2) provide preliminary evidence describing changes to EEG relative power in frequency bands between visits 1, 3, and 5. We implemented Independent Component Analysis (ICA) for data analysis. We found multiple factors collectively impacting the analysis results, including the number of sample points as controlled by varying the sampling rate of EEG, incorporating a wide frequency band in the signal filter process, decreasing ICA learning rate, and increasing ICA step count, all contributing to improved signal quality by both visual inspection, mean brain IC probability (as determined by iMARA, a machine learning based algorithm for identifying brain IC in infant EEG), and number of brain ICs identified. After preprocessing the data according to the protocol above, we used Repeated Measures Analysis of Variance to test for a significant difference in EEG relative power across visit 1 (little/no reaching), to visit 3 (reaching skill emerging), and visit 5 (skilled reaching). Significant differences (at alpha = 0.10) were found in the theta band (4-6 Hz; p = 0.044), but not in the alpha (6-9 Hz; p = .209) or delta bands (2-4 Hz; p = .132). Conducting a post-hoc pairwise comparison revealed a significant difference between visit 1 and visit 5 (p = 0.09 adjusted for multiple comparisons), with higher theta power in 5. Limitations of this work include that these are preliminary analyses of an ongoing study (intended N = 100) and that we did not explore manually removing EEG artifacts confirmed through video identification during the reaching trials. In future work we plan to conduct additional EEG analyses (source localization and electrode coherence) to explore changes in cortical activity, as well as utilize video coding to isolate only reaching movements. Ultimately, this project will provide insight into changes in neurologic function related to infant learning and development.

P1-I-40 Networks in nonlinear fMRI connectivity are present during infancy and exhibit associations with age

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Summary: We previously estimated functional brain networks from nonlinear resting-state fMRI connectivity, uncovering valuable network information missed by linear functional connectivity analyses. This study seeks to investigate the presence of such networks in infants and their associations with age during critical postnatal periods.

Details: Objective: The objective of this study was to uncover latent network features from nonlinear resting-state fMRI connectivity patterns and their relationships with postnatal age.

Materials and methods: We analyzed resting-state fMRI data from n = 153 infants. Scans were collected using a non-uniform longitudinal sampling design (mean ± standard deviation of age in postnatal days = 105.96 ± 54.42). After implementing standard preprocessing steps, we constructed linear (LIN) and explicitly nonlinear (ENL) connectivity matrices for each scan using our previously developed framework (Kinsey et al., 2023 https://doi.org/10.1101/2023.11.16.566292). Group-level spatial independent component analysis (ICA) was implemented on LIN and ENL datasets via GIFTv4.0 software with model order = 20 to extract large-scale networks. Networks were identified, matched, and labeled according to rigorous criteria. For neurotypical infants, voxel-wise GLMs were used to assess spatial variation between network counterparts and to assess associations with postnatal age. Infants were considered to be neurotypical based on screening for family history of autism, developmental delays, pre/perinatal complications, history of seizures, known medical conditions and genetic disorders, and hearing loss or visual impairment.

Results: We discovered 11 common networks and 1 network unique to each dataset. GLM statistics revealed that LIN and ENL network counterparts exhibit distinct spatial distributions during infancy. For instance, the primary sensorimotor (MTR1) and posterior default mode (pDM) networks exhibit visible ENL-LIN gradients (Fig. 1a). Importantly, we also discovered distinct age association patterns for LIN and ENL networks, with many ENL voxels exhibiting associations missed by LIN, as seen within right frontoparietal (rFP) and unique ENL networks (Fig. 1b).

Conclusions: In conclusion, our results indicate that ENL network counterparts are present during early infancy, are differentiated from LIN via their spatial distributions, and may provide valuable information about brain development that has been missed by standard approaches. Future work will analyze how spatial gradients between LIN and ENL network counterparts change over the course of development from infancy through adolescence and adulthood.

L – Prenatal Programming

P1-L-41 The use of MRI for fetal movement analysis: An exploratory study

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Summary: Fetal movement can serve as an indicator of fetal health. Assessments of fetal movement have relied on maternal perception or ultrasound imaging, which can have limitations. MRI has recently been optimized to capture motion. Could these advances be leveraged to identify body segments and duration of movement? We aimed to report these findings

Details: Background: The optimization of imaging techniques provides a new opportunity to assess fetal motor behavior. Previous studies have documented the successful capture of mid-gestation fetal movement using MR imaging techniques; however, a standardized movement criterion has not yet been validated. Challenges to movement analysis include limited limb segment visibility (fetuses often shift position during the scan) and movement variability (each fetus has a unique movement pattern, which does not occur at regular intervals). Our purpose was to determine the feasibility of using Cine-MRI scans to observe fetal movements. Specifically, we aimed to quantify the visibility and movement duration of body segments. Methods: Thirty-nine datasets were examined from typically developing fetuses. Fetal gestational age at time of MRI ranged from 22 weeks to 38 weeks. Researchers annotated segments of head, trunk, arms, and legs when visible and as moving or not moving when visible. Annotations were analyzed using custom R code to determine the total duration of segment movement for each fetus and to test for associations with gestational age. Results: Fetal movement was observed in 34 of 39 datasets. On average, collectively segments were visible 98% of the time and moved 19% of the time they were visible. Duration of movement ranged from 0-42.93 seconds for head, 0-72.15 seconds for arms, and 0-63.09 seconds for legs. Distributional regression analyses showed that arm and leg movement duration was shorter at greater gestational

age (arms: b = -0.10, p = 0.01; legs: b = -0.08, p = 0.02), whereas head movement duration did not show such trend (b = 0.02, p = 0.69). Conclusion: Fetal MRI and the annotation of fetal movement in a systematic way show potential for establishing a criterion to define a typically developing movement repertoire.

P1-L-42 Prenatal psychosocial determinants of neonatal brain structure: exploring microstructural and volumetric alteration related to the limbic system using structural equation modeling (WIP)

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Summary: This study examines how prenatal psychosocial factors, including parental well-being, mood, and relationships affect newborn brain development. Through questionnaires, we explore their impact on brain structure, aiming to identify protective mechanisms that mitigate prenatal risks and reveal novel insights into vulnerabilities and resilience.

Details: In the present study, we use data from a sample of N = 174 neonates from the FinnBrain Birth Cohort Study to investigate how prenatal parental psychosocial factors—such as maternal and paternal emotional distress, quality of life, resilience, and attachment styles—affect neonatal brain development. Our objectives are twofold: to identify prenatal psychosocial risk and protective factors and to explore how these factors interact with neonatal brain structures (i.e., amygdala, hippocampus) and frontolimbic white matter tracts relevant for emotion regulation. We hypothesise that increased prenatal psychosocial protective factors correlate with larger intracranial volume, smaller amygdala volumes, larger hippocampal volumes, higher global and local fractional anisotropy (FA), and lower mean diffusivity (MD). The mean age of the neonates at scan was 26.66 days (SD = 7.77, range = 11-54 days). Neonates were scanned with a Siemens Magnetom Verio 3T scanner. We conduct exploratory factor analysis of 8 psychosocial questionnaires (EPDS, WHOQoL-8, SCL-90/Anxiety, PRAQ-R2, CD-RISC, PBI, SOC, and ECR-R) completed at gestational weeks 14, 24, and/or 34 to identify latent factors. We then employ structural equation modeling to assess how these factors are related to the neonate's brain structures relevant for emotion regulation, specifically focusing on intracranial volume, amygdala-, and hippocampal volumes, and white matter integrity globally and within specific tracts. The study is pre-registered (https://osf.io/pkbju), and the psychosocial scales meet the assumption checks described in the registration. More detailed results are presented in the congress. Our study has the potential to uncover the interplay of risk and protective mechanisms in determining structural brain development of regions relevant to emotion regulation at the point of development with minimal postnatal influence. This study offers a novel approach to prenatal research by examining a broad range of environmental factors, both positive and negative. It highlights new pathways for addressing vulnerabilities that may lead to psychopathologies, thereby informing prenatal care and public health strategies.

P1-L-43 Fetal head growth and head circumference at birth in offspring of mothers with psychotic disorders and population-based controls (WIP)

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Summary: Offspring of parents with psychotic disorders have a >50% increased risk to develop mental illness. Deviant brain development may underly this familial risk. We previously found a smaller intracranial volume in adolescent offspring of parents with schizophrenia and propose that it may represent anomalous prenatal neurodevelopment.

Details: We investigate the association between the presence of a prenatal maternal psychotic disorder and fetal head growth, suggesting a link between high familial risk for mental illness and altered early neurodevelopment in offspring. We collected fetal ultrasonography assessments (USs) at 20, 30, and 36 weeks of gestational age (GA) from medical records of N=168 pregnant women, who had a diagnosis of a psychotic disorder and at 13, 20, and 30 weeks GA in N=8605 pregnant women participating in the Generation R study. HC was additionally measured in offspring at birth with measuring tape.

At birth, we did not find a significant effect of group on HC (p=.205). However, we found a significant effect of group on birth weight (p<.001, lower in high-risk offspring) and HC/birth weight ratio (p<.001). See Figure 1. At 20 weeks of gestation, HC, HC/abdominal circumference (HC/AC), biparietal diameter, femur length and transcerebellar diameter were significantly smaller in familial high-risk offspring than in controls (all p's<0.04; uncorrected for GA which was on average 20.5 v 20.7 weeks respectively). Analyses on differences in fetal growth trajectories will be presented during the conference.

In preliminary analyses we found that head size at birth relatively to overall body size is larger in familial high-risk offspring. At 20 weeks of GA, we found that several metrics of brain growth were reflective of smaller brains in familial high-risk fetuses compared to controls, however GA was subtle lower. Fetal brain growth trajectories will be presented during the conference. Together, these findings will give us directions for possible underlying neural mechanisms during the prenatal phase related to the intergenerational transmission risk of mental illness.

Legend Figure 1. Differences in birth measurements between offspring of mothers with psychotic disorders (red) and control offspring (blue), plotted by gestational age at birth in weeks. A: Head circumference at birth (in cm) did not differ between groups. B: The head circumference at birth/birth weight ratio was significantly higher in high-risk offspring vs. controls. C: Birth weight (in g) was significantly lower in high-risk offspring vs. controls.

P1-L-44 Using precision functional mapping to assess cortical areas at birth (WIP)

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Summary: This project aims to characterize cortical area boundaries in individual neonates using precision functional neuroimaging. By characterizing cortical area boundaries at the individual-level, rather than the group-level, we aim to reveal individual-specific cortical areas that are established at birth.

Details: Introduction: Cortical areas are fundamental macroscale units of the central nervous system which are defined as contiguous portions of cortex and are distinguished from their neighbors by function, architectonics, connectivity, and topography. Neuroimaging has allowed for the study of cortical areas in vivo in humans, whereby resting state functional connectivity (RSFC) exhibits abrupt transitions between putative cortical areas. Thus, patterns of RSFC can be used to parcellate the entire cortex into discrete areas. Prior work indicates that zones of transition in RSFC patterns across the cortical surface, or "boundaries", between cortical areas are thicker and smoother in group-averaged neonatal data compared to adults. We posit that this is either due to heterogeneity in the exact location of cortical area boundaries across individual neonates, or because the boundaries of cortical areas are not yet established at birth. Thus, we propose to use precision functional mapping (PFM) to characterize areal boundaries in individual infants. We hypothesize that individual neonates exhibit sharp cortical area boundaries at birth, similar to adults, which are not discernable at the group level. Methods: To test this hypothesis, we will characterize cortical area boundaries in eight individual neonates using PFM (42 – 137 minutes of low motion data per neonate). Following the notion that adjacent cortical areas are separated by abrupt changes in function and connectivity, previously established methods will be used to identify transitions in RSFC across the cortical surface. We will use boundary smoothness and boundary reliability to assess whether the boundaries of cortical areas are established and reliable at birth in an individual. Boundary smoothness will be assessed by measuring magnitude of the local RSFC gradient. Boundary reliability will be assessed by evaluating the spatial overlap of cortical area boundaries generated using split halves of each neonate's RSFC dataset and will be quantified using the dice similarity coefficient. Discussion: We predict that cortical areas will have low within-subject smoothness, high reliability, and low similarity with other neonates. If this is true, it supports the notion that neonates have highly individual-specific cortical areas which are established at birth.

M – Variation/Relation to Symptoms

P1-M-45 Preterm toddlers' interactions with their caregivers depend on caregiver behaviors and toddlers' white matter connectivity

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Summary: Preterm birth is associated with disrupted white matter development. Fortunately, warm and contingently responsive interactions with caregivers can support preterm toddlers' development. This novel study investigated the role that toddler white matter connectivity plays in caregiver-child interactions following preterm birth.

Details: Objective: Preterm birth disrupts prenatal brain development and puts children at risk for long-term neurocognitive difficulties. Caregivers are a key source of socioemotional and cognitive support for children born preterm. The current study examined the relationship between white matter connectivity and caregiver-toddler interactions following preterm birth.

Methods: Thirty-five preterm toddlers (15-30 months old) and their caregivers were asked to play together for five minutes. Videos of the play interactions were coded for caregiver warmth, contingent responsiveness, maintaining child's attention, verbal stimulation, and toddler responsive communication and initiating social engagement. Diffusion MRI data was collected from toddlers during natural sleep. Fractional anisotropy (FA) was extracted from a self-regulation network (i.e., bilateral hippocampus, amygdala, ACC, and medial SFG) and a language network (i.e., bilateral IFG and STG). We compared multiple regression models predicting toddler outcomes from gestational age at birth and adjusted age; parent behaviors; and FA.

Results: The extent to which toddlers responded to caregivers during the interaction depended on both parent behaviors and toddler brain structure. Caregivers who exhibited more contingent responsiveness (beta = 0.38), maintaining child's interests (beta = 0.43), and verbal stimulation (beta = 0.32) had toddlers who were more responsive. FA in both the language network and self-regulation network explained additional variance in toddlers' responsive communication with their caregivers, such that greater FA was associated with less responsive communication (betas ranged from -0.35 to -0.46). The extent to which toddlers initiated social engagement was related to caregiver behaviors, but not toddler brain structure: greater caregiver contingent responsiveness (beta = 0.49) and maintaining (beta = 0.55) predicted greater social initiation by the child, regardless of FA.

Conclusions: Warm and contingently responsive caregivers who maintained their child's interests had more socially responsive and initiative toddlers. At the same time, preterm toddlers with more mature white matter connectivity were less responsive to their caregivers, perhaps reflecting an increased desire for independence, which is typical of toddlers this age. These results highlight biological and environmental factors that converge to predict toddler development following preterm birth.

POSTER SESSION 2
THURSDAY, SEPTEMBER 26, 2024 15:25 - 17:00

A – Big Data

P2-B-1 Is tactile sensory processing regulation in preterm neonates an early determinant of neurodevelopmental outcomes at age 2 years (WIP)

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

[1]*University of Caen Normandy*

Summary: Years of research on neurodevelopmental disorders have yielded limited understanding. Our innovative approach merges recent findings on neonatal perception & attention, emphazing tactile perception's role in cognitive development. Using EEG, our study on high-risk preterm babies seeks early predictors of neurodevelopmental outcomes at age 2.

Details: Background: Premature birth heightens the risk of later Neurodevelopmental Disorders (NDD). However, this link remains to be fully explained, and we lack reliable vulnerability markers that would allow us to propose early screening and effective interventions. Exploring sensory processing regulation holds promise: a core process in cognitive development is sensory prediction (SP), which modulates sensory processing via repetition suppression (RS) during irrelevant stimuli or amplification during relevant ones. NDDs often entail sensory deficits, especially tactile. Altered tactile SP and RS may constitute early mechanisms of cognitive deficits seen in autism and attention disorders. This study assesses tactile SP and RS in preterm babies and their link with neurodevelopment at 2 years.

Methods: At 35 weeks of corrected Gestational Age (GA), we measured EEG evoked potentials in 62 preterm infants born between 26 and 34 weeks GA, during a tactile oddball-omission paradigm (290 vibrations on the forearm). The first and last 40 stimuli served as standards for assessing RS. Interspersed were blocks of stimuli (5 standards, 1 deviant, and an omission in pseudo-random order). All patients take part in an ongoing 2-year follow-up with NDD screening, cognitive and social milestone assessments (BRIEF-P/ESSENCE 2-5, ASQ), neurosensory evaluation (Dunn Sensory Profiles), and sleep quantity/quality analysis. Neonatal somatosensory processing measures will be compared with these outcome measures.

Results: Prematurity significantly influences somatosensory processing measures: lower GA at birth is associated with greater RS ($r=0.38$, $p=.002$), increased EEG amplitude during stimulation omission ($r=0.33$, $p=.007$), but lower amplitude of the mismatch response to deviants ($r=0.49$, $p<.001$). Preliminary findings from the first 25 patients with outcome measures at age 2 will be discussed, emphasizing the link between the three neonatal measures and attention/executive functions assessments.

Discussion: Sensory processing is modulated in premature infants at term equivalent age, potentially compromising subsequent sensory development and impacting neurodevelopment. Our cohort's 2-year follow-up, including NDD screening and cognitive assessments, will elucidate whether neonatal somatosensory processing predicts cognitive development at 2 years. If so, these measures could act as early predictors for neurodevelopmental outcomes in at-risk patients, guiding preventive strategies.

B – Clinical Populations

P2-B-2 Language learning in sync: How child EEG power and parent-child synchrony during naturalistic interaction relate to child language ability and disorder risk (WIP)

Brittany Manning[1], Julia Nikolaeva[1], Soujin Choi[1], Serena Mon[1], Judith Licht[1], Ania Holubecki[1], Jiyoon Kim[1], Lauren Wakschlag[1], Elizabeth Norton[1]

[1]*Northwestern University*

Summary: Measuring behavioral and neural synchrony and assessing the brain during naturalistic interactions are important new frontiers in developmental cognitive neuroscience that may offer new insights into early indicators of child abilities, especially language, which is learned via social interaction.

Details: Parent responsiveness and language input promote child language development, but little is known about how parent-child behavioral and neural synchrony relate to child language skills. Here, we examine parent-toddler synchrony (behavioral and neural) in ~150 2-year-olds oversampled for child late talking and irritability, risk factors for later language and mental health disorders. Dyads interacted naturally during EEG recording from the parent and child. Dyads participated in varying contexts designed to create opportunities for more or less social engagement including: social interaction (puzzle play, book reading), a non-interactive shared activity (watching a movie but not interacting) and non-interactive separate activities (child watching a movie, parent fills out forms). Videos were coded for dyadic state (adapted from Adamson et al., 2004): social engagement (joint engagement or person engagement) and object engagement (i.e., movie watching, coded as separate or parallel object engagement). For child analyses, EEG data were processed using EEG/ERP Lab in MATLAB. We analyzed child EEG power in alpha and theta frequency bands and asked whether EEG power differed during moments of social engagement compared to non-social engagement. Across language abilities, child EEG power showed alpha suppression ($p<.001$) and theta enhancement ($p<.01$) during social engagement relative to non-engagement. Next, dual parent-child EEG data will be processed using the DEEP hyperscanning pipeline. In progress analyses will examine whether behavioral and neural synchrony differs across the social interaction, non-interactive shared activity, and non-interactive separate activities contexts. We will also examine whether behavioral and neural synchrony during the social interaction context is associated with toddler language ability. We will consider how behavioral synchrony (% of time spent in social engagement) and neural synchrony (inter-brain power correlation/phase locking values in alpha and theta bands) between the parent and child relate to concurrent child language ability and whether neural synchrony adds predictive value above current behavioral measures. Findings from this work will reveal how moments of synchronous parent-child interaction may support the development of language skills, including in a clinical at-risk population (late talkers).

P2-B-3 Mapping prenatal depression variation and its association with infant brain connectivity

Vinus Mahmoodi[1], Janel Excell[1], Sanjana Inala[2], Bin Cheng[3], Dustin Scheinost[4], Marisa Spann[1]

[1]Columbia University, [2]Columbia University, Vagelos College of Physicians and Surgeons, [3]Columbia University Irving Medical Center, [4]Yale School of Medicine

Summary: This study aimed to characterize the variance of depressive symptoms across gestation and identify their associations with amygdala and hippocampus functional connectivity.

Details: Prenatal depression is a significant risk factor for women to develop postpartum depression, medical complications, and adverse neonatal brain development. Studies have shown that prenatal depression associates with functional connectivity of the amygdala and hippocampus. However, most of these studies characterize prenatal depression at a single timepoint or as an average over all of pregnancy. Therefore, this study aimed to characterize the variance of depressive symptoms across gestation and identify their associations with amygdala and hippocampus functional connectivity.

As part of a larger study, healthy, pregnant participants completed the Patient Health Questionnaire-9 (PHQ-9) across pregnancy at three time points, roughly once per trimester. Of the 109 women recruited for the study, 82 completed at least two prenatal sessions. Few demonstrated a change in their depression score. 9% of participants were characterized as depressed. Mean and standard deviation scores of the PHQ-9 were calculated. Imaging data was collected for twenty infants scanned between 0-6 months. Standard fMRI preprocessing was performed. Functional connectivity for each subject was constructed with the 90-node infant atlas. Connectivity values for the hippocampus and amygdala were extracted. Values for the left and right hippocampus (and amygdala) were combined, resulting in 89 hippocampal connections and 89 amygdala connections to associate with PHQ-9 scores.

Five hippocampal connections and one amygdala connection significantly correlated ($p<0.05$) with the mean PHQ-9 scores. In contrast, one hippocampal connection and seven amygdala connections significantly correlated ($p<0.05$) with the standard deviation of the PHQ-9 scores.

Overall, we found that prenatal exposure to maternal depression symptoms correlated with infant functional connectivity of the amygdala and hippocampus, aligned with previous literature. However, these correlations mapped on to different aspects of maternal depressive symptoms over time. Amygdala functional connectivity mapped better on to variation of PHQ-9 scores over pregnancy, while hippocampal functional mapped better on the average of PHQ-9 scores.

P2-B-4 Reduced cortical hemodynamics of ostensive cues in temporal regions in toddlers with ASD

Angelina Vernetti[1], Suzanne Macari[1], Katarzyna Chawarska[1]

[1]Yale School of Medicine

Summary: Conducting fMRI studies with very young children with autism, especially toddlers, presents practical challenges due to their limited ability to remain still during scans. To address this gap, our study employed fNIRS to examine temporal cortical activity in responses to gaze and speech in toddlers with autism.

Details: Limited attention to the faces of social partners represents one of the earliest and best replicated markers of autism spectrum disorders (ASD). This decreased attention is detectable as early as 6 months of age (Chawarska et al, 2013; Shic et al., 2014; Macari et al., 2021) and it is most pronounced when children observe a person using canonical ostensive cues for social engagement, a combination of eye contact and infant directed speech (Chawarska et al., 2012; Shic et al., 2020). Over the past two decades, substantial neuroimaging work (fMRI, DWI, fNIRS) in infants and adults has been conducted with the aim of characterizing brain-based biomarkers of ASD and uncovering insights into autism etiology. The so-called "social brain" regions, including the bilateral superior temporal sulcus (STS) - temporoparietal junction (TPJ) regions, are frequently implicated in ASD (for review, see Sato & Uono, 2019). However, the practical difficulties to conduct fMRI studies with young children have prevented to examine brain responses to social signals in autism during toddlerhood, a critical period during which early autism diagnosis becomes reliable. Here we present the findings of an fNIRS study examining temporal cortical activity in toddlers (Mean age= 22.4months, SD=4.3) with ASD (n=10) and typically developing toddlers (n=22) when exposed to the ostensive cues consisting of a combination of direct gaze and infant directed speech compared to displays when both types of cues were absent. TD toddlers exhibited a reliable hemodynamic response to gaze and speech in both left and right temporal regions. In contrast, toddlers with autism showed a reduced neural response to ostensive cues in temporal hemispheres compared to their TD peers (see Figure 1). This is the first study demonstrating reduced hemodynamic responses in awake toddlers with ASD corroborating behavioral biomarker of diminished attention to ostensive cues in ASD. The study is ongoing, and we hope to present a larger sample of toddlers with autism at the time of the conference.

C – Cognitive Development

P2-C-5 Examining the spatial scale of infant visual representations using deep neural network models and awake fMRI

Áine Dineen[1], Cliona O'doherty[1], Anna Truzzi[1], Anna Kravchenko[1], Lorijn Zaadnoordijk[1], Alex Wade[2], Graham King[1], Chiara Caldinelli[3], Enna-Louise D'arcy[1], Jessica White[1], Tamrin Holloway[1], Eleanor Molloy[4], Adrienne Foran[5], Angela Byrne[6], Ailbhe Tarrant[5], Rhodri Cusack[1]

[1]Trinity College Dublin, [2]University of York, [3]University of California, Berkeley, [4]The Coombe Hospital, Trinity College Dublin, [5]The Rotunda Hospital, Children's Health Ireland, Temple Street, [6]The Coombe Hospital, Children's Health Ireland at Crumlin

Summary: We probed the spatial extent of the features used to represent objects across the ventral visual stream in infancy, to further understanding of the development of visual object representations.

Details: Human adults preferentially use global shape to classify objects, requiring extended spatial integration, while deep neural networks (DNNs), computational models of the ventral visual stream (VVS), tend to rely on high spatial frequency, local object features. We investigated whether the infant VVS has a bias in the spatial extent of the features used to represent objects, hypothesising that the distribution of features would change across development. We used functional MRI (fMRI) to characterise the representational geometry of the early visual cortex (EVC) and ventral temporal cortex (VTC) in awake 2-month (N=103) and 9-month-old (N=37) infants and adults (N=17) as they viewed 36 high resolution images, comprising 12 objects with 3 exemplars. DNN models (ResNet-50) were trained on

1000 categories of objects (ImageNet), with varying levels of smoothing (gaussian blur with sigma ranging from 0-6 pixels), which increases the propensity of the network to preferentially use global over local object features. Network representational geometry was calculated for the same set of high resolution stimuli and also for transformed versions of the stimulus set, stimuli were smoothed (gaussian blur with sigma ranging from 0-6 pixels), scrambled, or centre cropped. Representational similarity analysis was used to compare the representational geometry of each layer of the DNNs for each test stimulus set with that of the EVC and VTC for each cohort. Correlation was then averaged across layers. For both regions, the infants and adults shared a considerable portion of representational geometry with the DNNs (Spearman r~0.2-0.5). For blurry trained networks tested on high resolution stimuli, higher levels of blur correlated more with the brain for all cohorts in EVC and VTC. These correlations decrease for all cohorts when the networks' test stimuli are scrambled or centre cropped, suggesting that global shape and low spatial frequency features are already important at 2-months. When test stimuli were blurred to match training blur, the advantage of blurry training dissipated, indicating that a mismatch between training and test feature distributions is key. Our results suggest that global shape and low spatial frequency features are already important characteristics of visual representations at 2-months.

P2-C-6 Learning language from the social environment: The role of contingent responsive caregiving in shaping infant brain development to support language learning in the first two years of life

Sonja Hunter[1], Ruohan Xia[2], Zoe Pestana[2], Olufemi Shakuur Nyabingi[3], Serena Mon[4], Aditi Hosangadi[2], Tahli Frenkel[5], Lindsay Bowman[2]

[1]University of California Davis, [2]University of California, Davis, [3]University of California - Davis, [4]Northwestern University, [5]Reichman University

Summary: Decades of research have investigated language development, exploring factors like child-directed speech, statistical learning, joint attention, and social interactions. However, little is known about how these factors interact, and what the underlying neurological mechanisms are that shape language acquisition within the social environment.

Details: Recent theory (Masek et al., 2021) proposes a framework suggesting that the social context progressively provides attentional cues (i.e. joint attention) for language learning, culminating in proficient language. This highlights the importance of investigating how the evolving social context shapes language acquisition. However, research often examines contributors to language learning in isolation, limiting our understanding of their combined effect on language. Furthermore, the neurological mechanisms underlying the influence of the social environment on language remain largely unexplored. A neuroscientific approach to study how the social environment shapes language learning is critical given that neural circuitry foundational to infant cognition is thought to be 'wired up' in social interactions within the first year of life (Atzil et al., 2018). The present study provides the first empirical test of the hypothesis that early contingent interactions with caregivers at 4 months influences infants' neural activity to support social attention (i.e., joint attention) at 12 mo that then facilitates emerging language at 12 and 24 months. Longitudinal data collection is ongoing (N 4mo = 68, N 10-12mo = 45, N 24mo = 12), but preliminary results from a separate analyzed sample demonstrate initial support for aspects of the proposed model: Maternal contingent responsiveness at 4 months (unstructured free play coded using the Coding Interactive Behavior scales [CIB]; Feldman, 1998) predicts infant vocalizations and attempts to initiate joint attention at 4 and 10-12 months (unstructured free play using CIB) (Figure 1), and infants' neural responses (event-related EEG during live contingent interactions with their caregivers), are related to infants' communicative attempts and attempts to initiate joint attention (assessed with CIB) (Figure 2). Additional analyses will examine how maternal contingent responsive caregiving, infant joint attention, and infant neural responses to contingent interactions and joint attentive interactions with caregivers predict language measures such as the MaCArthur Communicative Development Inventory.

P2-C-7 Resting state functional connectivity associated with gross motor skill at 4-months

Caroline Groves[1], Sydney Takemoto[2], Nathan Fox[3], Courtney Filippi[1]

[1]New York University, Langone, [2]NYU Grossman School of Medicine, [3]University of Maryland

Summary: This study aims to identify neural correlates of gross-motor skill at an age where this has never been explored but when gross motor development is rapidly changing.

Details: Developments in gross motor skill facilitate new ways for infants to explore the environment and opportunities of social interaction (Adolph & Robinson, 2015). Yet, to date, we know little about the neural basis of gross motor development in infancy. To date, limited work has examined neural correlates of motor development in the fetal (Thomason et al, 2018) and 12-month-old brain (Marrus et al, 2018). However, no studies have been done in the first six months of life. The current study aims to identify resting state functional connectivity (rsfc) associated with gross motor skills at 4-months of age.

Full-term 4-month-olds (N = 33, Mage = 4 months 21 days, SDage = 15 days; 13 male) participated in a functional magnetic resonance imaging (fMRI) study. Parents reported on their infant's motor skill using the Early Motor Questionnaire (Libertus & Landa, 2013). Resting state fMRI was estimated across 200 regions of the brain (7 networks). Enrichment methods were used to identify networks that showed a higher density of significant brain-behavior associations than expected by chance. Permutation was used and multiple testing correction was applied. Associations between rsfc and gross motor skill were modeled controlling for fine motor skill and perceptual-action abilities, age, sex, and framewise displacement.

Results demonstrated that gross motor skill was negatively associated with connectivity within the visual network ($p = 0.020$) and between Control-Limbic networks ($p = 0.033$, See Figure 1). The negative association between gross motor skill and network connectivity was strongest within the visual network (~95% of associations were negative; See Figure 2). In contrast, the significant relation between gross motor skill and Control-Limbic network connectivity was negative for 53% of node pairs (See Figure 2). Visualization of the Control-Limbic associations suggest that positive associations were found between the posterior cingulate/parietal regions- orbitofrontal cortex. Whereas, negative associations were found between parietal/lateral PFC- temporal poles.

These unexpected results suggest that individuals with greater gross motor skills show less connectivity within the visual network, more connectivity within some regions of the Control-Limbic network and less connectivity within other regions of the Control-Limbic network. These findings differ from associations reported from the fetal brain and 12-month-old infants.

P2-C-8 Longitudinal changes in the infant attention-related brain networks

Courtney Filippi[1], Alice Massera[2], Anderson Winkler[3], Sydney Takemoto[4], Caroline Groves[1], Dana Kanel[5], Jed Elison[6], Daniel S. Pine[7], Nathan Fox[8]

[1]New York University, Langone, [2]NYU Langone Health, [3]The University of Texas Rio Grande Valley, [4]NYU Grossman School of Medicine, [5]National Institute of Mental Health, [6]University of Minnesota, [7]Section on Development and Affective Neuroscience, Emotion and Development Branch, NIMH, [8]University of Maryland

Summary: Identifying brain network change is challenging. Limited data have used a data-driven approach on longitudinal MRI data understand resting state networks change over the first years of life.

Details: In infancy, attention plays a foundational role in learning and develops rapidly over the first few years of life. At present, we know relatively little about how attention-networks in the brain develop (Gao et al., 2013; 2015). This study uses the Baby Connectome Project (BCP) dataset (Howell et al., 2019) to characterize longitudinal changes in intrinsic functional connectivity in the salience, executive control, and visual networks of the brain using a data-driven approach to network identification.

To evaluate changes in resting state brain networks from 0–2 years, we used the BCP dataset (n=180). On average, each infant contributed 2.29 (range=1–6) longitudinal timepoints of fMRI data (396 imaging visits total). Group-level Independent Components (IC) Analysis was conducted to identify attention networks of interest: salience, executive control, and primary visual networks. All infants/timepoints contribute to the group network identification process equally. Figure 1 for group-level spatial map. Dual regression was conducted to generate subject-specific spatial maps and associated timeseries. Figure 3 depicts group-level functional connectivity matrix with clustering. Regression was used to identify age-related change in rs-FC controlling for sex, maternal education, income, and framewise displacement. Permutation testing was used to determine statistical significance.

Results indicated that infants exhibited two networks anchored by nodes of the canonical salience network: one network (Figure 1 – IC1) was anchored by the insula/mid-cingulate/supplementary motor cortex and a second network (Figure 1 IC12) was anchored by the medial PFC. There were also two networks anchored by nodes of the executive control network (Figure 1 – IC7 and IC13)—these two networks represented spatially independent regions of the lateral PFC. Results further demonstrated that insula/mid-cingulate/supplementary motor cortex – Medial PFC connectivity significantly increased over time (Eta Squared=.137, pFWER<.008; See Figure 3). There were significant age-related decreases in Visual – PFC1 (Eta Squared=.13, pFWER<.045) and Visual – Medial PFC (Eta Squared=.10, pFWER<.021) connectivity. No other age-related changes were observed.

To conclude, over the first two years of life communication within the salience network (greater integration) and between the visual system and PFC (less integration) changes. Ongoing work is determining how these changes relate to toddler attention.

P2-C-9 Comparing infant-aligned artificial neural networks' (ANNs) categorization of objects to actual infant EEG (WIP)

Matthew Rooney[1], Kira Ashton[1], Olivia Lowman[1], Benazir Neree[1], Richard Aslin[2], Alexis Black[3], Lauren Emberson[3], Laurie Bayet[1]

[1]American University, [2]Yale University, [3]University of British Columbia

Summary: ANNs' power to model the development of visual object categorization in infancy has limitations. This research compares leading ANNs to actual infants. Establishing such a similarity benchmark is a first step to motivate/inform further development of more infant-aligned models that can better account for the development of the human visual stream.

Details: While there has been impressive progress in the ability for artificial neural networks (ANNs) to categorize visual objects in ways that parallel human performance, these models are unrealistic in accounting for the development of visual object categorization in infancy. Infant object categorization is not based on the millions of image inputs to current "adult" ANNs, but rather must rely on a more limited set of inputs to which a typical infant is exposed during the first year or two of development. Consequently, a model which excels in general object categorization may not necessarily be the best at representing infant object categories. Recently, new ANN models such as TC-SAY-resnext RDM (Orhan & Lake, 2023) have started to bridge this gap by utilizing current self-supervised deep learning methods paired with developmentally realistic natural videos recorded from the infant's perspective. The current study seeks to establish the extent to which such newer, infant-aligned ANN models can account for how human infants represent visual objects.

We will compute representational dissimilarity matrices (RDMs) for visual objects using both the consensus "adult" ANN (Figure 1) as well as the infant-aligned TC-SAY-resnext ANN and compare these ANN model RMDs with RDMs computed from infant brain responses using these same visual objects (Figure 2). The TC-SAY-resnext RDM will be created by using cosine similarity applied to model outputs (Ito and Murray, 2023). The infant-derived RDMs were created using pairwise multivariate classification accuracy, estimated within participants, to classify images based on spontaneous EEG responses collected from infants 12-15 months as they viewed these images. Stimuli consisted of 16 images of 8 commonplace items known to infants (e.g. cat, dog, bottle). Using representational similarity analysis (RSA) with Spearman's correlations and permutation-based cluster-correction for multiple comparisons across the EEG time-points, we will examine the differences between the two types of RDMs. Findings hope to show that the infant-aligned TC-SAY-resnext ANN are more similar to the EEG-based infant RDMs than the adult model RDMs. Establishing such a similarity benchmark advances the computational understanding of early high-level visual development. Ultimately, such findings may inform the future development of even better infant-aligned ANN models that provide a more accurate account of the development of the human visual stream.

P2-C-11 Infant communication outcomes relate to language network connectivity in utero

Rutva Master[1], Emily Nichols[1], Emma Duerden[1], Sandrine De Ribaupierre[1], Roy Eagleson[1]

[1]Western University

Summary: The fetal auditory system matures in utero, enabling sound perception. The predictive value of in utero brain connectivity for language outcomes is unclear. There is a link between language disorders and conditions like ASD. This study uses rs-fMRI to explore fetal brain connectivity and improve early diagnosis and interventions.

Details: Evidence suggests the language network begins to develop in utero; however, whether connectivity strength can predict short-term language outcomes is unknown. To fill this gap, this study utilized resting-state functional MRI data to examine the functional

connectivity of the language network with cognition-related brain regions in utero, and how it relates to developmental outcomes. 29 pregnant women were scanned during the third trimester (27-40 weeks) using resting-state MRI and then completed the Ages and Stages Questionnaire, version 3 (ASQ-3) when infants were 3 months of age. Infants were divided into high-communication and low-communication groups based on the communication subscale (median split). Resting-state functional MRI data was used to evaluate functional connectivity patterns between Heschl's gyrus and the frontal and temporal lobes of the brain. Left Heschl's gyrus showed significant functional connectivity with the precentral, inferior frontal, and middle frontal gyri in the high communication group. In contrast, low-communication infants showed no significant functional connectivity between regions of Heschl's gyrus and the frontal lobe. The interhemispheric connectivity between these regions was further assessed. In infants with high communication skills, critical language-processing areas such as the pars triangularis and pars opercularis that make up Broca's area exhibited robust connectivity both within and between hemispheres with regions of the temporal lobe like Heschl's gyrus. The enhanced functional connectivity observed in high-communication infants suggests a more efficient and widespread neural network supporting language skills, emphasizing the importance of early life development in shaping subsequent communication abilities. Identifying specific functional connectivity patterns associated with later communication skills may inform targeted interventions for infants at risk of language delays.

D – Developmental Psychology

P2-D-12 Trajectories of vocabulary growth in toddlerhood and later language outcomes: Relations to EEG power and coherence (WIP)

Julia Nikolaeva[1], Brittany Manning[1], Soujin Choi[1], Lauren Wakschlag[1], Elizabeth Norton[1]

[1]Northwestern University

Summary: Understanding toddlers' vocabulary development is crucial for early identification of language disorders. Baseline-state EEG has been proposed as an early marker of language ability. It is unknown whether EEG measures are associated with distinct trajectories of vocabulary growth, and how both contribute to prediction of language outcomes.

Details: This study aims to examine whether EEG power and coherence at one point in toddlerhood (age 2 years) is associated with distinct trajectories of vocabulary development from 18-36 months, and whether EEG and vocabulary trajectory group predict language at 5-8 years. Analyses will explore EEG power in theta (4-6 Hz), alpha (6-12 Hz), and gamma (30-50 Hz) frequency bands, which have been linked with language abilities in children. Analyses will also include EEG coherence in these bands, given their role in facilitating communication between brain regions/networks that underlie cognitive and language development.

We will analyze data collected from 138 children with baseline EEG data at age 2 and caregiver-reported vocabulary size at multiple timepoints between 18-36 months. Approximately ~40% are late talkers; defined based on clinically validated criteria for vocabulary size and combining words at age 2, and who are thus at higher risk for language disorders. We conducted growth mixture modeling (GMM) to subgroup toddlers based on their underlying growth trajectories (latent classes) of vocabulary size over time. The Figure shows the model with optimal fit based on objective characteristics (e.g., entropy, BIC/AIC) which identified three classes, aligning with theorized and clinically observed patterns: a) typical language growth (64% of children), b) early delay with remitting/improving growth (25%), and c) early delay with persistent difficulty (11%). Proposed analyses: we will conduct separate multinomial logistic regressions with latent class of vocabulary growth as the dependent variable and 2-year EEG as the independent variable. EEG power will be investigated in five brain regions (frontal, central, parietal, right/left temporal), employing FDR correction for multiple comparisons. EEG coherence will be investigated in frontal-parietal and left-right temporal regions. Next, we will conduct multiple regression with language ability at age 5-8 as the dependent variable, and latent class of vocabulary growth and EEG as predictors. EEG measures most strongly associated with latent class will be used in the longitudinal model. Demographic covariates associated with language are included in all models. This study will support the understanding of vocabulary development in relation to EEG and later language, thus advancing the use of EEG markers in early identification of language disorders. Funding Source: R01DC016273.

P2-D-13 Topographic organization of gray matter microstructure in one-month-old infants

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

Summary: Recent investigations have revealed that the brain develops along a hierarchical sensorimotor–association (S-A) axis, which were evidenced in cortical volume and connectivity, but remains unknown in GM microstructures. The current project aims to characterize the topographical organization of GM microstructures in one-month-old infants.

Details: Individual differences in gray matter (GM) structure have provided key insights into neurological disorders, psychopathology, cognitive functioning, and development. The human cortex undergoes remarkable growth during the first months of life, with significant increases in volume, cortical thickness, and myelination. These macrostructural changes are well-documented, but the underlying microstructural development remains unknown. Advanced multi-shell diffusion-weighted MRI and multicompartmental modeling offer a promising path to delineating the complex features of GM at the microstructural level. Specifically, Neurite Orientation Dispersion and Density Imaging (NODDI) provides measures for the Neurite Density Index (NDI) and the Orientation Dispersion Index (ODI). Within the context of cortical GM, NDI indexes myeloarchitecture (density of myelinated axons and dendrites), and ODI reflects cortical cytoarchitecture (axonal and dendritic complexity).

We collected dMRI data from 84 infants aged 2.29-6.13 weeks, with 32 and 64 directions with b-values of 700 and 2000 s/mm^2, respectively. Preprocessing included noise estimation and removal, along with eddy and susceptibility distortion corrections using MRtrix3 and FSL. We are manually editing image segmentations and anticipate completing segmentations for ~60 subjects by the conference, enabling detailed analysis of NDI and ODI across the cortical surface. We will compute NDI and ODI using the NODDI Matlab Toolbox. We hypothesize that at one month old, infants will exhibit higher NDI and ODI in primary sensorimotor and visual regions, and lower values in transmodal association areas. To test this, we will perform Spearman correlations between regional indices of NODDI metrics and regional rankings of the previously identified S-A axis (Sydnor et al., 2021), expecting a strong correlation.

Initial pilot analysis on one subject with accurate segmentation revealed higher NDI and ODI values in the parietal and occipital lobes, and lower values in the prefrontal and temporal lobes, indicating a potential systematic variation along the S-A axis.

This project will, for the first time, characterize the topographic organization of GM microstructure in one-month-old infants, advancing the theoretical understanding of GM microstructural profiles and facilitating future studies on potential links between individual differences in GM microstructure and infant development.

P2-D-14 Neural tracking in infants: Understanding accent familiarity and its role in speech processing

Holly Bradley[1], Anna Czepiel[1], Christina Vanden Bosch Der Nederlanden[1], Elizabeth Johnson[1]

[1]University of Toronto

Summary: Our research addresses how neural processing varies with accent familiarity. Preliminary findings show stronger neural tracking for unfamiliar accents at lower frequencies and familiar accents at higher frequencies.

Details: Neural activity synchronises to the amplitude envelope of speech (e.g. Leong et al., 2017), in a process called neural tracking. How neural tracking is modulated by infant listening preferences is poorly understood. The relationship between adults' neural tracking and behavioural speech outcomes also remains unclear, with some studies indicating that greater neural tracking relates to greater comprehension (e.g., Peelle et al., 2013) and others finding it relates to worse comprehension (e.g., Song & Iverson, 2019). In the current study, we test infant speech preferences by manipulating accent familiarity. If neural tracking reflects easier speech processing, we hypothesise that neural tracking will be higher in sentences spoken in a familiar accent compared to an unfamiliar accent. If neural tracking reflects more difficult speech processing, we hypothesise that neural tracking will be higher in sentences spoken in unfamiliar accents. These hypotheses and the methods have been preregistered (embargoed in Open Science Framework). Infants (current n=6, goal n=40) aged 7-8 months were exposed to familiar (Canadian accented English) and unfamiliar (Mandarin accented English) sentences (total sentence n = 320) while their neural activity was recorded. Neural tracking was assessed as the phase coherence between the amplitude envelope and EEG channels for frequencies up to 40 Hz, each accent condition (familiar/unfamiliar).

Our preliminary findings show that neural tracking appears stronger for the unfamiliar accented speech at lower frequencies (4-8 Hz), but stronger for familiar accents at higher frequencies (~10Hz). As lower frequencies are associated with syllabic processing (Meyer, 2018), our results may indicate that listeners are following the prosodic structure of the unfamiliar accent. In contrast, higher frequencies are typically linked to rime and onset (Goswami, 2022) suggesting that listeners are focusing more on the phonemic details of the speech. This shift in frequency processing may indicate that the cognitive strategies employed by listeners vary depending on accent familiarity, with a higher reliance on fine phonetic discrimination for familiar accents and a broader prosodic focus for unfamiliar ones.

P2-D-15 Associations between functional brain development and cognitive abilities in children born into poverty (WIP)

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Summary: Children living in poverty show lower scores in assessments of school readiness. The evidence linking brain activity as a key factor in these disparities is sparse and conflicting. This study will present the largest investigation to date linking brain activity among children born into poverty to cognitive and language skills.

Details: A growing body of research has detailed associations between family income and children's functional brain development. Theory and empirical work suggest that early patterns of functional brain activity lay the groundwork for and support cognitive abilities. Resting state electroencephalography (RS-EEG) is a passive and non-invasive neurophysiological method ideal for studying features of children's brain activity at rest. While theory suggests that there should be longitudinal and concurrent relations between RS-EEG power and cognitive and language skills for children living in poverty, the empirical evidence is sparse and sometimes conflicting. Here we propose the largest investigation to date linking functional brain development among children born into poverty to neurocognitive functioning. We will leverage RS-EEG data from 1- and 4-year-old children (estimated n= 400) in the low-cash gift group of a randomized control trial of poverty reduction in early childhood (The Baby's First Years Study). Using linear regressions, we will examine the associations between RS-EEG power in the age-adjusted theta, alpha, beta, and gamma bands in infancy (age 1), in early childhood (age 4), and how changes in RS-EEG power between age 1 and age 4 contribute to age 4 measures of executive function (MEFS), vocabulary (Receptive One-Word Picture Vocabulary Test), visuospatial reasoning (Matrices subscale of the Wechsler Nonverbal Scale of Ability), and early literacy (Reading House). Understanding the contributions of individual brain frequencies to cognitive and language measures will not only advance our understanding of how early brain signals support thinking and learning , but it may also inform the design of targeted screenings and interventions for children who have experienced poverty.

P2-D-16 Infants' perception of partially visible objects: Pilot studies (WIP)

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Summary: Infants as young as 2 months can recognize partially hidden objects as a unified object (Johnson, 1995). However, the mechanisms that support this process in infants are not fully understood. We aim to validate a set of stimuli partially obscured by visual noise, to understand the underlying neural mechanisms of partial object perception.

Details: As a first step in determining the neural basis of how infants process partially occluded objects we seek to create a set of stimuli whose visual features are obscured by visual noise but nevertheless are sufficient to support object perception. Images of common objects were paired with pure phasic noise patches to create a set of image-noise pairs (Fig. 1B). Both images and noise patches were then partially obscured at different visibility levels using Gaussian bubbles (e.g., Gosselin & Schyns, 2001). Bubbles are randomly placed on the image to reveal a portion of the image plane. Visibility level is determined by the percentage of image pixels visible based on the number of bubbles placed. The 16 different images presented are commonplace items infants can easily recognize, such as a bottle, banana, or dog. Visibility levels of 10%, 20%, 25%, 30%, 40%, 50%, 60%, and 100% (Fig. 1A) were generated for each image-noise pair, to

estimate psychometric curves. In ongoing pre-registered (AsPredicted #167473) behavioral validation studies, infants aged 12-15 months are participating in looking-times tasks using the platform Children Helping Science (formerly known as Lookit). In the first study, infants are shown the image-noise pairs, and differential looking times are measured and coded from recorded video using the programs Datavyu and ICatcher+. Because infants tend to look longer at objects than pure noise, differential looking times towards the partially obscured images will identify the threshold visibility level by which infants can distinguish a partial object from noise. Using the threshold visibility level determined from the initial study, infants in a future study will then be presented with partially occluded images while their neural activity is measured using electroencephalography (EEG).

P2-D-17 Untangling brain and behavioural measures of visual statistical learning over the first postnatal year (WIP)

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Summary: We aim to understand whether the infant brain can extract visual regularities during stimulus exposure and whether this is reflected by post-exposure behavioural learning outcomes. Further, we aim to track how these neural and the behavioural measures of statistical learning evolve over the course of the first postnatal year.

Details: Thus far, most evidence of visual statistical learning in infancy has relied on post-exposure behavioural paradigms. Nevertheless, the directionality of the behavioural learning outcome (i.e., novelty or familiarity effect) may be hard to predict and, in turn, this may raise interpretative challenges. In this context, electrophysiological measures obtained with a frequency-tagging paradigm can be acquired while learning occurs and can help to better characterize or disambiguate unclear behavioural findings. In the present work, we aimed to compare neural and behavioural evidence of visual statistical learning longitudinally. We investigated early learning skills over the first year of infancy at three timepoints, namely at 3 (T1), 6 (T2), and 9 months of age (T3). Data collection is still ongoing, with T1 concluded and T2 and T3 in progress. The final sample at T1 was a group of 30 (17 females) 3-month-old infants (M = 108 days, SD = 9.6 days). At each timepoint, infants took part in an EEG frequency-tagging paradigm in which they were exposed to a sequence of shapes organised in doublets. Shapes were individually presented at the centre of the screen at a frequency of 6 Hz, hence a doublet appeared at a frequency of 3 Hz. Following a familiarization phase of at least 8 sequences and 120 s of cumulative looking, participants began a test phase in which 4 novel and 4 familiar doublets were presented and looking time was recorded. Preliminary EEG results at T1 revealed that the 3-month-olds' brain could already detect the visual regularities in the stream of shapes with significant occipital activity at the doublet frequency, especially at the first harmonic of the doublet frequency (9 hz). At the individual level, 60% of the 3-month-old participants showed significant occipital activity at the doublet frequency and its harmonics. On the other side, looking time measures at test phase did not reveal any significant difference between novel and familiar doublets. These results suggested an early-emerging brain mechanism to detect visual statistical regularities during stimulus exposure, which seems already in place at 3 months of age and may be a more robust index than post-exposure behavioural measures. Data collection at T2 and T3 is still ongoing and results will be presented at the conference.

P2-D-18 Neural correlates of empathy in preschoolers

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Summary: Empathy is vital for navigating the social world and promotes helping, sharing, and comforting behaviors. What supports the development of empathy? We uniquely examine preschoolers' neural responses as they naturally interact with an experimenter in distress to reveal how empathy is supported in the brain during this time of rapid change.

Details: Empathy is vital for social interaction, but despite extensive behavioral work, we have limited understanding of the neural correlates of empathy in preschoolers. Examining empathy's neural correlates is vital because it allows us to see individual differences that may not necessarily be captured by more distal behavioral measures of empathy. While some prior work has examined children's neural responses to static images of distal body parts (e.g., hands/feet) experiencing pain or not, this work is limited in its ecological validity and its ability to capture empathy's complex, multifaceted nature (Cheng et al., 2014). Therefore, to further our current conception of the neural correlates of empathy, we must examine empathic responding in the brain, as it occurs during a live, naturalistic interaction.

The present study undertakes this novel approach by collecting electroencephalography (EEG) as 3-to-5-year-old children participated in a live interaction with an experimenter feigning both emotional and physical 'distress'. Participants observe an experimenter pretending to pinch their finger in a clipboard (physical distress) and tearing a treasured stamp sheet (emotional distress); the experimenter feigns distress for 30 seconds followed by a 30-second recovery period (as in Young et al., 1999). We compared preschoolers' neural correlates during these distress conditions to a 'neutral' condition, wherein children watch moving bubbles and shapes (resting state). We target an EEG signal implicated in social reasoning (e.g., children's perspective-taking and mentalizing) that is related to empathy– 6-9 Hz 'alpha' suppression in frontal, central, and temporoparietal scalp regions during 'distress' relative to neutral (Joyal et al., 2018). We relate alpha suppression to children's behavioral responses during the empathy tasks.

Data collection is ongoing. Preliminary results (N= 15) show that children's neural activity during the physical and emotional distress differ from the neural activity during the non-distress neutral condition. Moreover, the physical distress neural activity is related to children's expressions of concern for the experimenter during the interaction. Taken together, results reveal the first clear neural indices of children's empathic responding during a live, naturalistic interaction, demonstrating feasibility of our novel, ecologically valid task, and elucidating how the brain may be supporting preschool empathy development.

E – Early Life Stress

P2-E-19 Early exposure to intimate partner violence and its association with EEG microstates in South African infants over the first postnatal year

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Summary: Little is known about how early exposure to stress may influence the development of the infant brain brain. This study explored the relationship between exposure to intimate partner violence and the development of brain networks using EEG in the first year of life in a sample of South African infants.

Details: Objective: Environmental factors are known to influence sensory (auditory and visual) and attentional brain networks. However, little is known about how threat in the early environment may shape the developmental emergence of these functional networks. In South Africa, approximately 20-28% of children witness intimate partner violence in the home. This preliminary study explored the relationship between early exposure to intimate partner violence and the occurrence and duration of electrical microstates in the developing brain.

Methods: As part of a longitudinal birth cohort study study, resting state electroencephalography (EEG) was collected from infants in Cape Town, South Africa at three timepoints, which were at around three months (M = 3.80, SD = 0.90, N = 242), six months (M = 8.80, SD = 1.54, N = 249), and twelve months (M = 14.26, SD = 1.25, N = 261) of age. We also measured recent (past-year) exposure to intimate partner violence (emotional, physical, and sexual) at all three time points using a maternal self-report questionnaire. We pre-processed the EEG data and computed microstates using HAPPE v4.1. All linear regression models controlled for child sex and age at EEG assessment.

Results: Five microstate networks emerged, comprising auditory (A), visual (B), attention (D) and two default mode networks (C and E). Across all time points, 97 (33%) mothers reported recent exposure to IPV. Exposure to IPV at any point during the first postnatal year was significantly associated with fewer occurrences of the visual microstate at three months ($t(203) = -3.17$, $p = .002$). Infants exposed to IPV also showed longer durations of time spent in the attention microstate at three months ($t(204) = 2.31$, $p = .022$). Exposure to IPV did not predict any microstate features at six or twelve months.

Conclusion: These preliminary data suggest that developing visual and attentional networks are sensitive to threat in the environment, especially in the early postnatal period.

P2-E-20 Analysis of neurodiversity in neuromaturation and overt cognitive abilities in the first months of life and interactive effects with psychosocial factors

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Summary: This study addresses 1) if the differences in brain development account for differences in acquiring cognitive habilities - that is, the essential skills we use on a day-to-day basis to complete tasks - and 2) how psychosocial stress, such as poverty, may influence brain development and acquisition of cognitive habilities.

Details: Few large scale studies address the considerable neurodiversity in brain development and how it affects the outcome of overt cognitive abilities, nor environmental factors that may affect these variables. In this analysis we aimed to (1) assess how interindividual variability in neural development is related to the development of overt cognitive abilities and (2) how psychosocial environmental factors - such as maternal depression and poverty - may influence neurodiversity. These questions were addressed through a sample of 555 infants participating in an ongoing cohort longitudinal study about neurodevelopment of executive and language functions along the first 36 months of life in São Paulo, Brazil. Neural activity was registered using eletroencephalography (EEG) at two time points, 3 months (T1) and 5-9 months (T2). The Visual Evoked Potential (VEP) task on EEG was used to assess neural development. During, the infant is presented with a rapidly reversing black-and-white checkerboard pattern, a stimuli known to stimulate basic sensory processes in the visual cortex. Overt cognitive abilities were assessed through the Bayley III Cognitive Composite Scale, a gold standard instrument for assessing development in infancy. Psychosocial environmental factors were measured through questionnaires that assess family's socioeconomic and parental experiences of stress. This analysis used statistical methods of structural equation modeling and regression to examine bidirectional associations between the VEP's event-related potential components N1 and P1 and (1) development of cognitive abilities according to the Cognitive Composite score on the Bayley III Scale and (2) measurements of poverty and psychosocial stress. The findings of this analysis will be important to the understanding of neurodiversity in neurodevelopment and cognitive development at the beginning of life, as well as the if and how psychosocial stress and poverty affect these variables.

P2-E-21 Maternal stress during pregnancy and the association with fetal brain development and infant cognitive outcomes explored using neuromelanin MRI

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Summary: This study was conducted to determine the effects of antenatal stress on the developing brain using a novel neuroimaging technique. The findings suggest that NM-MRI has the potential to enhance our understanding of underlying pathophysiological mechanisms that influence cognitive outcomes among infants.

Details: Antenatal maternal stress is associated with adverse cognitive outcomes in infants and may be mediated by alterations in the hippocampus and dopaminergic projections from the midbrain's ventral-tegmental area (VTA), which are foundational for memory processes. Recent advancements in neuromelanin magnetic resonance imaging (NM-MRI), has offered a unique and non-invasive way to examine dopamine concentrations in the human midbrain, reflected in NM signal changes in the ventral tegmental area (VTA) and substantia nigra (SN).

The present study aimed to 1) examine the association between prenatal maternal stress and fetal hippocampal volumes; 2) examine the association between fetal hippocampal volumes and VTA-SN neuromelanin signal change in infants; and 3) examine the association between VTA-SN neuromelanin signal change and cognitive outcomes in infants.

Maternal stress was assessed twice in utero, separated by a duration of 2-4 weeks, and once post-birth in 11 pregnant women (22-41 years old) using the Perceived Stress Scale (PSS), a 10-item questionnaire that has been validated for use in pregnant women. Hippocampal volumes were measured in 11 fetuses at timepoint 1 (28.6-36.4 weeks' gestation) and timepoint 2 (31-38 weeks' gestation) using a T1-weighted 3T MRI image.

11 infants (5-17 weeks of age) were scanned with a modified NM-MRI protocol using a three-dimensional gradient recalled echo sequence with magnetization transfer (MT) contrast (~5 minutes) on a 3T Prisma fit MRI scanner (Siemens, Erlangen, Germany). Cognitive outcomes were assessed using the Ages and Stages Questionnaire – Third Edition (ASQ-3).

Maternal stress at timepoint 2 significantly predicted fetal hippocampal volumes at timepoint 2 ($p<.001$). Further, fetal hippocampal volumes at timepoint 2 predicted of VTA/SN NM-MRI signal change ($p<0.05$) in infants. Lastly, VTA/SN NM-MRI signal change predicted of problem-solving scores among infants ($p<.005$).

Findings indicate that stress during the third trimester of pregnancy can have lasting effects on the developing brain, and memory-related functions in infants. NM-MRI has the potential to enhance our understanding of underlying pathophysiological mechanisms that influence cognitive outcomes among infants.

P2-E-22 The role of positive and negative early life experiences on cortical expansion in the first three years of life (pre-registered report)

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Summary: In this preregistration, we propose using a longitudinal cohort of infants oversampled for poverty to study how exposure to stressful life events or enriching experiences impact cortical expansion in the first three years of life. This work will allow us to identify potential interventions to support healthy brain development.

Details: Background: 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 vulnerability to exposures like poverty, stressful life events, and/or enriching experiences. We aim to investigate how these exposures may influence patterns of cortical expansion.

Previous results: We analyzed MRI data from a cohort of full-term infants oversampled for poverty using the anatomically constrained multimodal surface matching (aMSM) pipeline, an innovative technique which uses vertex wide point correspondence to create smooth maps of cortical expansion for each subject. 83 subjects underwent structural MRIs at birth and age 2 years; 64 subjects at birth and age 3; and 38 subjects at ages 2 and 3. Cortical expansion did not occur linearly nor uniformly; from birth to age 2, certain brain regions nearly doubled in size, whereas from age 2 to age 3, maximum expansion was only 10% (Figure 1). While greater social disadvantage was associated with smaller surface area at all ages, it did not predict rates of cortical expansion.

Analysis plan: To explore how other exposures may impact individual differences in expansion, we will investigate the role of stressful life events (measured using the CLES survey) and the thrive factor (which is composed of child sleep, positive parenting, neighborhood safety, child nutrition, and environmental stimulation), both of which have been linked to brain development and cognitive/psychiatric outcomes in children. We will use PALM (permutation analysis of linear models) software to determine if our variables of interest are related to expansion for each of our time windows of interest (birth to age 2, birth to age 3, and age 2 to age 3). For all models, we will control for age at scan, time between the two scans, birthweight, and sex.

Implications: Association regions, which are critical for emotion regulation and executive functioning, experience pronounced growth relative to hemispheric expansion during toddlerhood and show the most variability in rates of expansion. However, it has yet to be determined how exposure to stressful life events or enriching life experiences may impact expansion in these regions. If we find that the thrive factor relates to expansion, this would identify areas of possible intervention to support healthy brain development.

P2-E-23 Fetal exposure to greater neighborhood disadvantage is associated with altered functional brain network architecture in utero

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Summary: Neighborhood disadvantage (ND) is associated with altered brain development and behavioral concerns later in life. To date, the impact of disadvantage remains unexplored during this the fetal period, a critical period for early brain development. This study aims to assess the association between ND and brain development in the fetal period.

Details: Objective: To assess the association between neighborhood disadvantage and developing functional network architecture of in utero fetuses.

Methods: We utilized a prospectively recruited cohort of pregnant women from Washington, DC to study in-vivo fetal brain development. Using a sample of 79 scans from 68 fetuses (mean gestational age of 33.7 weeks, 46% male), we calculated functional network architecture using graph theory metrics of clustering coefficient (C), characteristic path length (L), global efficiency (GE), local efficiency (LE), and small world propensity (SWP). We then used the addresses at time of pregnancy to identify census tract residence and characterized neighborhood disadvantage using the Social Vulnerability Index. We then assessed the relationships using linear mixed effects models, testing the association between each network metric with SVI, gestational age (GA) at scan, and the interaction of the two, controlling for repeated scans.

Results: We observed significant main effects for GA with all metrics, with L increasing and C, GE, LE, and SWP all decreasing with GA (Table 1). For SVI, we observed significant main effects with three metrics, with L increasing and both GE and SWP decreasing with greater disadvantage. However, on the same three metrics we also observed a significant interaction between SVI and GA (Figure 1). In the case of L and GE, disadvantage was associated with altered network development earlier in gestation, but the effect diminished to a negligible association by term age. Alternatively, while SVI was associated with diminished SWP at earlier ages, by term age it had inverted and was associated with greater SWP.

Conclusions: Our findings are the first to report significant associations between neighborhood disadvantage and in utero brain development. Within the context of GA related changes, our observed results associated with SVI are indicative of accelerated maturation in fetuses in more vulnerable census tracts. This work expands the existing literature in childhood and adolescents finding an association between ND and maturation. These findings offer significant implications for the early impacts of social determinants of health and social vulnerability even prior to birth on the developing brain.

P2-E-24 Aperiodic EEG activity in early childhood is associated with temperament, socioemotional functioning, and maternal psychopathology

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Summary: Aperiodic EEG activity was historically dismissed as 'background noise', but more recent research demonstrates associations with brain function and mental health outcomes in older children and adults. The present study sought to investigate whether aperiodic EEG, measured in infants and toddlers, is associated with behavior and mental health.

Details: Background: Recent research has investigated aperiodic EEG power, characterized by a variable 1/f distribution in which power decreases as frequency increases. This distribution can vary in 'slope' (i.e., rate at which power decreases as frequency increases) and 'offset' (i.e., uniform shift of power across frequencies). The slope and offset are hypothesized to index the synaptic excitatory-inhibitory balance (flattened/reduced slope=increased excitation over inhibition) and broadband neuronal firing, respectively. Studies in adults and older children suggest changes in aperiodic EEG may characterize various psychopathology. Studies are needed to determine whether aperiodic EEG is associated with socioemotional functioning in early childhood and whether associations are affected by adverse exposures (e.g., maternal psychopathology).

Methods: Data were analyzed from N=401 infants and caregivers, with follow-up at age 3 years (N=226). At both assessments, children completed baseline EEG; aperiodic activity was calculated using the "specparam" (spectral parameterization) algorithm, modified for use in infants and toddlers. Mothers completed the State-Trait Anxiety Inventory and Beck Depression Inventory at both timepoints to measure maternal anxiety and depressive symptoms; the Infant Behavior Questionnaire-Revised at infancy to measure child temperament (surgency, negative affectivity, orienting/regulation); and the Infant-Toddler Social and Emotional Assessment at 3 years to assess child socioemotional problems (internalizing, externalizing).

Results: In linear regression analyses, offset and maternal anxiety symptoms were additively associated with infant surgency and orienting/regulation. Greater offset was associated with greater surgency and lower orienting/regulation. Greater slope (increased inhibition) was additionally associated with greater orienting/regulation; an interaction effect further showed that the observed negative association between maternal anxiety and orienting/regulation was more robust in infants with greater slope. At 3 years, greater offset and maternal anxiety symptoms were additively associated with greater child externalizing symptoms.

Conclusions: These findings provide evidence for associations between aperiodic EEG and socioemotional functioning in early childhood, including interaction effects with adversity exposures. Aperiodic EEG may index early development in excitatory-inhibitory networks associated with socioemotional outcomes.

G – Methods: Analytics/Statistics

P2-G-25 Identification of reliable and Canonical Multi-Scale Intrinsic connectivity networks in Resting-State fMRI of typically ceveloping infants

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Summary: During the first six postnatal months, the human brain undergoes its most dramatic network development. This study investigates multi-scale ICNs (analogous to those found in adults) in neurotypical neonates. Identifying ICNs could significantly contribute to the early detection and intervention of neurodevelopmental disorders.

Details: Objective: Resting-state functional magnetic resonance imaging (rsfMRI) captures spontaneous fluctuations in blood-oxygenation-level-dependent (BOLD) signals to investigate brain connectivity, enabling the identification of intrinsic connectivity networks (ICNs) that reflect coherent neural activity patterns. ICNs have been extensively studied in adults, offering vital insights into the brain's functional interactions. A recent study involving over 100k+ participants identified 105 canonical and replicable multi-scale ICNs, showcasing functional segregation at various levels of brain granularity. Here, we employ extensive analyses to assess the presence of these normative multi-scale ICNs in infants as young as six months using various advanced analytical methods.

Methods: Preprocessing steps included discarding ten initial volumes, correcting head motions, and performing slice timing correction. A two-step normalization procedure was applied to align the infant fMRI data with age-specific T1 templates and then to the MNI space, followed by smoothing with a 6 mm Gaussian kernel.

The initial analysis involved the development and application of burst Independent Component Analysis (bICA), a blind ICA method that conducts ICA in sequential model orders. This approach enhances the reproducibility of ICA analysis and removes the necessity of selecting a specific model order.

In the second analysis, we employed multivariate-objective optimization independent component analysis with reference (MOO-ICAR),

a spatially constrained ICA method, along with the 105 multi-scale ICN template to estimate subject-level corresponding ICNs for each infant data.

To ensure the reliability of the estimated ICNs, a comparison was made between the ICNs derived from the infant dataset in both analyses and those components estimated from a simulated null dataset.

Results: The study successfully identified 105 multi-scale ICNs in the infant brain, demonstrating high similarity between the ICNs derived from the infant dataset and the adult templates using both methods, as shown in Fig.2. The null analysis confirmed the estimated ICNs have significantly higher spatial similarity with their templates compared to a simulated null dataset, as depicted in Fig.3.

Conclusion: The study demonstrates that canonical and reproducible multi-scale ICNs are detectable from birth, offering a unique opportunity to investigate the developmental trajectory of these ICNs across different datasets and age groups.

P2-G-26 Multi-way multiscale brain network interaction: insights from birth to 6 months

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Summary: Information interaction beyond pairwise. In this study, we supplied evidence that multi-way multiscale brain functional network interaction indeed has the strongest interaction from birth to 6 months and has the strongest association with age compared to pairwise interaction.

Details: Background: Understanding the intricate multi-way information exchange is crucial because the brain is a complex system that cannot be fully characterized by pairwise interactions. This study investigates multi-way multiscale brain functional network interactions from birth to 6 months, elucidating how these interactions evolve over age.

Objectives: 1) Introduce an approach to capture multi-way multiscale brain network interaction. 2) To examine the impacts of gestational age at birth on the multi-way multiscale brain information interaction.

Methods: Participants were 126 typically developing infants (age range 4–179 days, 50 female). Data were collected from each infant at up to 3 randomized time points between birth and 6 months. After standard Neuromark preprocessing, the subject-specific intrinsic connectivity networks (ICNs) and time course were estimated using Multivariate-Objective Optimization ICA with Reference to 105 multiscale brain network templates. Next, we employed total correlation (TC) to estimate the triple brain network interaction, resulting in a 105×105×105 matrix per subject. ICA with model order 20 was applied to identify triple components in the infant brain. Furthermore, a general linear model was employed to estimate their dependencies.

Results: The selected top two ICN triple components from all 20 triple components are illustrated in Fig.1. Firstly, we noticed that triple interactions mainly occur among the visual, subcortical, sensorimotor, and high-level cognitive domains, suggesting that these brain networks are the strongest and develop the fastest during the first 6 months of infancy. Secondly, we observe that the strongest age associations in triplet interactions among DMN (ICN102, ICN90) and salience network (SN, ICN94) increase with age advancement (R-squared: 0.2418), and interactions among DMN (ICN102), SM (ICN68), and CEN (ICN89) show negative association with age in the opposite way, as depicted in Fig.2. Notably, the pairwise interactions among these triplets exhibit weak age association patterns.

Conclusions: We show multi-way brain network interaction in early infancy brain development. Our results reinforce growing evidence that high-order information interaction can capture information that might be hidden from pairwise interactions.

H – Methods: Data Acquisition

P2-H-27 Improving precision with ultra-high field functional MRI in infants

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Summary: Infant brains are small compared to commonly used voxel sizes which leads to a lack of spatial precision in functional MRI data. Ultra-high field imaging (7T) allows for up to 4 times smaller voxels compared to 3T, due to the almost quadratic SNR gains. This opens up new possibilities for precision functional imaging in infants.

Details: Important insight into brain function during early development can be gained from fMRI in infants. However, working with infants faces a number of methodological challenges. Typical voxel sizes encompass larger proportions of brain volume, resulting in reduced spatial specificity of connectivity patterns. Characterization of individual specific functional brain organization requires large amounts of low motion data, which is difficult to acquire in a single session with an infant.

Ultra-high field (7T) imaging can help overcome these challenges, by achieving a level of spatial precision that allows us to uncover details of connectivity patterns that are difficult to resolve with 3T acquisitions, and - as seen in adults - by decreasing the amount of data needed for precision functional mapping. Despite the availability of FDA approved 7T MRI scanners, they are rarely used with infants because the increased field strength requires additional safety considerations. To make 7T acquisition with infants feasible, we developed an in-house system to assess individualized safe operating power limits based on each infant's head volume derived from their anatomical scans at 3T. Here we show initial results from a 7T ME-fMRI acquisition in three healthy full-term infants (seven, five and ten weeks old).

Functional data at 3T was acquired using a four-echo sequence (14ms, 39ms, 64ms, 88ms, TR=1.761s, 2mm3 res) together with T2w and T1w anatomical references. Functional data at 7T was acquired using a three-echo sequence (14ms, 35ms, 57ms, TR=1.768s, 1.6mm3 res). All data acquisitions were performed during natural sleep. We preprocessed data using NORDIC for thermal denoising and an infant specific preprocessing workflow for functional connectivity processing (BIBSnet, Nibabies and XCP-D). Functional connectivity matrices were calculated using low motion data (framewise displacement < 0.3mm) only.

All datasets showed high functional tissue contrast, and direct (within infant) comparison of spatial resolutions at 3T and 7T emphasized

the gain in spatial precision and reduced partial voluming. Functional connectivity matrices showed similar correlation patterns between brain regions for data acquired at 3T and 7T with an increase of the absolute magnitude of functional connections in 7T data. Our initial results show that ME-fMRI in infants at 7T is not only feasible but feasible with much higher voxel resolutions, resulting in data with high specificity and sensitivity.

P2-H-28 Behavioral strategies to minimize head motion reduce the need for general anesthesia in pediatric patients undergoing MR neuroimaging

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Summary: Does preparation before neuroimaging reduce the need for general anesthesia in pediatric patients? Our study shows in a clinical population that behavioral training may obviate the need for sedation or general anesthesia in clinical magnetic resonance imaging, paving the way for better clinical care and more patient-friendly experiences.

Details Objectives: Many pediatric patients routinely undergo magnetic resonance imaging (MRI) in general anesthesia (GA) despite concerns regarding the long-term effects of GA and increased costs. Utilizing preparation together with advanced MR image acquisitions, we aimed to reduce the need for GA in a pediatric patient population. We aimed to evaluate the effectiveness of preparation combined with motion correction in pediatric patients undergoing brain MRI.

Method: Fifty pediatric patients (aged 4-10) with various clinical indications were enrolled. Exclusion criteria included certain medical conditions and impairments. Patients were prepared at home with a mobile phone app and trained in a mock scanner prior to their clinical examination. Anxiety levels were assessed five times during the course of the study using the State -Trait Anxiety Inventory (STAI-C) Questionnaires for children. First, a baseline questionnaire was completed at home and then once directly before and after the mock scanner training as well as directly before and after clinical imaging. Imaging was conducted on a Siemens 3 T scanner. Acquisition protocols varied between patients depending on the clinical indication. Motion was tracked during scans using a markerless optical tracking device, and half of the patients underwent prospective motion correction (PMC). Image quality was evaluated by a neuroradiologist and computationally.

Results: The gender distribution was balanced (25 M/25 F) with a mean age 7,24(±1,87) years at the time of the scan. Of the 50 pediatric patients, 47 successfully completed the MR scan, and the neuroradiologist approved the quality of the scans for clinical diagnosis, equaling a 94% success rate. Three pediatric patients were referred to a scan in GA.

In a linear mixed model controlling for age, sex and the baseline trait anxiety an overall decline of anxiety over time was detected. Assessing image quality for the most common imaging sequence (MPRAGE, N=45 patients) indicated no significant difference in image quality between PMC ON (N=24) and OFF (N=21) cases.

Discussion and Conclusion: Preparation combined with motion correction enables high-quality diagnostic imaging in pediatric MRI without sedation or GA. The preparation process effectively minimizes motion. Additional advanced imaging with PMC had little impact on image quality in this study, warranting further investigation.

P2-H-29 Maybe it's researchers who are "hard to reach" - lessons learned from a year of collecting racially and socioeconomically inclusive two-brain fNIRS data in childcare centers and schools

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Summary: Many of our lowest-income families are typically characterized as "hard to reach," but as an educator I know families are actually very easy to reach, and very excited to contribute to science, when we make it accessible to them.

Details: In the last few years, parent-child fNIRS studies have suggested that neural synchrony may support children's healthy cognitive and emotional development by linking socially contingent experiences with outcomes in domains including language and emotion regulation. However, most neural synchrony studies to date have been conducted with White, middle- to high-SES families. In a 2023 review of 16 neural synchrony studies(Alonso et al., 2023), no study reported inclusion of Hispanic families, and only 4 included Black families. The majority did not report SES, or included only middle- to high-SES families. It is critically important that we design inclusive two-brain studies to understand mechanisms supporting the healthy development of all children.

In the Family-inspired Neural Synchrony (FINS) study, we aimed to practice inclusive neuroscience while investigating moment-to-moment mechanisms supporting preschool socioemotional and language development. Our sample is 65% non-White, SES-diverse, with 78% moms, 18% dads, and 4% grandmas. We achieved this by running a mobile study to meet families where they are, which also adds ecological validity to our approach. I will share how inclusion influenced our study, including hypothesis development, regions of interest, budgeting, recruitment, compensation, and session protocol. Not only did we collect the sample we were hoping for, we heard anecdotally from our partners that our approach "just felt different," and we learned a lot.

To date our sample is 65% non-White, and highly diverse in terms of SES, approximately representative of the communities surrounding the University of Maryland, College Park, and enriched for families in the lowest SES bracket (less than $10k per year). We also recruited 78% mothers, 18% fathers and 4% grandmothers.

P2-H-30 Ultra-high field quantitative susceptibility mapping of the neonatal brain

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Summary: Iron is essential for neurodevelopment yet measuring it non-invasively in infancy is challenging due to low brain iron levels. Because of enhanced SNR, resolution, and susceptibility effects, 7T quantitative susceptibility mapping (QSM) affords high sensitivity to iron variations, but has never been applied to the new-born brain.

Details: We explored the feasibility and sensitivity of 7T QSM for assessing brain iron in neonates.

Methods: 5 neonates (median age: 39.7 weeks postmenstrual age (PMA)) were imaged in natural sleep at 7T with a T2w acquisition and a 3D T2*w GRE sequence for QSM. For comparison, 11 children (mean age: 11.9 years) were imaged on the same scanner with 3D MP2RAGE, 3D FLAIR, and 3D T2*w GRE sequences.

Combination of complex data and QSM computation were carried out using the approach outlined in Chari et al. (2023).

Neonates' T2w images were registered to a 37-week PMA template. Magnitude images were registered to the corresponding T2w volume. QSM normalisation to the template was achieved through composition of the above transformations. Tissue segmentations and surfaces were generated using the dHCP pipeline.

Children's magnitude images were registered to the corresponding MP2RAGE volume, and QSM normalisation was achieved through the composition of the above transformations. FLAIR and MP2RAGE images were analysed with the HCP pipeline to perform tissue segmentation and surface reconstruction.

Susceptibility (χ) was examined in caudate, lentiform nucleus, corpus callosum (CC) and lateral ventricles. Additionally, χ was sampled along the grey/white matter (GM/WM) boundary.

Results: χ in GM nuclei is negative in neonates and positive in children, where clearer structural boundaries are observed, reflecting greater iron deposition. In children, χ in the CC is more negative, reflecting increased myelination. Positive χ values are observed in posterior cortical areas in neonates, while in children positive χ values are more widespread, corresponding to the underlying myeloarchitecture, and consistent with a posterior to anterior pattern of myelination in neurodevelopment.

Discussion: We demonstrate the feasibility of QSM of the neonatal brain at 7T and its ability to detect regional variations in tissue composition through different stages of brain development.

I – Methods: Data Processing

P2-I-32 Advancing EEG processing and analysis in neonatal music interventions: introducing a specialized qEEG pipeline for premature infants in NICU

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Summary: Our study aims to fill a significant gap in NICU care by developing a specialized qEEG pipeline for preterm infants undergoing music interventions. This innovative approach will enhance understanding of music's neurodevelopmental impacts, paving the way for optimized care practices and improved outcomes in this vulnerable population.

Details: Background: In neonatal intensive care units (NICUs), understanding the brain activity of preterm infants is crucial, particularly when assessing the clinical and developmental impact of music interventions.

Research Gap: However, traditional clinical EEG analysis methods, such as amplitude-integrated EEG (aEEG), often fall short in capturing the nuanced dynamics of the preterm infant brain, while there is a significant lack of standardized procedures for quantitative EEG (qEEG) data processing and analysis tailored for neonatal populations in music-related research.

Methods: Aiming to address this gap, our approach involves developing a quantitative EEG analysis pipeline that combines the capabilities of the EEGLab software platform and the NEURAL code (MatLab based), both refined to suit neonatal data acquired during musical interventions. The process begins with raw EEG data collection using an 8-channel system, while specialized preprocessing techniques, including ICA and manual artifact removal, filtering, and downsampling, are employed to maintain high data quality in the challenging NICU environment. The pipeline further applies adjusted to this population quantitative EEG analysis to extract critical features such as amplitude, spectral characteristics, connectivity, and burst intervals, providing deep insights into the neurophysiological effects of auditory stimuli on preterm infants.

Results - Conclusion: This novel pipeline is suitable for varying music protocols, and EEG hardware systems, while it offers a systematic and robust framework for understanding the neurodevelopmental impact of music on preterm infants in the NICU. Our methodology sets a new standard in neonatal music and EEG research, contributing significantly to neonatal care practices and infant brain development understanding.

P2-I-33 Novel connectome predictive modeling techniques to circumvent issues in infant neuroimaging analysis (WIP)

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Summary: Traditional infant neuroimaging analyses are based on assumptions made from the adult brain, which may not be appropriate for infants' (e.g., atlases over-smooth the infant brain and the adult HRF is faster than infants' BOLD response). This project aims to introduce methodologies that circumvent the need for these conservative assumptions.

Details: The infant hemodynamic response function (HRF) is longer in latency (about 12-16 seconds) compared to adults' (4-8 seconds). This biophysiological difference can cause errors in analyses that convolve the infant's BOLD response around the default adult HRF. Additionally, current infant atlases have notable issues with their development (e.g., low tissue contrast intensity, small, underdeveloped neural structures, and variable water and fat content in infant brains). Thus, it is critical to develop methods that circumvent the need to apply a convolution or atlas. This research aims to use connectome predictive modeling and machine learning to identify significant functional regions of interest (ROIs) that are specific to the processing of social versus non-social touch. Seventeen infants (nine female) participated in functional magnetic resonance imaging at The University of Virginia. During the functional scan, infants underwent gentle stroking with a paintbrush on their left shin at a rate of 3 cm/sec for the social stimulus to activate C-tactile afferents, and then repeated the process with a thin plastic film on the skin to block these mechanoreceptors for the non-social stimulus. Time series data will be extracted from each participant and a ward parcellation will be used to identify ROIs that are functionally meaningful. Pairwise functional connectivity matrices will be created for the social and non-social conditions. Vectors will be concatenated from each matrix for each participant. A machine learning classifier will be trained on 16 of the participant's vectors and then tested on the remaining participant in a leave-one-out cross validation. Classifier performance above chance (50%) will signify this approach's ability to distinguish between social and non-social tactile information. Features will then be extracted to identify the most meaningful components of tactile processing. Success in this technique will allow for a novel methodology that avoids the most problematic aspects of infant neuroimaging analysis.

P2-I-34 Learning-based cerebral cortical surface reconstruction in newborns

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Summary: Precise mathematical modelling of the brain surfaces is essential for analysing small but consistent changes in early development. There is a scarcity of reliable software tools for this purpose. Here, we report first results from adapting a deep-learning-based framework to a newborn cohort.

Details: Precise tracking of macroscopic and microscopic changes in healthy perinatal neurodevelopment requires robust software tools that are adaptive to the rapid and continuously changing nature of the brain reflected in MRI scans during this early life period. While deep learning methods are known for their versatility, not all architectures generalise well, particularly to images acquired of newborns. Here, we show that a cerebral cortical surface reconstruction tool, TopoFit [1], which was originally introduced for adult populations, can be efficiently adapted to newborns. We report preliminary results.

TopoFit learns to predict deformations that map a template mesh to the subject-specific anatomy of the grey-white boundary, perceived through deep convolutional features. At inference time, TopoFit generates topologically correct mesh surfaces 150x faster than traditional optimisation-based methods. We trained a naïve TopoFit model on 1107 mixed T1w and T2w MRI volumes and cortical surfaces of the dHCP [2] cohort until convergence. The validation and test data comprised of 160 and 316 mixed T1w and T2w MRI volumes, respectively. We evaluated the model performance by calculating vertex-wise and aggregated mean surface distances.

Qualitative and quantitative overviews of the cortical surface reconstruction accuracy are shown in Figure 1. The fitted surface contours are closely aligned with the pial surface of the brain on three representative subjects, spanning the age range of the dHCP cohort. The distribution plot shows typical sub-millimetre values of the distance between the reconstructed surface and the ground truth in one subject. All reconstructions succeeded. The spatial distribution of the cohort-wise mean reconstruction errors is shown on the average surface in three views, staying under 0.8 mm. In Figure 2, our infant TopoFit model's performance is plotted against that of the adult TopoFit on the same test cohort. The infant model yielded consistently superior performance, regardless of the MRI contrast, age, or sex of the inputs. Reconstruction errors were slightly lower on T2w images and older subjects.

The TopoFit architecture can be used to reconstruct highly accurate cerebral cortical surfaces in the 28-45 week gestational age group from both T1w and T2w volumes. Further research is necessary to evaluate the model's robustness on other datasets.

Ref: [1] Hoopes, 2022; [2] biomedia.github.io/dHCP-release-notes

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P2-I-35 IBAv2.0: Brain Atlases Charting Myelination from infancy to early childhood

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Summary: Existing infant brain atlases capture spatiotemporal changes in brain morphometry but do not delineate whole-brain microstructural changes. In this abstract, we present brain atlases of the T1w/T2w ratio characterizing myelination for the first five postnatal years.

Details: Brain atlases play a key role in providing a common space for mapping typical brain development and for comparing neuroimaging measures of individuals to identify deviations. Although structural brain atlases for the infants have been constructed, these atlases do not quantify whole-brain myelination during the early development years. Here, we construct temporally-dense atlases that characterize myelination from infancy to early childhood. We used T1-weighted (T1w) and T2-weighted (T2w) images acquired between 2 weeks and 60 months for the Baby Connectome Project (BCP) and computed myelination as the T1w/T2w ratio. Atlases were constructed every month between 2 weeks and 24 months and every 12 months between 36 and 60 months. To construct age-specific T1w/T2w ratio atlases, we used surface constrained dynamic elasticity model (SCDEM) to consistently align the surfaces and volumes of the subjects. We first constructed the 12-month atlas by spatially normalizing the images of subjects scanned between 11 and 13 months using SCDEM groupwise registration. The atlases at other time points were constructed by registering the images of subjects scanned in a given time window to 12-month atlas and back propagating them to the current time point using the weighted-average deformation field. We quantified myelination across different supratentorial and infratentorial compartments by modeling for each compartment the median of T1w/T2w ratio as a smooth function of age using generalized additive model (GAM). Myelination increases throughout infancy and early childhood as depicted by the brain atlases of T1w/T2w ratio at select time points (Fig. 1). The growth

trajectories for T1w/T2w ratio show that the brainstem is heavily myelinated compared to the other compartments (Fig. 2 (left)). The percentage change in myelination in the first postnatal year for cerebral white matter (WM) is 306%, brainstem (BS) is 290.5%, deep gray matter (dGM) is 182.5%, cerebral GM is 142%, cerebellar WM (cWM) is 141.3%, and cerebellar GM (cGM) is 140.8% (Fig. 2 (right)). This growth analysis signifies that different brain compartments exhibit distinct developmental patterns for myelination during the first five years of life.

J – Methods: Tool Sharing and Data Dissemination

P2-J-36 A BIDS App for neonatal hippocampal subfield segmentation and unfolding

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Summary: The hippocampus is a brain structure important for cognitive and emotional processing, made up of subfields with their own structure and function. To study these subfields, they have to be segmented, which takes a long time if done by hand. We have created a free and easy to use tool to do this automatically and accurately in babies.

Details: The hippocampus is a highly plastic subcortical structure that shows protracted development throughout early life, and plays an important role in the development of cognitive and affective processes. Anatomically, the hippocampus is a grey matter structure with a complex folding pattern, and is made up of distinct subfields, comprising the cornu ammonis (CA1-3), the dentate gyrus (CA4/DG), the subiculum, and the stratum radiatum lacunosum-moleculare (SRLM), and research has demonstrated the variability in subfield volumes related to different developmental disorders and stressors. Currently, the infant hippocampus and its subfields must be segmented manually, a difficult and time-consuming task that requires expertise and training. Thus, our objective was to train an existing adult hippocampus segmentation tool, HippUnfold, to automatically segment the neonatal hippocampus into subfields, generating volumetric and morphological measures. Data from 547 singleton neonatal participants (78 with longitudinal data; 625 scans total) from the Developing Human Connectome Project were used to train and optimize the segmentation software. 428 term-born neonates (mean age at birth = 40.05, SD = 1.15, mean age at scan = 41.26, SD = 1.63) and 119 preterm-born neonates were included (mean age at birth = 31.39, SD = 3.88, mean age at scan = 36.65, SD = 4.23). Segmentations were visually inspected for accuracy, and the model was re-trained on the high-quality segmentations. Final model output (separate for left and right hemispheres) was graded as pass/fail. The relationship between segmentation success and sedation, singleton pregnancy, preterm birth, sex, cerebral hemisphere, and scan age were investigated using chi-square tests of independence and two-sample t-tests. Overall, HippUnfold performed with 88% accuracy, successfully segmenting 1097 out of the 1250 total segmentations (see Figure 1 for a representative segmentation). Singleton pregnancy, being term-born, being male, and a later postmenstrual age at time of scan all led to higher rates of successful segmentations (Figure 2). Sedation and hemisphere did not predict whether a segmentation was likely to succeed. We demonstrate the applicability and generalizability of HippUnfold, a BIDS App for hippocampal subfield segmentation and unfolding, to a large, variable neonatal sample. Future iterations will improve segmentation in preterm-born infants and at earlier postmenstrual ages.

K – Other

P2-J-37 The use of spectral parameterization to examine the developmental trajectories of periodic and aperiodic neural activity in the infant: A HEALthy Brain and Child Development (HBCD) Pilot data study

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Summary: Compared to older population data, differences in the power spectra of infant data present unique challenges when using spectral parameterization. The purpose of this poster is to demonstrate the optimization of this approach to infant data.

Details: Primary Question(s) to be addressed

Spectral analyses of the electroencephalogram (EEG) allow researchers to characterize cortical brain activity in terms of frequency and power. However, traditional ways of characterizing EEG data treat the 1/f-like shape of the power spectral density (PSD) as noise and can confound oscillatory activity with aperiodic brain activity. The use of specparam to analyze EEG data solves these issues by decomposing the PSD into periodic (oscillatory) and aperiodic (1/f-like) components. This approach offers valuable insights into the underlying neural organization and functional maturation that occurs during different stages of brain development. While this is evident during developmental stages spanning early childhood to late adulthood, differences in the power spectra of infant data present unique challenges when using this approach. The primary aim of this poster is to demonstrate the optimization of this approach to infant data for HBCD. For this we will describe a pipeline for applying specparam to HBCD infant pilot data. This new pipeline will be added to create derivatives for the HBCD study. The secondary aim of this poster is to provide recommendations to other researchers interested in applying specparam to infant data.

Brief Description of Methods, Analyses, Models

We will use the HBCD V3 Video Resting State pilot data to demonstrate the feasibility of the specparam method (https://fooof-tools.github.io/fooof/) with this age range (3-10 months). In addition, we will compare the standard specparam algorithm to a modified algorithm specifically designed for use with infants (Wilkinson et al., 2023). Finally, we will examine the effects of different preprocessing parameters on the model fit, as well as commonly used specparam outputs such as aperiodic exponent and slope, and alpha peak frequency and amplitude.

P2-K-38 Smart on the inside: Functionally rich differences in connectivity within the Dorsolateral Prefrontal Cortex are present in Neonates

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Summary: Understanding the development of goal-directed behavior is crucial in understanding brain development. Recent studies challenge the hierarchical view of brain development, suggesting frontal areas may mature earlier. Measuring infant cognition is challenging due to limited behavior, for this reason we use neuroimaging to assess brain maturity.

Details: Goal-directed behavior and intelligence are critically important during childhood and adult life, but their development is still poorly understood, particularly during the earliest stages in infancy. Corresponding to this behavioral evidence, brain development has long been seen to follow a hierarchical progression as a specialization from low-level (e.g., perceptual areas) to high-level regions (e.g., frontal areas; Gao et al, 2015). However, recent evidence suggests that the frontal lobes may be functionally active in neonates (Ellis et al., 2021; A. Linke et al., 2018; Dehaene-Lambertz et al., 2010, 2002;). High-level regions may be functioning to some degree, but it is not clear how mature they are. We examined the covariation of task selectivity and connectivity within the executive control network. Five clusters of tasks with distinct functional activation patterns in the dorsolateral prefrontal cortex in adults were selected using the Human Connectome Project. In adults, we found using machine learning that the distribution of structural connectivity of a vertex in the prefrontal cortex to the rest of the brain was predictive of its functional selectivity. Next, we examined the developmental origins of this structural connectivity: was it a result of repeated functional co-activation (i.e., fire together, wire together); or might the connectivity be innate and provide a "proto-organization" that guides the development of functional selectivity. To do this, we mapped the five clusters into neonates and assessed the maturity of structural connectivity, using data from the Developing Human Connectome Project. We found that the structural connectivity was present in neonates, at an age when none of the tasks used in adults can yet be performed. This is consistent with structural connectivity preceding functional specialization. The infant results suggest that as early as one month, the connectivity of sub-regions of the prefrontal cortex to some degree already mirrors the pattern of connectivity in adults.

P2-K-39 On the maturation of cortical body representations in the first months after birth (WIP)

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Summary: Touch is critical to perceive and use our body, and the somatosensory cortex is key for its processing. While largely characterised in adult individuals, very little is known about the evolution of somatosensory maps in the first months after birth and in particular whether different body parts exhibit different trajectories of development.

Details: The primary somatosensory cortex (SI) plays a major role in our ability to perceive and use our body. Widely characterised in adult individuals, only a handful of neuroimaging studies investigated the development of SI body representations, reporting the existence of proto-maps in preterm neonates and 7mo infants (Meltzoff et al, 2018; Dall'Orso et al, 2018). Studies comparing adult individuals who lost a hand at different developmental stages (Hahamy et al, 2017) re-emphasised the crucial role of early development in determining sensorimotor organisation, large-scale plastic changes being observed after atypical development. Interestingly, recent work revealed the presence of distributed representational content throughout the adult SI (Muret et al, 2022), with the ability to decode actions performed by a body part (e.g., foot) in remote parts of SI (e.g., face region). This normally hidden activity could explain the atypical organisation observed in previous studies. However, very little is known about how SI maps and their representational content evolve in the 1st months after term birth. We addressed this gap by scanning (3T functional MRI) typically-developing full-term infants at 1 month (n=13 out of 21 included) and 3 months of age (n=15 out of 22 included). All infants received soft tactile stimulation on 3 body parts on the right side (i.e., the cheek, hand and foot) during EPI functional imaging (TR = 2.2s, TE = 40ms, resolution: 2x2x2mm). A block design with 8s of stimulation interleaved with 7s of rest was used. Recording was performed during infants natural sleep (6 to 24 blocks per body part collected for each infant). Three SI regions of interest (corresponding to the leg, hand and face regions) defined based on anatomical landmarks were used to perform classical univariate fMRI analyses (i.e., selectivity profiles, winner-takes-all maps, group maps) but also multivariate analyses allowing to quantify representational content. Preliminary univariate group maps obtained from 11 1- and 3-mo infants confirmed the expected topographical organisation with the feet represented most medially and the face most laterally. Further analyses will aim to quantify individual's profiles of i) univariate selectivity and ii) multivariate content across regions of interest, hemispheres and age. This unique dataset combined with state-of-the-art analyses will provide the first evidence of the development of body representations in the first months of life.

P2-K-40 EEG spectral power is not related to GABA levels in the neonatal brain

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Summary: Beta and gamma neuronal oscillatory activity is thought to relate to GABAergic inhibitory neurotransmission. In the neonatal brain, GABA's inhibitory function may not be established. Thus, we aimed to assess whether this relationship between beta and gamma oscillations and GABA concentrations is already present in this critical development period.

Details: In adults, beta and gamma neuronal oscillatory activity is thought to relate to GABAergic inhibitory neurotransmission across multiple brain regions including the visual and frontal cortex [1-4]. However, in the neonatal period, GABA function appears to switch from depolarisation to hyperpolarisation. Therefore, GABA may not necessarily exert the same regulation on neuronal oscillations [5]. We aimed to explore the relationship between resting-state magnetic resonance spectroscopy (MRS)-measured GABA levels and electroencephalography (EEG) spectral power in the occipital and frontal lobes of healthy term age neonates.

EEG and MRS data were collected from 11 healthy term age neonates with normal brain appearances (37.29 - 43.29 weeks postmenstrual age, 1-27 postnatal days at scan, 4 females) during natural sleep. Studies were performed with National Ethics Committee approval and parental consent.

MRS data were acquired with a 3T Philips system using MEGA-PRESS [6] (TE 68ms, TR 2000ms, 320 averages) and a short TE PRESS (TE 35ms) for water correction from 27ml midline voxels over the occipital and frontal lobes (Figure 1A). Raw data were processed with Osprey [7] and GABA concentrations were estimated with tissue-correction (Figure 1B) [7]. 25-32 channel EEG data were acquired for 10-15 mins outside the scanner within 1 hour of the scan. Raw data were bandpass filtered (0.1-70Hz) and ICA-denoised using MATLAB (2021a) and EEGLAB (Figure 1C) [8]. Power spectral densities (PSD) were estimated and averaged across O1, O2, Oz, POz over the occipital area and across Fp1, Fp2, F3, F4, Fz over the frontal area (Figure 1D).

Spearman's rho partial correlation coefficients were calculated (regressing out age) between GABA+ and frequency power in 1Hz-intervals from 0-70Hz and across frequency bands (delta: 1-4Hz; theta: 4-8Hz; alpha: 8-12Hz; beta: 13-30Hz; low gamma: 30-45Hz; high gamma: 55-70Hz).

There were no significant relationships between occipital or frontal GABA+ levels and any of the EEG frequency power bands (Figure 2).

These results indicate that the regulatory role of GABAergic activity on neural oscillations may be different in 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.

P2-K-41 Exploring the relationship between Brain Functional and Structural Changes in Prematurity: an EEG-MRI study (WIP)

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Summary: Prematurity is linked to various neurodevelopmental disorders, but early brain alterations are poorly understood. Characterizing early impairments at structural and functional levels is crucial to propose diagnostic and prognostic markers for evaluating rehabilitation programs aimed at improving neurodevelopmental outcomes

Details: Objective: Our goal was to investigate the relationships between functional and structural markers of brain development in premature-born infants by integrating EEG and MRI information at term equivalent age. Through this, we aimed to better understand associations with perinatal risk factors, including gestational age at birth and sex.

Methods: Forty-one preterm infants with a mean gestational age (GA) at birth of 27.1±1.7 weeks underwent MRI and EEG exams on the same day (post-menstrual age PMA: from to 39 to 42w). 3T-MRI T2-weighted images were acquired in three slice planes and reconstructed with a super-resolution of 0.8mm (NiftyMIC tool). Images were segmented into different compartments (iBEAT and DrawEM tools: Fig 1a; [1]), and White Matter volume was considered for further analysis. Resting-state EEG data were collected using a 128-channel net (EGI) at a sampling rate of 1kHz and were analyzed within active sleep for all infants (average duration ~ 6 minutes). The temporal dynamics of EEG activity were characterized by parsing it into 7 "microstates" (Figure 1c) [2,3]. We selected three microstates, based on their duration sensitivity in capturing aspects of brain dysmaturation when comparing premature-born and full-term infants [3]. Using a regression linear model, we related the interindividual variability in microstate duration and WM volume, while accounting for some perinatal risk factors (i.e. GA at birth, sex; [3]) and PMA at MRI/EEG.

Results: In addition to a significant effect of GA at birth and to a lesser extent sex on the duration of all 3 microstates [3] (Figure 1d) and on WM volume (Figure 1b), we observed some association between these functional and structural measures: longer duration residuals (after correcting for PMA) were related to higher WM volume residuals (Figure 1e):

Conclusion: These preliminary findings suggest a relationship between the development of resting state EEG microstate activity and MRI measures of WM growth. Specifically, higher WM volume correlated with extended microstate duration, suggesting a slower neuronal impulse conduction. This highlights the potential of multimodal investigations to characterize the interindividual variability of brain development in premature-born infants. To gain a deeper insight into WM development and its implications for functional brain maturation, further analyses are planned to include complementary measures of WM maturation, provided by diffusion MRI.

L – Prenatal Programming

P2-L-42 The relationships between maternal characteristics and fetal movement

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Summary: Fetal movements can be indicative of the health of the developing fetus. This study explores whether maternal attributes – including health behaviors such as weekly exercise, as well as socioeconomic factors like income and education – were correlated with fetal movements observed in Cine MRI.

Details: Decreased fetal movement has been connected to adverse postnatal outcomes, and identifying factors associated with decreased fetal movement could help identify potential pregnancy risks. Past studies have correlated subjective perceptions of fetal movement with some maternal characteristics; however, because fetal movement was measured by asking maternal report, it is unclear whether confounding variables impacted the conclusion. Our aim was to investigate associations between maternal characteristics and objectively quantified fetal movement captured using Cine MRI. Movement was quantified as the total number of seconds of movement observed across 2 videos per fetus (total video per fetus = 166 s) for 36 fetuses. Our novel schema for annotating fetal movement involved using the videos generated to track the duration of fetal movement for relevant body segments and using this to calculate total movement duration for each fetus. Duration of fetal movement ranged from 0s -83s per fetus. Data on six maternal characteristics—age, work status, physical activity, race-ethnicity, income, and educational attainment— were self-reported. Associations were tested at a significance level of 0.05. We used Spearman's rank correlation tests to examine the relationship between

fetal movement time and maternal age (rs(36) = -0.018, p = .92), physical activity (rs(30) = 0.112, p = .56), and work status (rs(33) = 0.068, p = .71). We fit a linear regression model to examine whether maternal education level predicted fetal movement time (R2 = -0.02, F(1,32) = 0.07, p = .79). We were unable to interpret data on race-ethnicity or income as the sample was not equally distributed. We did not find a statistically significant association between fetal movement and the variables tested. Limitations of this study include that fact movements observed in videos may not be representative of a fetus' total movement. Our work describes use of a promising quantitative tool for investigating the relationship between maternal wellbeing and fetal neuromotor health.

P2-L-43 Network controllability of the fetal structural connectome

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Summary: We characterized fetal white matter development across the perinatal period. Trajectories were nonlinear, demonstrating the complexity of fetal development and the need for advanced computational approaches. Results also highlight differences in in-utero and ex-utero (i.e., preterm birth) brain development during the fetal period.

Details: The brain rapidly develops during the fetal period. The structural connectome has hallmark properties that support efficient brain dynamics by birth. Using ex-utero preterm infants as a model for normative fetal development, similar patterns appear over the third trimester. Yet, little work has investigated the structural connectome in in-utero fetuses using advanced approaches, like network control theory (NCT). We investigated the controllability of structural connectomes from 234 fetuses, 192 preterm infants, and 450 term infants from the developmental Human Connectome Project.

Diffusion-weighted data underwent standard preprocessing. Structural connectomes were created with the 90-node infant atlas. We used NCT to calculate node and edge average controllability (AC). AC is the ability to drive the brain toward nearby states. We asked several questions. First, we created trajectories for whole-brain AC from 20.86 to 45.14 weeks postmenstrual age (PMA). Second, we compared whole-brain AC between fetuses and preterm infants at the same PMA. Third, we tested whether fetuses and infants share similar developmental patterns in edge AC. A predictive model of PMA trained with edge AC from the fetal connectome and tested on the neonatal connectomes. We repeated this modeling by training on neonates and testing on fetuses. All analyses controlled for motion, head volume, sex, and network strength.

First, across the perinatal period, AC exhibited a u-shaped pattern ($r=0.60$, $p<0.001$). It decreased until 35.08 weeks PMA and increased afterward. Second, fetuses showed weaker AC than preterm infants at the same PMA. The greatest difference ($t=-5.85$, $p<0.001$) between fetuses and preterm infants happens at 35 weeks PMA—the same PMA as the minimum of the u-shaped trajectory. Third, predicted models of PMA trained on fetal edge AC generalized to the neonatal connectome ($r=0.86$, $p<0.001$, mean absolute error [MAE]=4.11 weeks). Likewise, models created from neonatal data generalized to fetal data ($r=0.83$, $p<0.001$, MAE=2.02 weeks).

Our study characterizes controllability in the fetal period. AC develops in a continuous, nonlinear pattern during the perinatal period. In-utero fetuses demonstrate weaker AC than ex-utero preterm infants. Despite these differences, maturation patterns across the connectome are similar enough for predictive models of PMA to generalize between fetuses and neonates.

P2-L-44 Longitudinal associations between maternal prenatal stress, systemic inflammation, and neonatal white matter microstructure (pre-registered report)

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Summary: Maternal prenatal stress (mPS) is linked to altered brain maturation in utero, increasing susceptibility to poor developmental outcomes. Stress is proinflammatory, and effects of maternal immune activation(MIA) on brain maturation mirror those of mPS. Yet whether MIA mediates relations of mPS to brain development has not been longitudinally studied

Details: Objective: We tested whether maternal immune activation (MIA) mediates associations of maternal prenatal stress (mPS) to neonatal white matter (WM) microstructure.

Methods: Pregnant women were recruited and followed longitudinally (N=398; eLABE sample). In each trimester, self-reported stress was measured using the perceived stress scale (PSS). At delivery (N=258) or shortly after (N=79), participants completed the STRAIN to assess the count and severity of stressful life events during pregnancy. PSS and STRAIN data were combined to create a total pregnancy mPS construct. In each trimester, pro-inflammatory serum cytokine concentrations (IL6, TNFa) were collected to measure systemic inflammation. Shortly after birth, diffusion-weighted images were collected from sleeping, non-sedated neonates, and diffusion tensor metrics were extracted (fractional anisotropy (FA); mean diffusivity (MD); axial diffusivity (AD); radial diffusivity (RD)) to assess WM microstructure.

Missing data for each participant will be imputed with conditional multiple imputation. Regression models will test whether (a) mPS is associated with increased pro-inflammatory cytokine concentrations and (b) mPS-related cytokines are associated with neonatal DTI metrics (FA, MD, AD, RD). Of the related metrics/variables, mediation models will test whether increased cytokine concentrations mediate associations between mPS and neonatal white matter microstructure.

Anticipated Results: We anticipate that increased pro-inflammatory concentrations (IL6, TNFa) will mediate associations between mPS and neonatal MD and AD. Progress to date: We have completed collection and preprocessing of mPS (PSS, STRAIN), maternal inflammation (IL6, TNFa), and neonatal diffusion data. All analyses will be completed before the conference.

Conclusions: As the first human longitudinal study of its kind, this study will better elucidate whether maternal inflammation is a plausible mechanism through which maternal prenatal stress influences in utero brain development in humans. As such, results will have important implications for identifying inflammation as a potential target for preventative intervention. This is particularly notable given the relevance of inflammation in multiple disease pathologies, enabling preventative interventions to draw on existing work developing anti-inflammatory therapies.

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