Emerging Research in Infant Neuroimaging: A Fit'ng Overview

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Symposium

Infant neuroimaging studies have unique potential to elucidate early brain developmental trajectories and how different experiences may alter these trajectories. With large-scale initiatives, like the Developing Human Connectome Project, the Baby Connectome Project, and the HEALthy Brain and Child Development Study, more and more researchers are joining this exciting field. However, despite the potential of and interest in infant neuroimaging, the overall field is still nascent and a relatively few infant neuroimaging talks have been presented at OHBM. Here, we offer four cutting-edge infant neuroimaging works, exploring a wide-range of topics. First, a systematic review presents an overview of different common space templates used in infant neuroimaging and how the lack of standards hurts infant neuroimaging. Next, we present two talks on individual differences in infant functional networks and connectomes. Finally, we present on how experienced discrimination of BIPOC, pregant women affects amygdala and hippocampus connectivity in their infants. By attending this symposium, researchers will gain a greater understanding of where the field of infant neuroimaging is heading.

Objective

Learn what common space templates are popular in the field, how these choices have changed over time, and how a lack of a standard hurts the field.
Learn how to probe individual differences in functional networks and connectomes during infancy.
Learn how prenatal exposures (like maternal experience of discrimination during pregnancy) is associated with changes in infant brain connectivity

Target Audience

The target audience is anyone interested in infant neuroimaging, from beginers and newcomers to experienced researchers.

Presentations

(Un)common Space in Infant Neuroimaging Studies: A systematic review of infant templates

In infant neuroimaging, there remain several technical challenges that have prevented the establishment of a standardized template for spatial normalization.To quantify the popularity and variability of these approaches in infant neuroimaging studies, we performed a systematic review of infant MRI studies from 2000 and later. Our goal is that, by quantifying what the most popular approaches are, standardized templates in infant neuroimaging can be established. A PubMed search was performed to gather relevant articles, returning 37,782 articles. We excluded duplicate articles, articles from before the year 2000, case reports, articles written in languages other than English, articles for animal studies, methodological articles, reviews articles, articles using subjects older than 18 months, articles using fetal MRI, and articles using imaging modalities other than MRI. Here, we present results from the first 101 papers meeting inclusion criteria. Articles were classified into 1) processing data in native space (i.e. forgoing spatial normalization), 2) creating a study specific template, or 3) using a predefined template. Our preliminary analysis shows that native space processing was used in over 50% of the studies (native space: 53.5%, study specific: 18.8%; predefined: 27.72%, X2=8.9, p=.01). Of predefined templates, the JHU Neonate Atlas (n=9) was the most commonly used. The preferred approach varied over time. Studies published prior to 2010 overwhelmingly used native space compared to using a template (either predefined or study specific; native space: 91.4%, template: 8.6%, X2=11.8, p<.001). In contrast, studies published after 2010 primarily used a template; though native space processing remained popular (native space: 33.3%, template: 66.7%, X2=5.3, p=.02). We highlight a lack of an established template brain in these studies. Given that infant neuroimaging is maturing in its use of image processing methods, establishing standardized templates is a needed next step in the field.

Presenter

Silvia Gini, University College London London, England, United Kingdom

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Low Infant Functional Connectome-based Identification Accuracy Across the First Year of Life

In adolescents and adults, an individual's functional connectome (or connectivity matrix) is unique and stable over months to years. This uniqueness and stability can be measured using connectome-based identification or "fingerprinting", which identifies an individual from a pool of other individuals and achieves high accuracy (80%-95%) in adolescents and adults. However, it is unclear if a high identification rate can be achieved during infancy, when the brain is rapidly developing. We examined identification rate in 33 infants with longitudinal resting-state data acquired at 1-2 months of age (S1) and 9-10 months of age (S2). Connectomes were extracted from infant resting-state data using an infant-specific parcellation resulting in an 83 by 83 connectivity matrix. Similarity between connectomes was measured with correlation and geodesic distance. We tested identification using both the raw connectomes and connectomes transformed into tangent space. Using raw connectomes and correlation, identification was low, ranging from 6% (S1 to S2) and 9% (S2 to S1). Results were similarly low using raw connectomes and geodesic distance with accuracies of 3% and 9%. Connectomes transformed into tangent space resulted in accuracies of 15% and 6%. Potential explanations for the low identification accuracy include low uniqueness and stability at the level of individual edges; average edge-wise test-retest reliability was poor (mean ICC=0.07, SD=0.09, range=0-0.57). The low identification rate may reflect unparalleled developmental changes in the functional organization of the brain during this period but may also reflect issues with measurements of functional connectivity being reliable across the first year of life.

Presenter

Alexander Dufford, Yale University Child Study Center, New Haven, CT, United States

Using Template Matching to Generate Individualized Resting State Networks in Infants

The brain is organized into a set of large scale functional neural networks. Recent evidence shows that the precise network topology of these systems is highly specific to individual adults, adolescents, and children. However, individual network distinctions are lost in most studies due to averaging, potentially obscuring important individual differences. Moreover, although large scale functional networks already emerge in early infancy, the extent to which reliable individual differences in network topology exist at these early development timepoints remains unknown. Our group has recently shown that a method referred to as template matching can reliably generate individual networks in adolescents and, unlike other approaches, does not require a prohibitively large amount of data. We therefore tested whether template matching could also be used in infants to generate resting state networks reliably, and measure their variability. We generated an infant template using 69 neonatal subjects from UCI (average gestational age 39.2 ± 0.2 weeks, average scan age 26.4 ± 1.4 days) and observed all major adult networks in the template. We had a unique opportunity to test the validity of the approach in two independent neonatal datasets with more extended acquisition times than are typical for infants (EXITO: 14 subjects with 38.5 ± 2.7 min rest, WashU: 26 subjects with 31.4 ± 1.6 min rest). Using these datasets, we compared the similarity of networks generated from the first versus the second half of each subject's resting state data. The similarity of networks generated from the same subject was significantly greater than networks generated from different subjects (EXITO: $t(376)=2.88$, $p=0.0041$, WashU: $t(559)=3.83$, $p=0.0001$), affirming that template matching identifies reliable, individual infant functional networks, much like in adolescents. Additionally, individual networks generated from different infant subjects were more similar to one another than individual adolescent networks ($p<0.0001$ for both EXITO and WashU normalized mutual information compared to adolescent), suggesting that the specificity of individual networks is further refined with development. These results provide a foundation for beginning to investigate the early emergence of individual functional network topology beginning soon after birth.

Presenter

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Effects of Maternal Experience of Discrimination During Pregnancy on Neonatal Brain Connectivity

There is emerging evidence that chronic exposure to racial discrimination during pregnancy is associated with various negative psychological and physical maternal outcomes including increased risk of depression, anxiety, and systemic inflammation. However, there is a lack of research examining the impact of maternal racial discrimination on offspring brain development. The current study aims to determine whether maternal exposure to racial discrimination affects neonatal functional connectivity of the hippocampus and amygdala, areas that have been linked to stress and depression. Forty-five pregnant women, aged 14-19, were recruited from Columbia University Irving Medical Center. They received routine prenatal care and had no major health problems. A majority of the women were Hispanic (88%). At 34-37 weeks gestation, the women completed self-report psychological assessments including the Experiences of Discrimination Scale. Resting-state functional MRI data was acquired in the neonatal period. Standard seed connectivity from the right and left hippocampi and amygdalae were performed. Women reporting discrimination during pregnancy compared to women who did not had neonates with weaker connectivity between the right hippocampus and dorsolateral prefrontal cortex. In kind, women experiencing discrimination relative to those who did not had neonates with weaker connectivity between the left amygdala and anterior prefrontal cortex. Our findings suggest that maternal exposure to racial discrimination is associated with neonatal connectivity of the hippocampal and amygdala regions to the prefrontal cortex, which are all brain regions implicated in stress and emotion processing. As our findings with infant brain connectivity are consistent with these brain regions associated with racial processing and social evaluative stress in adults, there could be a intergenerational effect of discrimination that will require further study. Future studies are necessary to relate these connectivity patterns to racial information processing in offspring, and to determine whether racial discrimination during pregnancy is associated with negative psychological and physical outcomes in offspring.

Presenter

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