Investigating electrophysiological bases of sensori-motor development in premature infants

Infant's brain development and plasticity are very intense during the last trimester of pregnancy and the first months after birth. Sensori-motor networks are among the firsts to develop, starting within the mother's womb but continuing to mature after birth in interaction with the environment. The maturation of these networks encompasses a complex sequence of mechanisms, and is in part genetically programed, but also relies on sensory inputs, motor actions and sensory feedbacks (perception-action loop). Premature birth and perinatal stress can interfere with the normal sequence of mechanisms serving the brain maturation and alter peri-natal experiences, with potential long-term consequences on infants' development. Early interventions may thus benefit from the early and intense plasticity mechanisms to improve the children's outcome.

The M2 research project will focus on the maturation of sensori-motor cerebral networks, in very-premature infants (born before 32 weeks of gestational age) with brain lesions, who are at high risk of atypical developmental outcome such as cerebral palsy. This study aims to investigate the maturation of brain activity, recorded non-invasively with high-density electroencephalography (HD-EEG, with 128 electrodes), at the age equivalent to full-term birth (at 0 month of age corrected for gestational age at birth) and 2 months later. A secondary objective is to evaluate the evolution of brain activity in relation to an early locomotor training (based on a comparison of infants with and without training). EEG recordings are acquired in infants at rest (no task) in Robert-Debré pediatric hospital (Paris). The maturation of brain activity will be evaluated by studying the frequency contents of the EEG signal, as well as the large-scale functional connectivity across the brain areas. Source reconstruction approaches will be tested based on individual MRI data acquired in the same infants at both ages. The predictive value of EEG measures will be studied in relation with the neurodevelopmental outcomes of infants followed until 2 years of age, but in a later step (outside the scope of the M2 project).

The M2 student will be mainly involved in EEG data analysis and statistical analyses (using MATLAB, python and R) since part of the EEG data will be already collected before the start of the internship. During the internship, the student will also be involved in the ongoing EEG data collections (~1 EEG recording per week).

This research project will provide important information on the maturation of functional architecture of sensorimotor networks in premature infants, and the effectiveness of early locomotor intervention. The EEG study of the resting-state functional connectivity in the infant preterm brain will be complementary to the team's on-going research in infants, such as the studies of MRI-based structural connectivity of sensori-motor networks and of body maps representations evaluated through task-based EEG in the same infants.

The student will work in the inDev team (Imaging Neurodevelopmental Phenotypes) of the Inserm NeuroDiderot laboratory. Located both at the Robert-Debré Hospital (Paris) and at the NeuroSpin neuroimaging center (CEA Paris-Saclay, in Paris metropolitan area), this dynamic team focuses on the characterization of the functional and anatomical variability of human brain development, with neuroimaging and in relation to neurological and cognitive functions. The student will work under the co-supervision of Jessica Dubois (researcher, PhD, HDR) and Parvaneh Adibpour (postdoctoral fellow, PhD), in an interdisciplinary environment allowing close interactions between fundamental and clinical research for the study of neurodevelopment. The internship project is part of the PremaLocom ANR-funded project conducted in collaboration with the PACD team (INCC laboratory, Paris, PI Dr Marianne Barbu-Roth), the Neonatology Department (head Pr Valérie Biran), the Radiology Department (head Pr Marianne Alison) and the Child Psychiatry Department (head Pr Richard Delorme) of the Robert-Debré Hospital.

Applicants interested in the study of early brain development, with prior experience in signal processing and programming are particularly encouraged to apply. Candidates are invited to email a letter of motivation and a CV detailing the academic background to: jessica.dubois@cea.fr and parvaneh.adibpour@inserm.fr

Additional information

- inDev team: http://neurodiderot.org/index.php/indev-en/
- NeuroDiderot lab: https://www.neurodiderot.com/
- NeuroSpin center: https://joliot.cea.fr/drf/joliot/en/Pages/research_entities/NeuroSpin.aspx
- PACD Team: https://incc-paris.fr/perception-action-and-cognition/

Recent publications in relation to the proposed research project :

Adibpour, P, Lebenberg, J, Kabdebon, C, Dehaene-Lambertz, G, & Dubois, J. Anatomo-functional correlates of auditory development in infancy. *Developmental cognitive neuroscience,* 2020. 42:100752
Access: https://www.sciencedirect.com/science/article/pii/S1878929319303391

Adibpour P, Dubois J, Moutard ML, Dehaene-Lambertz G. Early asymmetric inter-hemispheric transfer in the auditory network: Insights from infants with corpus callosum agenesis. Brain Structure and Function, 2018. 223:2893-2905
Access: https://hal.archives-ouvertes.fr/hal-02004827/document

Dubois J, Adibpour P, Poupon C, Hertz-Pannier L, Dehaene-Lambertz G. MRI and M/EEG studies of the white matter development in human fetuses and infants: review and opinion. Brain Plasticity, 2016. 2:49-69.
Access: https://hal.archives-ouvertes.fr/hal-02433924/document