M2 internship proposal, 4-6 months from January 2020

*** Title of the proposed project:**
Mapping the functional connectivity of sensorimotor regions in the newborn brain with MRI

*** Host laboratory:**
Inserm NeuroDiderot Unit U1141
Administrative adress of the lab: Hôpital Robert Debré, 48 boulevard Serrurier, 75019 Paris
Internship location: CEA/SAC/NeuroSpin, Bât 145, PC 154, 91191 Gif-sur-Yvette

*** Host team**:
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*** Proposed M2 research project**
Background and objectives:

Somatosensory perceptions are among the first that human fetuses experiment inside the mother's womb. After birth, infants and children further develop and refine the perception of their body parts while acquiring new motor skills and interacting with others. In the mature brain, each body part is represented in a specific area of the cortex (this correspondence is called 'somatotopy'). In animal brains, the development of these 'body maps' relies on a complex sequence of intrinsic and activity-dependent factors, but this emergence has been little explored so far in the human brain. Yet, it is important to define early brain markers of sensorimotor processing for clinical purposes, because a perinatal stress or insult (e.g. prematurity, neonatal stroke) may disturb this early process with a long-term impact on the child's emotional and cognitive development. Non-invasive neuroimaging techniques such as magnetic resonance imaging (MRI) then provide a unique opportunity to measure neural mechanisms and relate them with behavioral skills and clinical outcome.

The master project aims to investigate how sensorimotor brain regions develop in the infant brain, in terms of specialization and maturation. More specifically, it aims to characterize the functional connectivity of regions related to different body parts in full-term newborns, in terms of topography and maturation.

Indeed, the last trimester of pregnancy and the first post-natal weeks are a critical period for the development of the brain, during which several processes occur in relation to genetic, epi-genetic and environmental factors. The brain growth is intense, and the folding process leads to complex gyri and sulci. Cortical and sub-cortical regions start to be connected through white matter fibers, and the sensorimotor network becomes functional. At birth, the brain already shows a functional architecture, but the maturation is far from complete. Recent researches have suggested that the sequence of maturation across brain regions and functional networks depends on the infant's progressive acquisitions observed at behavioral level. In the context of sensorimotor development, we assume that cortical regions related to different body parts specialize and mature progressively as these parts are perceived and used. Concomitantly, the connections between somatotopic regions and other brain regions are supposed to gain in specificity and maturation.

Main tasks and methods:

The student will evaluate the development of functional connectivity of sensorimotor regions in a cohort of full-term newborns (data from the developing Human Connectome Project, UK), using resting-state functional MRI data (rs-fMRI). He/she will specifically investigate the connections of cortical regions related to different body parts based on a parcellation of sensory and motor regions. He/she will explore the topography of these connections, as well as their strength as a function of the newborns' age (37-44 weeks of post-menstrual age). This will provide information the connections' specificity and maturation throughout development.

The student will perform post-processing and statistical analyzes of rs-fMRI data (images are already available, no acquisitions are planned). Some post-processing tools are developed by NeuroSpin teams (e.g. in Python), some others by outside teams (but available at NeuroSpin). These tools have been developed for adults and children brains. Consequently, their application to newborns data will require development and validation stages.

Anticipated outcomes and potentials:

This internship research will provide important information on the developing architecture of sensorimotor regions related to different body parts in humans. This study on the functional connectivity in the newborn brain will be complementary to on-going work in the team, on the microstructure and structural connectivity of somatotopic regions.

Several complementary questions might be addressed during a PhD project, such as the characterization of cortical functional specialization with task-based fMRI, and the exploration of an extended developmental period (from the preterm period to early infancy). This is a required step to assess whether the development of body maps might be impacted by premature birth or by the tactile environment experienced during *ex utero* growth (e.g. supportive tactile care or exposure to painful experiences). This is central to implement early remediation strategies when a "risk" of developing long-term disabilities is suspected, as early infancy is a critical window of opportunity characterized by intense neuroplasticity.

*** Recent publications in relation to the proposed research project:**

- Dubois J, Kostovic I, Judas M, Development of structural and functional connectivity. Brain Mapping: An Encyclopedic Reference, ed. A.W. Toga. Vol. 2. 2015: Academic Press: Elsevier.
- Kulikova S, Hertz-Pannier L, Dehaene-Lambertz G, Buzmakov A, Poupon C, Dubois J. Multi-parametric evaluation of the white matter maturation. Brain Structure & Function, 2015. 220:3657-3672.
- Lebenberg J, Mangin JF, Thirion B, Poupon C, Hertz-Pannier L, Leroy F, Adibpour P, Dehaene-Lambertz G, Dubois J. Mapping the asynchrony of cortical maturation in the infant brain: a MRI multi-parametric clustering approach. Neuroimage, 2019. 185:641-653.