The developing Human Connectome Project (dHCP): minimal functional preprocessing pipeline for neonates

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Background: The dHCP aims to create a detailed 4-dimensional connectome of early life spanning 20 to 44 weeks post-conceptional age, recording structural, diffusion and functional MRI measures in utero and in neonates. Neonates present significant challenges to data processing due to low and variable contrast and high levels of head motion. This abstract describes a number of refinements integrated into the dHCP framework for preprocessing of neonate fMRI, and sampling to cortical surface.

Methods: Multi-band fMRI (acceleration factor=9, TR=0.392) was acquired at St. Thomas Hospital, London, on a Philips 3T scanner using a 32-channel neonatal head coil. The dHCP pipeline is inspired by the HCP minimal preprocessing pipelines¹ and the FSL FEAT pipeline², however there are several unique modifications required to make the pipeline more robust to the challenge of neonatal data, including: 1) an initial ICA-based clean-up stage prior to motion correction to remove artefacts associated with the multiband acquisition which are native to the scanner frame of reference; 2) the inclusion of high contrast tissue boundaries (in addition to the traditional white-matter boundary), combined with an unsigned cost function, in the boundary-based functional to structural registration; 3) the selection of the lowest motion time-point as the reference volume for motion correction; and, 4) a custom sampling procedure, to project the functional time-series to the surface, to accommodate constraints of spatial resolution and motion-induced signal loss.

Results: The enhanced data cleanup routines substantially lower motion-related artefacts, avoiding extensive data rejection. Scanner space ICA identified multi-band artefact efficiently and cleanly, requiring only 52.1% of the components as would be identified in standard post-motion ICA. While standard functional to structural registration often failed, the modified boundary-based registration procedure is reliable and accurate. Initial volumetric and surface RSN analyses from 100 dHCP (33-44 weeks post-menstrual) neonates reveal finely resolved grey matter resting state networks (Figure 1).

Conclusions: Processing refinements integrated into the dHCP functional pipeline provide reliable, high quality connectomic data from neonates. Future work shall extend these pipelines to in-utero acquisitions.