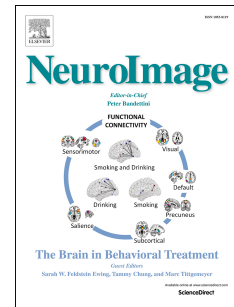


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The Developing Human Connectome Project: a Minimal Processing Pipeline for Neonatal Cortical Surface Reconstruction

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Abstract

The Developing Human Connectome Project (dHCP) seeks to create the first 4-dimensional connectome of early life. Understanding this connectome in detail may provide insights into normal as well as abnormal patterns of brain development. Following established best practices adopted by the WU-MINN Human Connectome Project (HCP), and pioneered by FreeSurfer, the project utilises cortical surface-based processing pipelines. In this paper, we propose a fully automated processing pipeline for the structural Magnetic Resonance Imaging (MRI) of the developing neonatal brain. This proposed pipeline consists of a refined framework for cortical and sub-cortical volume segmentation, cortical surface extraction, and cortical surface inflation, which has been specifically designed to address considerable differences between adult and neonatal brains, as imaged using MRI. Using the proposed pipeline our results demonstrate that images collected from 465 subjects ranging from 28 to 45 weeks post-menstrual age (PMA) can be processed fully automatically; generating cortical surface models that are topologically correct, and correspond well with manual evaluations of tissue boundaries in 85% of cases. Results improve on state-of-the-art neonatal tissue segmentation models and significant errors were found in only 2% of cases, where these corresponded to subjects with high motion. Downstream, these surfaces will enhance comparisons of functional and diffusion MRI datasets, supporting the modelling of emerging patterns of brain connectivity.

Keywords: Developing Human Connectome Project, dHCP, neonatal MRI, pipeline, segmentation, cortical surface reconstruction

1. Introduction

The period of rapid cortical expansion during fetal and early neonatal life is a crucial time over which the cortex transforms from a smooth sheet to a highly convoluted surface. During this time, the cellular foundations of our advanced cognitive abilities are mapped out, as connections start to form between distant regions (Ball et al., 2013b; Van Essen, 1997), myelinating, and later pruning, at different rates. Alongside the development of this neural infrastructure, functional brain activations start to be resolved (Doria et al., 2010), reflecting the development of cognition.

Much of what is currently known about the early human connectome has been learnt from models of preterm growth (Ball et al., 2013b; Counsell et al., 2013; Doria et al., 2010; Keunen et al., 2017).

¹These authors contributed equally

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