UNC-BCP 4D Infant Brain Volumetric Atlas

0. What this is

Spatial-temporal infant dedicated brain atlases are essential for neuroimaging analysis of early brain development. However, due to the difficulties in the acquisition of high-quality infant brain magnetic resonance (MR) images, substantial technical challenges in processing the acquired data, and the demand for large sample size, the existing infant atlases are generally constructed with fuzzy appearances and sparse time points. To enable accurate studying of the early brain development, high-quality spatial-temporal infant brain atlases are highly desired. To address this problem, we have constructed 4D volumetric atlases for infant brains based on the UNC/UMN Baby Connectome Project (BCP) dataset (Howell et al., 2019), named **UNC-BCP 4D Infant Brain Volumetric Atlas**. This 4D atlas has high spatial resolution, large age-range coverage and densely sampled time points (i.e., 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 18, 21, 24 months). Specifically, 542 MRI scans with T1w and T2w sequences from 240 infants up to 26-month scan-age were utilized for our atlas construction. Meanwhile, the widely used FreeSurfer Desikan cortical parcellation scheme (Desikan et al., 2006) was mapped to our 4D atlas, and the subcortical structures were manually delineated to facilitate ROI-based analysis. All the images were warped into the MNI space (Mazziotta et al., 1995). This 4D infant volumetric atlas with very dense time points will greatly facilitate the understanding of the dynamic and critical neurodevelopment during early postnatal stages.

1. Where to download

The atlas can be freely downloaded from:

https://www.nitrc.org/projects/uncbcp_4d_atlas/

2. What it includes

Our atlas comprised five major components: (1) the gray-scale average T1w and T2w images; (2) the tissue probability maps (TPMs) for each tissue type; (3) the tissue segmentation maps (TSMs); (4) the anatomical parcellation maps; (5) brain masks without cerebellum. **Fig. 1** and **Fig. 2** show the constructed 4D infant volumetric atlas with the major components at each time point.

All the image files are summarized in **Table 1** and located underneath the age-specific directories (0M, …, 24M) of the template folder:

Table 1. The name for each component.

File	Description
BCP–{00M,01M,02M, ⋯, 24M}-T1w.nii.gz	T1w image
BCP–{00M,01M,02M, ⋯, 24M}-T2w.nii.gz	T2w image
BCP–{00M,01M,02M, ⋯, 24M}-Seg.nii.gz	Tissue segmentation map
BCP–{00M,01M,02M, ⋯, 24M}-GM.nii.gz	Gray matter tissue probability map
BCP–{00M,01M,02M, ⋯, 24M}-WM.nii.gz	White matter tissue probability map
BCP–{00M,01M,02M, ⋯, 24M}-CSF.nii.gz	Cerebrospinal fluid probability map
BCP–{00M,01M,02M, ⋯, 24M}-Parc.nii.gz	Parcellation map of brain structures – 82 cortical and subcortical structures

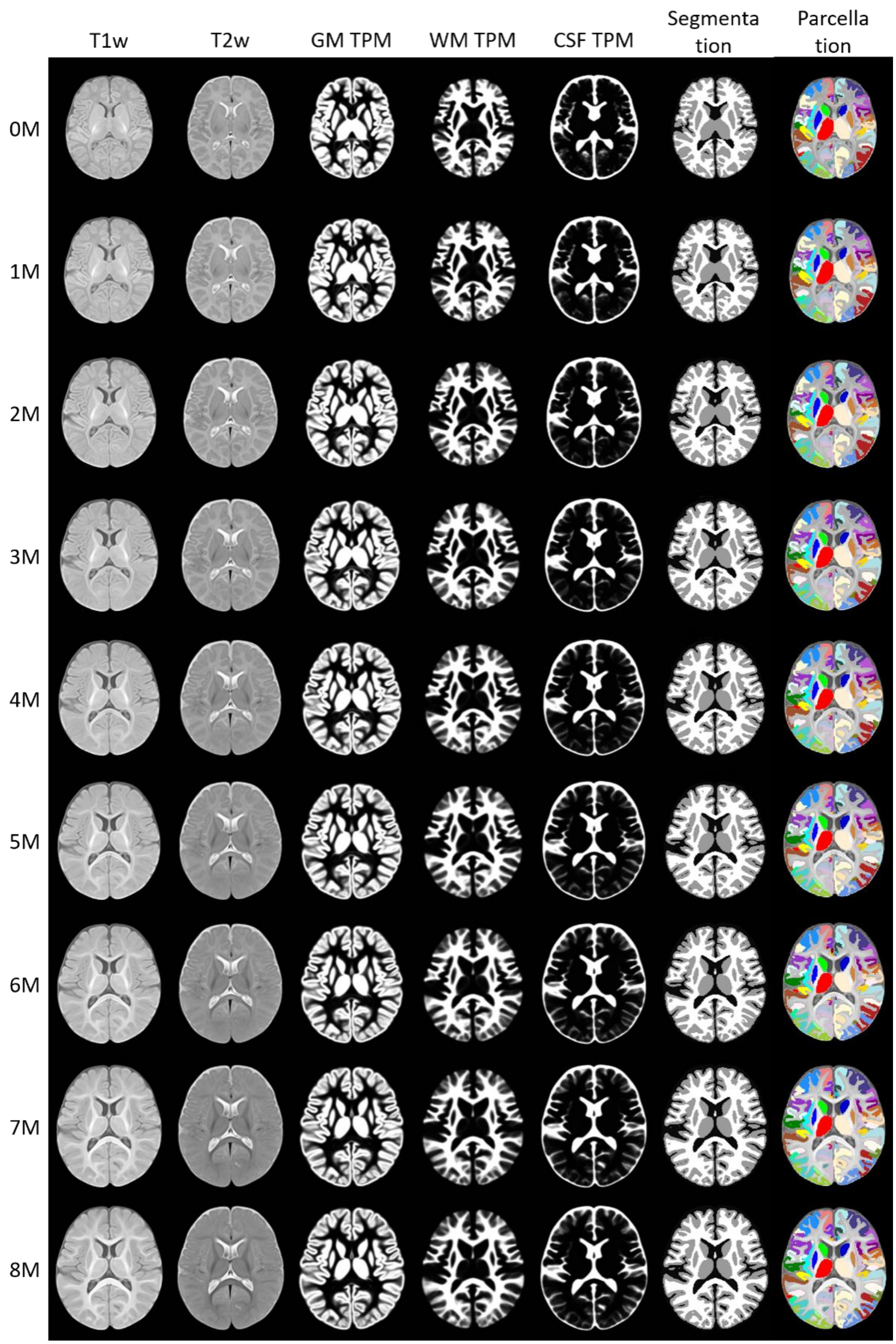

Fig. 1. Atlases from 0-month to 8-month.

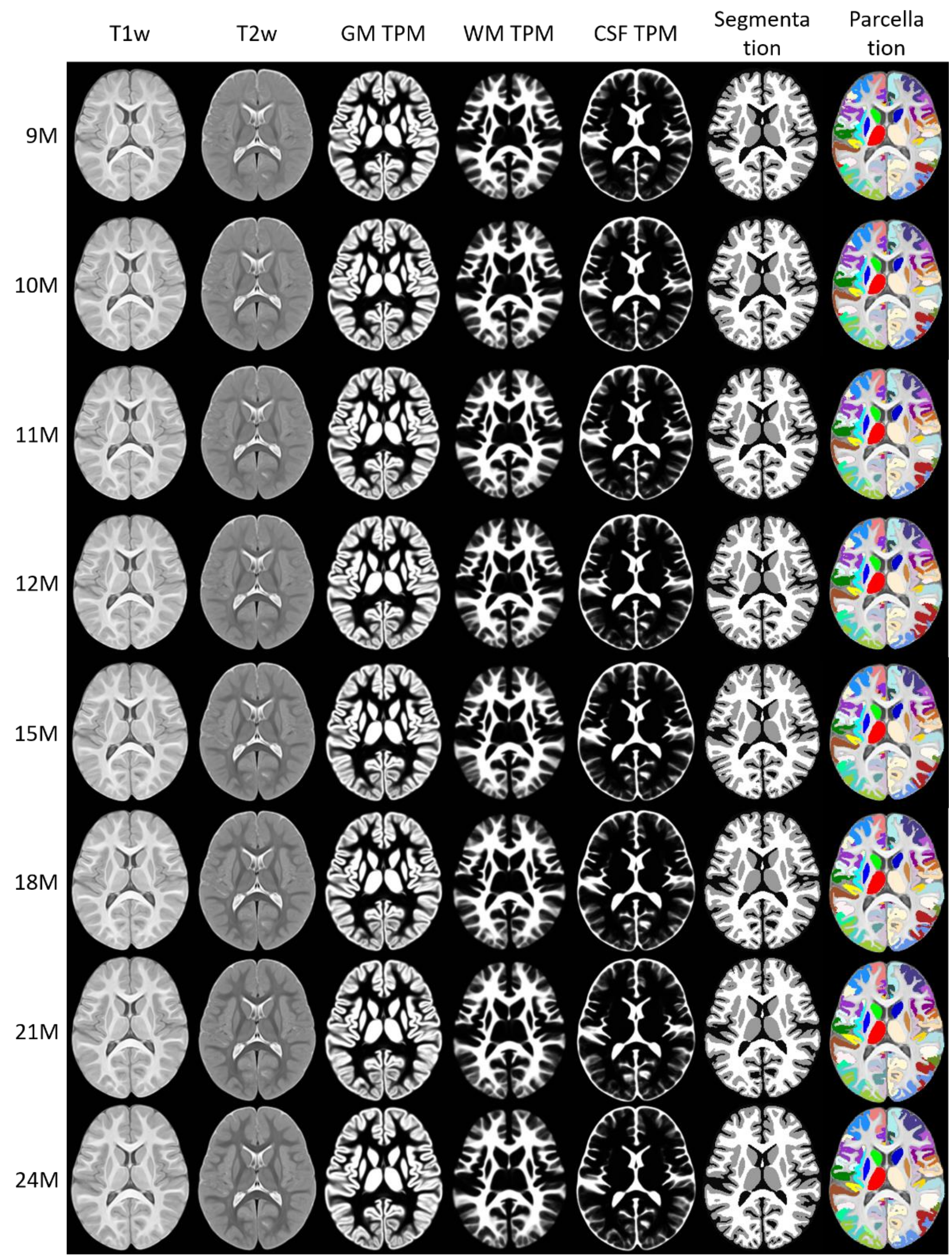

Fig. 2. Atlases from 9-month to 24-month.

3. Labels of brain structures

The parcellation maps of our 4D infant atlas were mapped from the widely used FreeSurfer Desikan parcellation, which includes 70 cortical regions. Moreover, we manually labeled 12 subcortical structures, e.g., thalamus, caudate, putamen, pallidum, hippocampus, and amygdala. Therefore, the parcellation map of each proposed atlas includes 82 structural labels, which are summarized in **Table 2**.

Table 2. The label number for each structure.

Region	Index	Region	Index
Left Banks Superior Temporal	101	Right Banks Superior Temporal	201
Left Caudal Anterior Cingulate	102	Right Caudal Anterior Cingulate	202
Left Caudal Middle Frontal	103	Right Caudal Middle Frontal	203
Left Corpus Callosum	104	Right Corpus Callosum	204
Left Cuneus	105	Right Cuneus	205
Left Entorhinal	106	Right Entorhinal	206
Left Fusiform	107	Right Fusiform	207
Left Inferior Parietal	108	Right Inferior Parietal	208
Left Inferior Temporal	109	Right Inferior Temporal	209
Left Isthmus Cingulate	110	Right Isthmus Cingulate	210
Left Lateral Occipital	111	Right Lateral Occipital	211
Left Lateral Orbito Frontal	112	Right Lateral Orbito Frontal	212
Left Lingual	113	Right Lingual	213
Left Medial Orbital Frontal	114	Right Medial Orbital Frontal	214
Left Middle Temporal	115	Right Middle Temporal	215
Left Parahippocampal	116	Right Parahippocampal	216
Left Para Central	117	Right Para Central	217
Left Pars Opercularis	118	Right Pars Opercularis	218
Left Pars Orbitalis	119	Right Pars Orbitalis	219
Left Pars Triangularis	120	Right Pars Triangularis	220
Left Peri Calcarine	121	Right Peri Calcarine	221
Left Post Central	122	Right Post Central	222
Left Posterior Cingulate	123	Right Posterior Cingulate	223
Left Pre Central	124	Right Pre Central	224
Left Pre Cuneus	125	Right Pre Cuneus	225
Left Rostral Anterior Cingulate	126	Right Rostral Anterior Cingulate	226

Left Rostral Middle Frontal	127	Right Rostral Middle Frontal	227
Left Superior Frontal	128	Right Superior Frontal	228
Left Superior Parietal	129	Right Superior Parietal	229
Left Superior Temporal	130	Right Superior Temporal	230
Left Supra Marginal	131	Right Supra Marginal	231
Left Frontal Pole	132	Right Frontal Pole	232
Left Temporal Pole	133	Right Temporal Pole	233
Left Transverse Temporal	134	Right Transverse Temporal	234
Left Isthmus Insula	135	Right Isthmus Insula	235
Left Thalamus	136	Right Thalamus	236
Left Caudate	137	Right Caudate	237
Left Putamen	138	Right Putamen	238
Left Pallidum	139	Right Pallidum	239
Left Hippocampus	140	Right Hippocampus	240
Left Amygdala	141	Right Amygdala	241

4. How it was constructed

To address the dynamic intensity changes and low tissue contrast, we exploited infant dedicated brain MR image preprocessing and segmentation methods and the state-of-the-art registration techniques to align the individual brains into the common space.

First, we applied a sliding-window strategy for selection of scans to build each age-specific atlas. Specifically, to better describe the rapid neurodevelopment and preserve more age-related anatomical properties in the first year of life, we constructed an atlas at each month with a sliding-window size of 3 months. Similarly, in the second year, we built an atlas every three months with a sliding-window size of 5 months. ***Second***, to improve the performance of registration on infant brain MR images, we first applied the infant brain extraction and analysis toolbox (iBEAT V2.0 Cloud, http://www.ibeat.cloud/) (Wang et al., 2018) to well preprocess and segment each scan and manually-checked each TPM. Then, the high-quality TPMs were used as the input images to perform the state-of-the-art symmetric group-wise normalization (SyGN, http://stnava.github.io/ANTs/) (Avants et al., 2010) to construct each atlas. ***Third***, we mapped the cortical parcellation map used in FreeSurfer to each age-specific atlas and manually delineated the subcortical structures to facilitate the ROI-based analysis. More information can be found in our Neuroimage paper below [Chen et al., 2022].

5. Acknowledgment

Please cite our Neuroimage paper:

Chen, L., Wu, Z., Hu, D., Wang, Y., Zhao, F., Zhong, T., ... & Li, G. (2022). A 4D Infant Brain Volumetric Atlas based on the UNC/UMN Baby Connectome Project (BCP) Cohort. NeuroImage, 119097.

6. Contact

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7. References

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