UNC Infant 0-1-2 Atlases

Infant Brain Atlases from Neonates to 1- and 2-year-olds

Updates

2014/03/25 Fix	xed the problem ir	n 2 yr old infant	with cerebellum w	which appears tilted slightly.
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Files changed: infant-2yr-withCerebellum.nii

2013/03/07 Atlases files are in NIFTI format. Origin is set on AC (Anterior Commissure) as [90

126 72]. This atlas is now included in AFNI, thanks to the work of Mr. Daniel

Glen.

2012/02/20 Label maps have larger coverage now. Note that the label map covers larger

region than the brain, so that it has better chance to cover the individual brains after alignment. When you calculate the ROI volume, you can use the individual segmentation image as a mask to remove the unnecessary regions in the

individual label map.

Files changed: infant-neo-aal.img, infant-1yr-aal.img, infant-2yr-aal.img

2011/11/08 We have updated our atlases by using (a) new segmentation results with surface

constraints [1] and (b) new implemented groupwise-HAMMER tool [2].

[1] L. Wang, F. Shi, P.-T. Yap, W. Lin, J. H. Gilmore, and D. Shen, "Longitudinally Guided Level Sets for Consistent Tissue Segmentation of Neonates," Human Brain Mapping, in press, 2011.

[2] The groupwise-HAMMER tool is now available with name "GLIRT" at http://www.nitrc.org/projects/glirt/.

0. Where to Download

http://bric.unc.edu/ideagroup/free-softwares/unc-infant-0-1-2-atlases/

The package is available free to the public for the academic research purpose. Note the ownership, copyright, and all rights are retained by UNC-Chapel Hill.

1. What it includes

Images are distributed at NIFTI (".nii") format. They can be opened by MRIcro/MRIcron/SPM.

'neo' refers to images at neonate, '1yr' refers to 1-year-old, and '2yr' refers to 2-year-old.

Below lists name convention for neonatal images.

Intensity model (mean image of all 95 infant-neo.nii registered intensity images) infant-neo-withSkull.nii Intensity model with skull infant-neo-withCerebellum.nii Intensity model with Cerebellum infant-neo-seg.nii Segmentation model infant-neo-seg-gm.nii Probability map for GM infant-neo-seg-wm.nii Probability map for WM infant-neo-seg-csf.nii Probability map for CSF Label map with 90 ROIs infant-neo-aal.nii

Fig. 1 shows the above images at a typical axial slice.

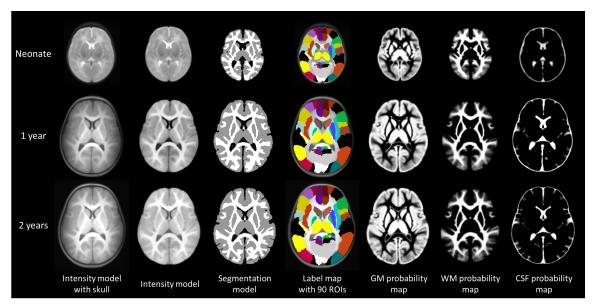


Figure 1. Atlas components for neonates, 1-year-olds, and 2-year-olds.

Intensity/Segmentation models are used to align with individual images, so that the label map can be transferred to individual images.

The anatomical description of regions in "infant-neo-aal.nii" image is detailed in Table 2. The definition is originally from N. Tzourio-Mazoyer et al, Neuroimage, 15: 273-289, 2002, but now it was warped into infant spaces.

Table 2. Regions of interest (ROI) defined in the infant-AAL template.

Index	Region	Abbreviation	Index	Region	Abbreviation
1	Precentral gyrus left	PreCG-L	46	Cuneus right	CUN-R
2	Precentral gyrus right	PreCG-R	47	Lingual gyrus left	LING-L
3	Superior frontal gyrus (dorsal) left	SFGdor-L	48	Lingual gyrus right	LING-R
4	Superior frontal gyrus (dorsal) right	SFGdor-R	49	Superior occipital gyrus left	SOG-L
5	Orbitofrontal cortex (superior) left	ORBsup-L	50	Superior occipital gyrus right	SOG-R
6	Orbitofrontal cortex (superior) right	ORBsup-R	51	Middle occipital gyrus left	MOG-L
7	Middle frontal gyrus left	MFG-L	52	Middle occipital gyrus right	MOG-R

9 Orbitofrontal gyrus right 10 Orbitofrontal cortex (middle) left 11 OR-R 12 Inferior frontal gyrus (opercular) left 12 Inferior frontal gyrus (opercular) left 13 Inferior frontal gyrus (percular) left 14 Inferior frontal gyrus (triangular) left 15 Orbitofrontal gyrus (triangular) left 16 Orbitofrontal gyrus (triangular) left 17 Inferior frontal gyrus (triangular) left 18 Inferior frontal gyrus (triangular) left 19 Orbitofrontal cortex (inferior) right 10 Orbitofrontal cortex (inferior) right 11 Inferior frontal gyrus (triangular) left 11 Inferior frontal gyrus (triangular) left 12 Orbitofrontal cortex (inferior) right 13 Inferior frontal gyrus (triangular) left 14 Inferior frontal gyrus (triangular) left 15 Orbitofrontal cortex (inferior) right 16 Orbitofrontal cortex (inferior) right 17 Rolandic operculum right 18 Rolandic operculum right 19 Supplementary motor area left 19 Supplementary motor area left 19 Supplementary motor area left 10 Inferior parietal lobule left 19 Supplementary motor area left 10 Orbitofrontal gyrus (medial) left 10 Inferior parietal lobule left 11 Inferior parietal lobule left 12 Inferior parietal lobule left 13 Inferior parietal lobule left 14 Inferior parietal lobule left 15 Orbitofrontal gyrus (medial) left 16 Supramarginal gyrus left 17 Supplementary motor area left 18 Rolandic operculum right 19 Supplementary motor area left 20 Supplementary motor area left 21 Olfactory left 22 Olfactory right 23 Superior frontal gyrus (medial) left 24 Superior frontal gyrus (medial) left 25 Orbitofrontal cortex (medial) left 26 Orbitofrontal cortex (medial) left 27 Rectus gyrus left 28 Rectus gyrus left 29 Rectus gyrus left 29 Insula left 20 Inferior parietal gyrus left 21 Olfactory left 22 Inferior parietal gyrus left 23 Anterior cingulate gyrus left 24 Superior frontal gyrus (medial) left 25 Orbitofrontal cortex (medial) right 26 Precuneus right 27 Rectus gyrus left 28 Rectus gyrus left 29 Insula left 30 Insula left 31 Anterior cingulate gyrus left 32 Anterior cingulate gyrus left 33 Middle ci						
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11 Inferior frontal gyrus (opercular) left IFGoperc-L 12 Inferior frontal gyrus (triangular) left IFGoperc-R 13 Inferior frontal gyrus (triangular) left IFGtriang-L 14 Inferior frontal gyrus (triangular) right IFGtriang-R 15 Orbitofrontal cortex (inferior) left ORBinf-L 16 Orbitofrontal cortex (inferior) right ORBinf-R 16 Orbitofrontal cortex (inferior) right ORBinf-R 16 Orbitofrontal cortex (inferior) right ORBinf-R 17 Rolandic operculum left ROL-L 18 Rolandic operculum right ROL-R 19 Supplementary motor area left SMA-L 20 Supplementary motor area right SMA-R 21 Olfactory left OLF-L 22 Olfactory right OLF-R 23 Superior frontal gyrus (medial) left SFGmed-L 24 Superior frontal gyrus (medial) right ORBmed-R 25 Orbitofrontal cortex (medial) right ORBmed-R 26 Orbitofrontal cortex (medial) right ORBmed-R 27 Rectus gyrus left REC-L 28 Rectus gyrus right REC-R 29 Insula left INS-L 30 Insula right INS-R 31 Anterior cingulate gyrus left MCG-L 32 Anterior cingulate gyrus left MCG-L 33 Middle cingulate gyrus left MCG-L 34 Middle cingulate gyrus left MCG-L 35 Posterior cingulate gyrus left MCG-L 36 Posterior cingulate gyrus left MCG-L 37 Posterior right SIGNER 38 Hippocampus right HIP-R 39 ParaHippocampal gyrus left HIP-L 30 Raydala left AMYG-L 31 Anterior cingulate gyrus left MCG-L 32 Anterior cingulate gyrus left MCG-R 33 Middle cingulate gyrus left MCG-R 34 Middle cingulate gyrus left MCG-R 35 Posterior rignulate gyrus left PCG-L 36 Posterior rignulate gyrus left PCG-L 37 Pediamus right HIP-R 38 Hippocampus right HIP-R 39 ParaHippocampal gyrus left PHG-L 40 Amygdala left AMYG-L 41 Amygdala left AMYG-L 42 Amygdala left AMYG-L 43 Calcarine cortex left CAL-L 44 Emporal pole (middle) left TPOmid-R 45 Calcarine cortex left CAL-L 46 Superior sengulate gyrus left PHG-R 47 Pediamus right TPOmid-R 48 Temporal pole (middle) left TPOmid-R 49 Alficeir reporal gyrus left TPOmid-R 40 Pararippocampal gyrus left CAL-L 40 Rectus gyrus left TPOmid-R 41 Amygdala left AMYG-L 42 Amygdala left AMYG-L 43 Calcarine cortex left CAL-L	9	Orbitofrontal cortex (middle) left	ORBmid-L	54	Inferior occipital gyrus right	IOG-R
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	45	Cuneus left	CUN-L	90	Inferior temporal gyrus right	ITG-R

2. How to use

Typical applications of the infant atlases are the spatial normalization, brain parcellation, and atlas-based segmentation.

Spatial normalization: Use registration algorithm to register all your infant subjects to their agematched atlas (the intensity model).

For registration algorithm, you can choose:

SPM (http://www.fil.ion.ucl.ac.uk/spm/),

HAMMER (http://www.nitrc.org/projects/hammerwml/),

Demons (http://www.insight-journal.org/browse/publication/154).

Brain parcellation: Use registration algorithm to register the age-matched atlas to your infant subjects. Then use the generated deformation field to transform the relative AAL map from atlas space to subject space.

Atlas-based segmentation:

Using iBEAT.

iBEAT (Infant Brain Extraction and Analysis Toolbox) is a MATLAB toolbox we recently developed with all modules for state-of-the-art infant brain segmentation and registration. It is available at http://www.nitrc.org/projects/ibeat.

Using SPM.

Prepare the data: First wrap the to-be-segmented image to the intensity image of template using the "Normalise: Estimate and Write" module from SPM, to make sure they are well aligned. Or you can wrap the template to the image, where the probability maps should be warped using "Normalise: Write" module. The point is to align them together so the probability maps can provide prior knowledge for the corresponding voxels.

Segmentation: Open the SPM in MATLAB environment, click the "Segment" in main menu, click "Data" to choose the to-be-segmented image. For use the infant atlas, Click "Custom", "Tissue probability maps", replace the three tissue priors with the agematched priors, with sequence from "pbmap_1", "pbmap_2", to "pbmap_0". Choose the option "Affine Regularisation" as "Average sized template". Do the segmentation.

Hint: Use "Check Reg" function in SPM to preview your to-be-segmented image and the infant atlases, make sure their orientations are similar and aligned, so that segmentation can be correctly carried out.

3. Data and MRI acquisitions

We constructed 3 atlases dedicated for neonates, 1-year-olds, and 2-year-olds. Each atlas comprises a set of 3D images made up of the intensity model, tissue probability maps, and anatomical parcellation map. These atlases are constructed with the help of state-of-the-art infant MR segmentation and groupwise registration methods, on a set of longitudinal images acquired from 95 normal infants (56 males and 39 females) at neonate, 1-year-old, and 2-year-old (Table 1).

Table 1. Demographic information of the normal infants used in this study

Scan	N	Gender	Age at Birth (weeks)	Age at MRI (weeks)	Group
First	95	56 m/39 f	37.9±1.8 (33.4 – 42.1)	41.5±1.7 (38.7 – 46.4)	Neonate
Second				94.2±3.4 (87.9 – 109.1)	1-year-old
Third				146.2±4.9 (131.4 – 163.4)	2-year-old

Images were acquired on a Siemens head-only 3T scanner (Allegra, Siemens Medical System, Erlangen, Germany) with a circular polarized head coil. For T1-weighted images, 160 sagittal slices were obtained by using the three-dimensional magnetization-prepared rapid gradient echo (MPRAGE) sequence: TR=1900ms, TE=4.38ms, inversion time=1100ms, Flip Angle=7°, and resolution=1x1x1mm3. For T2-weighted images, 70 transverse slices were acquired with turbo

spin-echo (TSE) sequences: TR=7380ms, TE=119ms, Flip Angle=150°, and resolution=1.25x1.25x1.95mm3. Data were collected longitudinally at 3 age groups: neonates, 1-year-olds, and 2-year-olds. Data with motion artifacts was discarded and a rescan was made when possible. Finally, complete 0-1-2 data of 95 normal infants was acquired.

4. How it was constructed

In particular, based on the observation that the images acquired at 2-year-olds can be segmented with relative ease and higher accuracy, we use their segmentation results to guide segmentation of images from earlier age groups, i.e., neonates and 1-year-olds. At the same time, longitudinal correspondences across three age groups are also established. With the 2-year-old images as the bridge, the anatomical parcellation, i.e., Automated Anatomical Labeling (AAL) map, is propagated to images of neonates and 1-year-olds. Finally, images at each individual age group are registered cross-sectionally with a groupwise algorithm to form a respective atlas. The obtained infant atlases can be used as references for spatial normalization of a group of infant images, as tissue priors for atlas-based tissue segmentation, and as templates for structural labeling. The effectiveness of our atlases, in comparison with other 3 widely used atlases, is evaluated with typical atlas-based applications. Results indicate that our atlases yield the highest spatial-temporal consistency in spatial normalization and structural labeling of individual infant brain images. Additionally, our atlases give the best performance in atlas-based segmentation of neonatal images.

5. How to cite

Please cite our below paper for using the atlas:

Feng Shi, Pew-Thian Yap, Guorong Wu, Hongjun Jia, John H. Gilmore, WeiliLin, Dinggang Shen, "Infant Brain Atlases from Neonates to 1- and 2-year-olds", PLOS ONE, 6(4): e18746, Apr. 2011. doi:10.1371/journal.pone.0018746.

6. Contact

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