A Stereotaxic MRI Brain Atlas for Infant Participants

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http:\\jerlab.psych.sc.edu\pdf\AtlasSRCD2013.pdf

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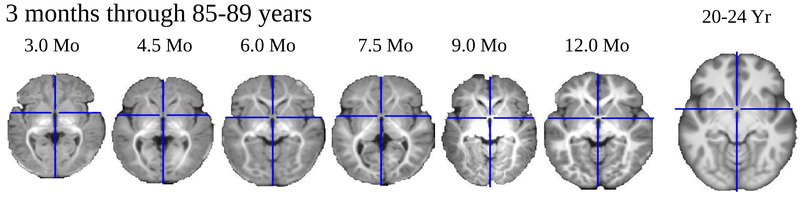
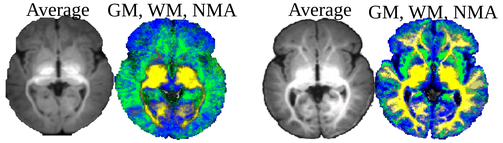
Background: The study of infant brain development is hampered by the lack of tools for doing automated brain structural analysis with MRI. The current study produced a stereotaxic atlas for average MRI templates in the first year (3 months through 12 months) and compared the automatic registration/transformation of the average to individuals with manually identified areas. We also used a majority vote procedure to create macroanatomical atlases on individual infants and compared them to manually identified areas.

Neurodevelopmental MRI Database

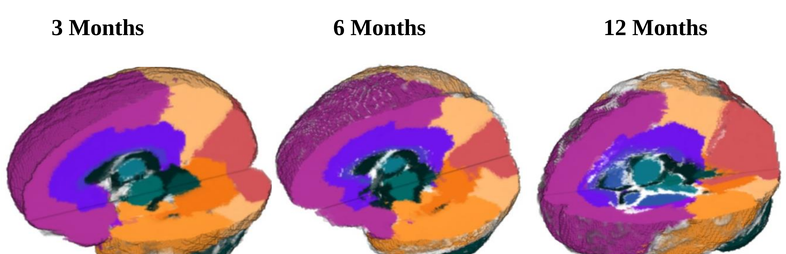
Average Age-Appropriate MRI templates across the Lifespan
Segmented head (GM, WM, CSF, Skull, Skin, Eyes)
3 months through 85-89 years





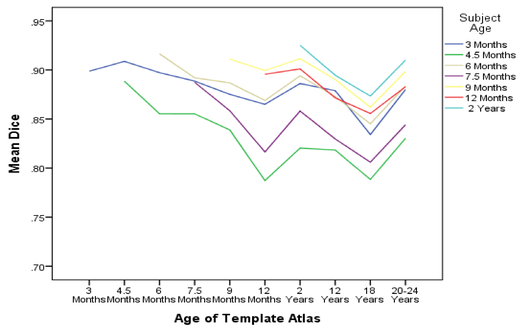
Stereotaxic Lobular Atlas

Methods: The ages were based on the existence of neurodevelopmental MRI average templates (3, 4.5, 6, 7.5, 9, 12 months). A stereotaxic atlas distributed with the FSL computer program, the MNI atlas, was used. The atlas was modified to fit an average brain template based on 20-24 year olds with high-resolution 3T scans (T1W, 3T, 3D, 1x1x1mm resolution, N = 99), transformed to the infant ages (3 to 12 months), and manually edited to fit precisely on the average template for each age. Stereotaxic atlases were also created for older ages (2 years, 12 years, 18 years) for comparison using the same methods.



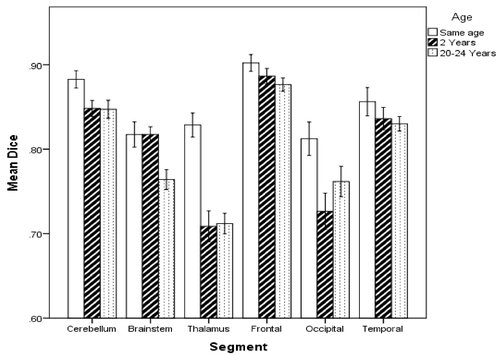
Test with Individual Participants

Test: The atlases were tested by examining 4 individuals at each age with six manually identified areas (frontal, occipital, temporal, cerebellum, brainstem, and thalamus). There was a close fit between the manually identified and automatically labelled regions for the age-appropriate atlas (DICE coefficient = .85) with systematic decrease for older age atlases.



Comparisons between age-appropriate and all older age atlases for frontal lobe.

Comparisons by regions between age-appropriate, 2 Years, and 20-24 Years atlases.



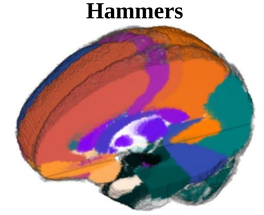
Macroanatomical Atlases

Methods: Using a majority vote approach, two macroanatomical atlases were created for individual infants from 3-12 months of age and individuals at 2 years, one based on the Hammers Atlases (Heckemann, et al., 2006) and one based on the LPBA Atlases (Shattuck, et al., 2008). For each individual MRI, the extracted brain was linearly registered to the adult brains and each segmented adult atlas was transformed to the infant space. The atlases were fused in a majority vote procedure described in more detail in Gousias, et al. (2008). The resulting atlas identifies the majority-voted brain segment for each voxel of the individual infant brain.

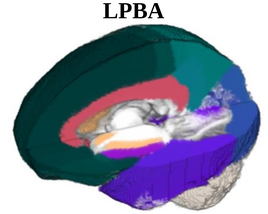
References: Gousias, I. S., Rueckert, D., Heckemann, R. A., Dyet, L. E., Boardman, J. P., Edwards, A. D., et al. (2008). Automatic segmentation of brain MRIs of 2-year-olds into 83 regions of interest. *NeuroImage*, *40*(2), 672-684.
Heckemann, R. A., Hajnal, J. V., Aljabar, P., Rueckert, D., & Hammers, A. (2006). Automatic anatomical brain MRI segmentation combining label propagation and decision fusion. *NeuroImage*, *33*(1), 115-126.
Shattuck, D. W., Mirza, M., Adisetiyo, V., Hojatkashani, C., Salamon, G., Narr, K. L., et al. (2008). Construction of a 3D probabilistic atlas of human cortical structures. *NeuroImage*, *39*(3), 1064-1080.

Macroanatomical Areas

3-0 Month Old Hammers



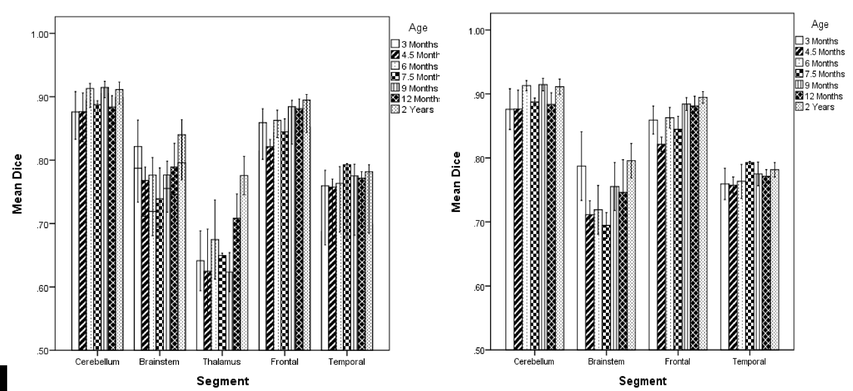
3-0 Month Old LPBA



Test with Individual Participants

Test: The atlases were tested by examining 4 individuals at each age with manually identified areas. There was a closer fit between manually identified areas and majority-voted areas at 2 years than at younger infant ages.

Comparisons by regions between manually-drawn areas and majority-voted macroanatomical areas (Left = Hammers; Right = LPBA).



Summary

These atlases allow more precise identification of anatomical areas in infant MRI studies.

While the majority vote procedures worked better for 2-year-olds, they may be a good choice for those desiring the localization of smaller, macroanatomical regions.

The atlases and age-appropriate MRI templates (template, segmenting, atlas) are available at: http://jerlab.psych.sc.edu/NeurodevelopmentalMRIDatabase/

Work supported by NIH, NICHD, HD R37 18942.