The Construction of MRI Brain Templates for Chinese Children and Adolescents from 8 Years to 16 Years of Age

Wanze Xie[1], John Richards[1], Kang Lee[2], Qiyong Gong[3], & Du Lei[3].

[1] Department of Psychology, University of South Carolina; [2] Department of Psychology, University of Toronto, Canada; [3]Huaxi MR Research Center (HMRRC), Department of Radiology, West China Hospital of Sichuan University, China.

Introduction

• A MRI brain template is a representation of human brain including anatomical information and provides a standard reference for assessment of brain structure and function (Ashburner & Friston, 1999).

•Brain templates are generated from the average of a group of subjects. Studies have shown that both developmental age and race have effects on brain morphology and structural variation (e.g., Gogtay et al., 2004; Lenroot & Giedd, 2006; Lee at al., 2005; Tang et al., 2010). For example, Tang et al. (2010) found that Chinese adults' brains are generally wider, shorter, and rounder in shape than American adults' brains.

•Thus, population-specific brain templates that provide finer brain information are beneficial to both structural and functional neuroscience studies.

•To date, age-specific templates have not been constructed for Chinese infants, children, or adolescents.

•In this study, we developed brain templates for 8, 10, 12, 14, and 16 year old Chinese children and adolescents using high quality magnetic resonance imaging (MRI) and well-validated image analysis techniques.

Methods

•*Participants*

- The MRI images for templates constructions were collected from 138 children and adolescents ranging in age from 7 to 16 years of age.
- Subjects were divided into 5 age groups in 2 years increments:
  - 7 to 8-year-old group (N=20) "CN8Years"
  - 9 to10-year-old group (N=22) "CN10Years"
  - 11 to 12-year-old group (N=37) "CN12Years"
  - 13 to 14-year-old group (N=39) "CN14Years"
  - 15 to 16-year-old group (N=20) "CN16Years"

•*MRI Data Acquisition*

- 113 subjects' scans were collected in Huaxi MR Research Center using a 3.0T Siemens Trio scanner; and the rest 25 subjects were collected in a different site using a 3.0T GE SIGNA MRI scanner.
- T1 scans were collected with 1 x 1 x 1 resolution.
- The 3T files were read from DICOM files to compressed NIFTI format (http://nifti.nimh.nih.gov/).

•*Iterative Average Procedure*

- Iterative routines constructed the average templates. The FMRIB's Linear Image Registration Tool (FLIRT) program was used for linear registration, and Advanced Normalization Tool (ANTS) program was used for nonlinear registration.

Construction of Brain Templates

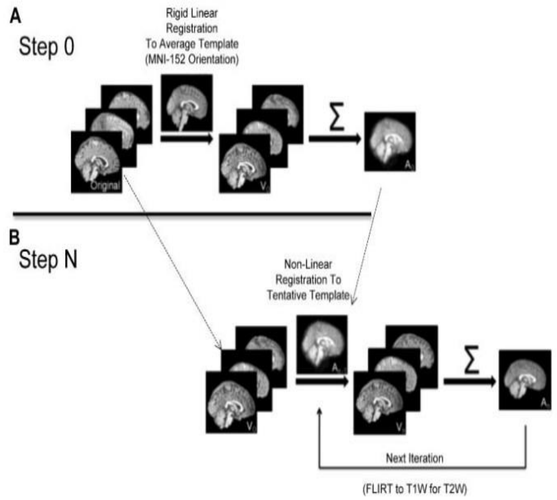
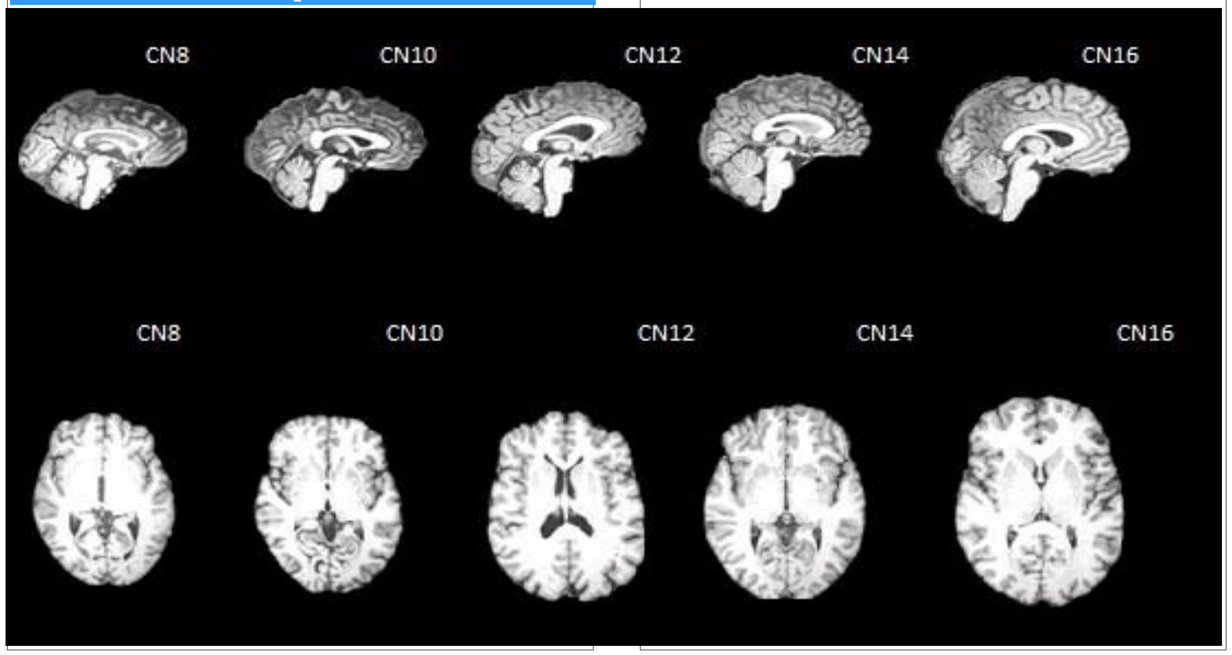
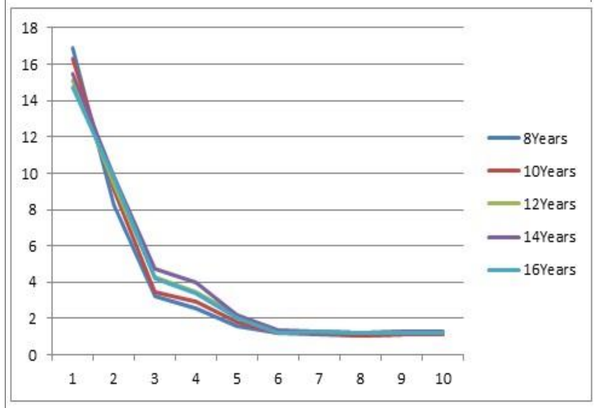


Figure 1. The pipeline for age-specific template creation. (A) In Step 0, the rigid registration occurred using FLIRT to the MNI brain with 6 DOF, with an output that was the same volume size as the original. Rigidly registered brains (V_0) were averaged to create a rough template (A_0). This template was used as the first guide in Step N. (B) With each iteration of Step N, the rigidly registered brains were nonlinearly registered to an iterative average (A_{n-1}) and transformed and then averaged to create a new average (A_n) for the next iteration.

5 Brain Templates Created



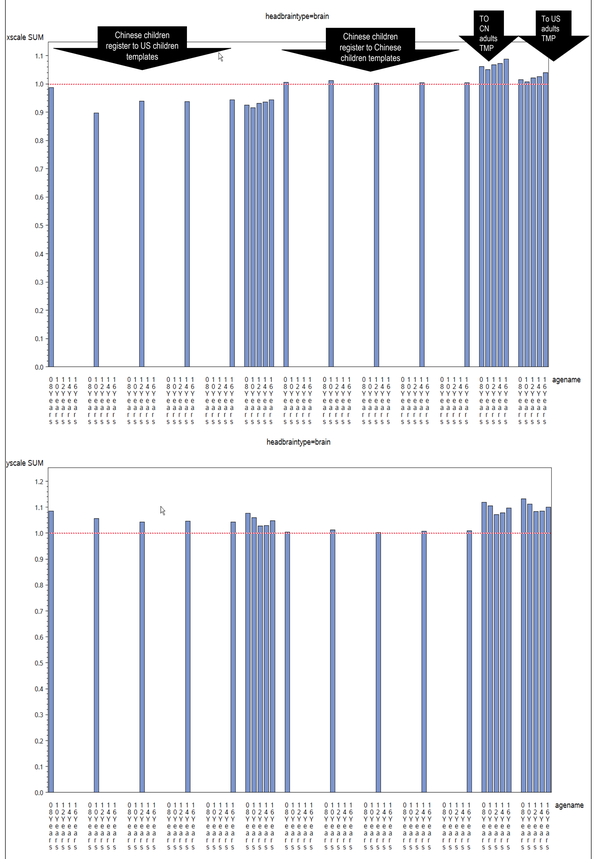
Results



Successive Root Mean Square (RMS) for Brain

- The RMS (root mean square) represents the difference between two templates, and the smaller the RMS value is the more similar the two templates are to each other.
- RMS difference between intensity values of successive reference templates was calculated and the iterative procedure was performed until the successive RMS values reached a minimum. The final template of the non-linear iterative construction process served as the final age-specific template.

Results (CN templates vs US templates)



•These two graphs indicated that 1) fewer deformations were needed to register Chinese children and adolescents to an Chinese age-specific templates than to US age-related templates, Chinese adult templates, and US adult templates; 2). Chinese children's brain is wider and shorter than their age-related US cohorts' brain, which is consistent with the Tang et al. (2010) study.

Conclusions

- 5 age-specific templates were constructed for 7 -8, 9-10, 11-12, 13-14, and 15-16 years Chinese children. The age-specific Chinese template fits significantly better to Chinese children than either American Age-related children or American or Chinese adult templates.
- The current work contributes to the developmental research and clinical community by providing 5 age-specific Chinese children and adolescents templates. These templates are also important and helpful for multi-subject structural and functional brain studies (e.g., fMRI studies), especially for brain studies on Chinese developmental groups.