Magnetic Resonance Imaging 34 (2016) 1043–1049

Contents lists available at ScienceDirect

Magnetic Resonance Imaging

journal homepage: www.mrijournal.com

Original contribution

Comprehensive cortical thickness and surface area comparison between young Uyghur and Han Chinese cohorts

Jun Lu [a], Chunhui Jiang [a], Jian Wang [a,*], Wenxiao Jia [b,*]

[a] Imaging Center, First Affiliated Hospital, Xinjiang Medical University, Urumqi, 830011, China
[b] Xinjiang Medical University, Urumqi, 830011, China

ARTICLE INFO

Article history:
Received 4 November 2015
Revised 4 March 2016
Accepted 27 March 2016

Keywords:
Cortical thickness
Surface area
Han Chinese
Mandarin
Uyghur

ABSTRACT

We hypothesized that the brain structural differences as discovered previously between Westerners and East Asians could also be revealed between Han Chinese and Uyghur, which were genetically related ethnic groups with distinct languages. We conducted a brain MRI structural comparison in terms of cortical thickness and surface area between 15 healthy young Uyghurs and 15 age-matched Han Chinese. Widespread regions with significantly greater cortical thickness were found in the Uyghurs, and their distribution showed strong resemblance to previous "Westerners vs. Asians" findings. While surface area analysis displayed less widespread brain differences. Notably, our detected regions with structural differences contained a large part of language-specific or at least closely language-related brain areas, which may partly be attributable to the brain plasticity respectively driven by Uyghur and Mandarin. Our findings will help to better understand the neurobiological basis of interethnic differences along with the language processing mechanisms of Han Chinese and Uyghur.

1. Introduction

Increasing structural imaging evidences have indicated that the brain structure is diverse across genetics [1,2], gender [3,4], age [5], diseases [6,7] etc. Comparison between different ethnic groups may provide hints to trace the internal and external factors responsible for brain's formation and alteration in structure. To date, a series of cross-ethnic studies have confirmed that the brain structure is diverse among different ethnic groups, say, Westerners and East Asians [8–12]. These observed differences are probably attributable to genetic and environmental factors, and the latter include language driven effect [11], culture-related behavior [13], or bias in diet [14] etc. While debates still exist over which one plays a dominating role in the interethnic brain structure differences. Moreover, majority of the available cross-ethnic studies on brain structure differences, though positive findings were gained, mainly focused on the differences between two ethnic groups with different cultures, geographic locations and genetics (e.g. Caucasians vs. Asians). Therefore, studies concerning two genetically related ethnic groups will help to understand to what extent and by what mean the ethnic factors affect brain structure.

Uyghur provides an appropriate model of "genetic transition" between East Asians and Europeans. Uyghur is one of the largest minorities in Xinjiang Uyghur Autonomous Region of China (located in the middle part of the Eurasian Continent) accounting for 46% (9.87 million) of the total population in Xinjiang. In terms of genetics, Uyghur is a substantial admixture of East Asian and European ancestry in the ratio of (East Asian: European) 40:60 [15], 53:47 and 48:52 [16], 69:31 [17], or 57:43 [18]. Besides that, the Uyghurs conserve their unique language – Uyghur, which is significantly different from the Han Chinese character in terms of both structure and pronunciation [19]. By the contrast between Han Chinese and Uyghurs, the admixture with roughly half East Asian ancestry and half European ancestry, the results obtained from this study would provide valuable evidence for studying the effect of ethnicity upon brain structure.

Cortical thickness which is one interesting aspect of brain structure has been emphasized recently by researchers on its susceptibility by postnatal factors, thus underlying its compatibility in studying the external (or environmental) factors of ethnicity on brain's formation and alteration; on the other hand, cortical surface area as another structural aspect is believed to reflect more genetic-related information and has advantage over thickness in detecting the internal (or inherited) cross-ethnic differences in brain structure [20–23]. So, in this study we selected these two metrics to comprehensively explore the brain structural differences between Uyghurs and Han Chinese.

To data, five cross-ethnic studies between Westerners and East Asians were conducted to evaluate brain's interethnic structural differences along with its anatomical plasticity driven by languages using MRI [8–12]. However, no findings were documented concerning two distinct but affirmatively genetic-related ethnic groups. To further understand the role of ethnic factor plays on the diversity of

* Corresponding authors.
E-mail addresses: jeanw1265@163.com (J. Wang), jwxxj007@163.com (W. Jia).

http://dx.doi.org/10.1016/j.mri.2016.03.018
0730-725X/

brain structure, we would like to compare populations who are genetic-related to find out (i) whether the ethnicity still be a reason which can lead to detectable brain structure variation (especially large scale differences) by imaging morphometry, (ii) whether regional differences can be found in some brain areas with specific functions, which are able to be related to the different social cognitions, behaviors, or experiences between the two ethnic groups (e.g. languages' driven effect upon brain structure addressed in previous cross-ethnic studies [9,11]). This study would not only help to shed light on the neurobiological basis for interethnic cognition and behavior differences (e.g. racial attitudes, prejudice, or type of behaviors [24]) between Uyghur and Han Chinese for further studies, but also provide evidences for the construction of ethnic-specific brain templates for further neuroimaging studies on Uyghur.

2. Methods

2.1. Participants

Fifteen young Uyghurs (8 female and 7 male, 18.3 ± 0.5 years old) and 15 young Han Chinese (8 female and 7 female, 18.4 ± 0.7 years old) were recruited. The Uyghurs were all undergraduate volunteers enrolled in formal Uyghur education system which the medium of instruction was Uyghur and they rarely contacted people who speak Mandarin. The Han Chinese were also all undergraduate volunteers enrolled in formal Chinese education system which the medium of instruction was Mandarin. Exclusion criteria of both groups include history of brain trauma, neural related diseases and bilingual speakers in Uyghur and Mandarin. Each individual received detailed language tests before the experiment, including spontaneous oral expression, reading and comprehension, listening, naming and repetition to verify their language proficiency. All subjects were right-handed and were informed with a written consent form. Ethical approval for the study was obtained from the university and hospital ethics committee. Two groups were well matched in gender, age, education, and handedness, and language proficiency. Demographic details and language tests results were summarized in Table 1.

2.2. Data acquisition

High resolution T1-weighted data of the whole brain was obtained from a 3.0 T MRI scanner (Signa HDx, GE Healthcare, Milwaukee, WI) with 8-channel head coil and FSPGR sequence (TR = 7.8 ms, TE = 1.7 ms, flip angle = 20°, slice thickness = 1.0 mM, number of excitation = 1, FOV = 240 mm × 240 mm, and matrix = 240 × 240 mm).

2.3. Imaging data analysis

The data analysis of the cortical thickness was performed using a well-recognized software, the Freesurfer (http://surfer.nmr.mgh.harvard.edu), developed by Fischl and Dale [25–27]. Freesurfer consists of automated tools for reconstruction of the brain from structural MRI data, facilitating the quantification of cortical metrics using a spatially unbiased analysis. First, a surface representation of each participant's anatomy was created by inflating each hemisphere of the anatomical volumes to a surface representation. The resulting surface representation was aligned to a template of average curvature. These surface representations were obtained by submitting each participant's MRI to a series of steps that included: (1) motion correction and affine transformation to Talairach space, (2) intensity normalization, (3) removal of non-brain voxels, (4) segmentation of gray matter (GM), white matter (WM) and cerebrospinal fluid (CSF), and, finally (5) tessellation of the GM/WM boundary, and automated topology correction. At each step, the results were visually inspected and manual interventions were performed when required to correct topological defects. The cortical thickness was defined as the vertex distance between the inner cortical surface which was the boundary between WM and GM, and the outer cortical surface which was the boundary between the GM and CSF or referred as pial surface. The WM was segmented by classifying all white matter voxels according to the method described by Dale et al. [25]. The connected WM voxels were then refined to represent the GM/WM boundary as an initial contour followed by deforming outward to obtain the pial surface [25,26]. Then the cortical thickness of each vertex on one surface was measured by the average distance between the target vertex to the closest corresponding point on the other surface [25,26], while the surface area was defined as the shortest distance between equivalent vertices in the pail and gray-white matter surfaces [25]. To achieve the inter-subject spatial normalization, the inflated inner cortical surface was registered to an averaged spherical surface followed by mapping, and smoothing the calculated measures with an FWHM of 20 mm to ensure differences are shown without significantly increased false-positive clusters. The resulting thickness and area maps of each individual were transformed to a common spherical coordinate system.

2.4. Statistical analysis

Vertex-wise cortical surface group analysis was performed by two-class general linear model (GLM). The GLM was used to estimate the time series image parameters, and then through the random effects analysis, obtain statistical parametric mapping. The stimulus pattern function of hemodynamic function after convolution as design matrix parameters are estimated through the design matrix, then the statistical test of specific parameters, draw each voxel values t. The statistical analysis for cortical surface thickness and area was performed by the QDEC interface of Freesurfer. The SPSS17.0 (SPSS Inc. Chicago, IL, USA) statistical analysis software package was used in the study. Normality test was performed for each group of data, under the premise of satisfying the normal distribution, the data in the group were tested by double sample t. Group analysis is remove the age, sex, and the mean of the whole brain signal of the 2 groups. The statistical threshold is set to the corrected $P \leq 0.05$. False discovery rate (FDR) with the threshold of $P < 0.05$ was used to regions that displayed differences in metric distortion to correct for multiple comparisons.

Table 1
Demographic details of Han Chinese and Uyghurs.

	Uyghur	Han Chinese
n	15	15
Age	18.3 ± 0.5	18.4 ± 0.7
Gender (female/male)	8/7	7/8
Education years	13	13
Handedness (right/left)	15/0	15/0
Listening	97.6 ± 2.2	98.9 ± 1.5
Naming	99.7 ± 0.9	99.8 ± 0.6
Repetition	96.1 ± 1.2	99.2 ± 1.6
Reading and comprehension	99.0 ± 2.1	99.3 ± 1.8

3. Results

3.1. Cortical thickness comparison

Comprehensive brain analysis for cortical thickness revealed widespread regions with significantly greater metric in the Uyghurs compared with Han Chinese (Fig. 1A–D). On the lateral surface of the cerebral cortex, these regions mainly located in the bilateral superior frontal, rostral middle frontal, pars triangularis, pars opercularis, middle temporal, supramarginal, superior parietal, inferior parietal, and the