Gender-Specific Anatomical Alterations of Hemispheric Asymmetry during Healthy Aging of Human Brain

Xiaojing Long[1], Chunxiang Jiang[1], Weiqi Liao[1], and Lijuan Zhang*[1]

[1]*Paul C. Lauterbur Research Center for Biomedical Imaging, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong, China*

Introduction

Gender effect on the age related evolution of the hemispheric asymmetry is still debatable in both healthy aging and dementia such as Alzheimer's disease [1,2]. In this study, we developed a multivariate model based on morphological variates including cortical surface area, curvature index, thickness, and subjacent white matter volume, to evaluate and track the differences of laterality alterations between male and female genders during healthy aging.

Materials and methods

Demographic and imaging data of a total of 313 right-handed healthy subjects were retrieved from the Open Access Series of Imaging Studies (OASIS) database (www.oasis-brains.org/) and the Alzheimer's Disease Neuroimaging Initiative (ADNI) database (http://adni.loni.ucla.edu/) (n=132 for male, n=181 for female), and categorized into young (aged from 20 to 29 years), prime to middle age (aged from 30 to 59 years) and elderly groups (aged from 60 to 89 years), respectively (Table). All subjects were ruled out for neurological or psychiatric illnesses with routine clinical examinations.

Table. Summary of the demographic information of subjects.

Groups	Male			Female		
	Mean age ± std	Age range	# of subjects	Mean age ± std	Age range	# of subjects
Young	23.16 ±2.64	20-29	51	22.56 ±2.35	20-29	68
Prime to middle age	44.63 ±9.63	30-59	32	48.19 ±7.28	30-59	48
Elderly	74.72 ±8.21	61-89	49	74.52 ±8.11	60-89	65

T1 weighted images of the entire brain were used to calculate morphological variables for each subject using FreeSurfer (http://surfer.nmr.mgh.harvard.edu/). Images were first segmented into gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF), followed by a construction of the cortical surface and WM surface. The surfaces were then parcellated into gyral-based regions of interest (ROIs) for each hemisphere. Surface area, mean curvature index, cortical thickness, and subjacent WM volume were calculated from the constructed surfaces on each ROI as detailed in [3]. MANCOVA was performed on the collective effect of the four variates using SPSS 17.0 (SPSS Inc., Chicago, IL, USA) to compare the shape characteristics between left and right hemispheres on each ROI for each group. Regions with significant asymmetry were identified as $P<0.05$. The lateralization index of each significant region was defined as $LI=\Sigma_i (L_i-R_i)/(L_i+R_i)$, where L_i and R_i were the mean value of the left and right hemisphere for the ith variate. $LI>0$ indicates a leftward asymmetry, and $LI<0$ a rightward asymmetry.

Results

As shown in the Figure, in young group gender poses no significant effect on the pattern of hemispheric asymmetry except for lingual gyrus and entorhinal cortex presenting opposite laterality for males and females. As age advances, the number of lateralized regions reduced to a greater extent in male as compared with female whose hemispheric asymmetry was fairly preserved. Extra asymmetry loss mainly occurred in the posterior cerebrum including the whole parietal lobe, lateral occipital gyrus, and isthmus cingulate for men in addition to the precentral gyrus, precuneus, lingual gyrus, and caudal anterior cingulate where lateralization disappearance was common to both genders during normal aging.

Conclusion

Both genders experience reduction of hemispheric asymmetries during healthy aging in regions that are associated with decline in functions of movement execution, episodic memory, visuospatial processing, and emotional behavior in old age. Further loss of laterality were found selectively located in regions for visual processing, language, mathematical operations, and body image for male gender during elderly life. These findings may necessitate the consideration of gender effect in brain analysis for age related structural variations.

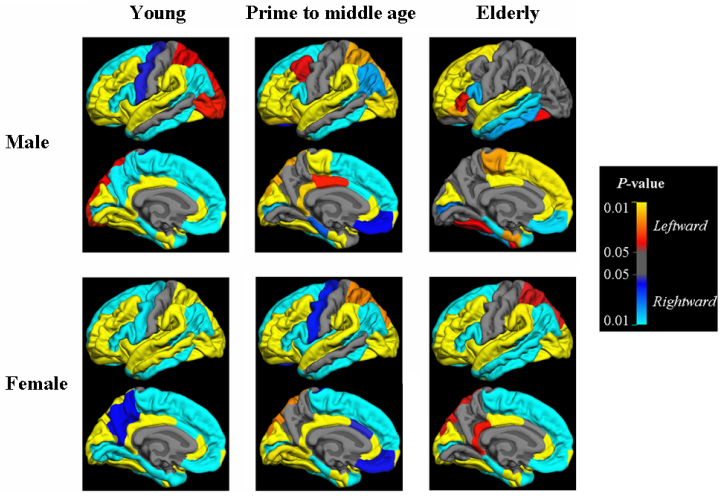

Figure. Hemispheric asymmetry of the six groups. The number of significantly asymmetric regions reduced during healthy aging in both male and female genders with further asymmetry loss in male in posterior cerebrum.

References

[1] Luders E., et al. Hum Brain Mapp. 27(4):314-24, 2006.

[2] Cabeza R., Psychol. Aging 17: 85–100, 2002.

[3] Long X, et al. Acad Radiol., 19(7):785-93, 2012.