Sex Differences in the Neuroanatomy of Human Mirror-Neuron System: a T1-VBM Investigation

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Introduction

At a population level, an amount of compelling evidence supports the existence of gender differences in interpersonal sensitivity i.e., the ability to perceive and respond with care to the internal states of another, understand the antecedents of those states, and predict the subsequent events that will result [1]. The human mirror-neuron system (MNS) has been proposed to play an important role in social cognition by providing a neural mechanism for the understanding and imitation of action [2]. It has been suggested that the action-perception coupling mechanism plays a critical role in social interaction, such as action understanding and empathy [3]. Thus, it is reasonable to speculate the MNS should differ between genders to reflect sex differences in social sensitivity. Here, the present study used T1 Voxel Based Morphometry (T1-VBM) to clarify whether the human MNS exhibits sex-related structural differences and to examine if its cores area, pars opercularis, is related to each participant's dispositional measures of empathy.

Methods

Fifty healthy right-handed participants (25 Female / 25 Male) were enrolled in the study. The female and male subgroups had matched age [27.6±8.3 y/o vs. 26.6±10.4 y/o] and education years [15.6±2.8 years vs. 15.5±2.5 years]. All MR scans were performed on a 1.5T MR system (Excite II; GE Medical Systems, Milwaukee, Wis., USA) at the Veterans General Hospital Taipei. Whole brain T1-weighted images were acquired using 3D FLAIR-FSPGR with TR/TE= 8.54/1.84ms, TI= 400ms, Flip angle =15°, voxel size=1.02*1.02*1.5 mm^3 and NEX=1. An optimized T1-VBM protocol [4] was used in this study. All image preprocessing were performed on the SPM2 (Wellcome Department of Imaging Neuroscience, London, UK). For the T1-VBM results, ANCOVA was employed with covarying for total intracranial volume (TIV) to uncover the differences between groups in gray matter volume. An uncorrected P-value < 0.001 as well as a cluster size more than 30 contiguous voxels was set to putatively detect the significant between-group differences. Prior to MRI scanning, participants filled out a series of self-report dispositional measures of empathy including the empathizing quotient (EQ) [5] the emotional contagion scale (ECS) [6], the emotional empathic tendency scale (EETS) [7] and the interpersonal reactivity index (IRI) [8]. Statistical comparisons between groups dispositional measure were conducted using Mann-Whitney test. To further elucidate the neuroanatomical correlates of individual differences in empathy, partial correlation analyses with TIV as a confounding covariate were performed in sex-combined groups to correlate the dispositional empathy scores with the regional brain volumes which were extracted from the peak coordinate showing a sex effect.

Results

Dispositional measurements:

There was a significant gender difference in the scores of the ECS (P = 0.023), the EETS (P = 0.002), and the empathic concern subscale of IRI (P = 0.035). Females were reported to have higher scores than males in these dispositional measures of empathy. However, there were no significant differences between the genders in the EQ and other subscales of IRI.

Regional gray matter volume difference between two groups:

Females than males had larger gray matter volume in the social cognition network with the involvement of medial prefrontal cortex and lateral occipital cortex as well as the human mirror-neuron system. Of note, females were showed to have larger grey matter volume of right pars opercularis and right anterior inferior parietal lobule, as the core areas of the human mirror-neuron system. Instead, males were significantly displayed larger grey matter volume in the amygdala, parahippocampus, and lentiform nucleus (Fig 1).

Correlation analysis between gray matter molume and behavior measurement:

The correlation analysis indicated that the volume of regions that belongs to the human MNS correlates with dispositional empathy measures (Fig 2). Specifically, within all females and males, the gay matter volume of pars opercularis of the right hemisphere showed a positive correlation with the ECS (P = 0.016), the EETS (P = 0.002), and the empathic concern subscale of the IRI (P = 0.040). The gray matter volume of the right inferior parietal lobule positively correlated with the EETS (P = 0.027) and the IRI empathic concern scale (P = 0.048). Moreover, the volume of right medial prefrontal cortex had a positive correlation with the empathic concern subscale of the IRI (P = 0.002). The other regions did not reach any significant correlation with the other empathy measures.

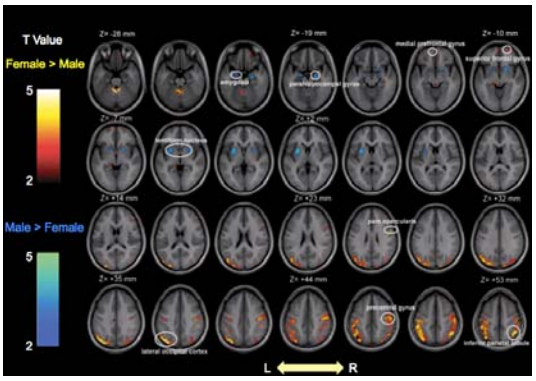

Figure 1.

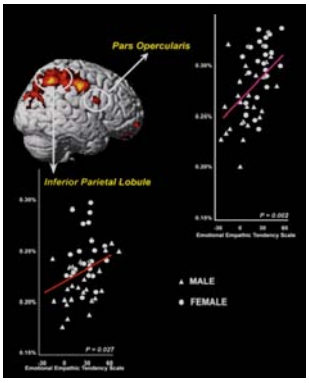

Figure 2.

Figure 1 : Gender differences in regional brain volume

The gray matter regions showing significant sex-dimorphism were rendered onto the averaged coronal images of the whole sample. (Red: Female > Male ; Blue: Male > Female)

Figure 2 : Neuroanatomical correlates of the MNS and EETS scale

The x axis depicts the scoring of EETS scale and the y axis represents the ratio of the regional gray matter volume over the TIV.
(Top-Right: Pars Opercularis; Bottom-Left: Inferior Parietal Lobule)

Conclusions

The results of the present study demonstrate that the neuroanatomical volume of regions which belong to the human MNS exhibits sex differences. Female participants were displayed larger gray matter volumes than male participants in the pars opercularis and inferior parietal lobule of the right hemisphere. In addition, the gray matter volume in right pars opercularis positively correlated with the ECS and EETS across all female and male participants. This result not only provide sex difference of human MNS system but also may lead some indirect support to the extreme male brain theory, posited by Baron-Cohen (2005), and may also offer some insight to the mirror neuron account in the autism spectrum disorders.

Reference

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Acknowledgements

This study was supported in part by National Science Council grant NSC 97-2752-H-010 -004 –PAE.