Intrinsically Organized Low Frequency Network for Face Perception

Z. hui[1], and T. Jie*[1]

[1]Institute of automation Chinese Academy of Sciences, Beijing, Beijing, China, People's Republic of

Introduction Evidences from cognitive neuroscience have found that there are some regions preferentially respond to faces, such as fusiform gyrus, inferior occipital gyrus, superior temporal gyrus, amygdale and parts of the frontal lobe. Haxby have proposed that these regions construct a distributed network for face perception [1]. The theory of distributed network is supported by some recent studies, especially the functional and effective connectivity analysis with BOLD-fMRI, However, all these studies are based on face viewing task, so it is not clear whether the face perception network was intrinsically organized or totally depending on external visual stimuli, and seldom study has focused on to what extend does the distributed face perception neural system was modulated by external stimuli. Here, by analyzing 0.01-0.08HZ low-frequency spontaneous fluctuations of BOLD-fMRI signals, we investigated the low-frequency fluctuations of distributed face perception network in resting states and the modulation of this network from resting states to visual task. Our result suggested an intrinsically organized low-frequency face perception network involving right lateral posterior fusiform gyrus (lateral pFg), inferior occipital gyrus (IOG), bilateral superior temporal sulcus (STS) and an altered extended network for face perception from resting states to face viewing task.

Subjects and measurements Nineteen healthy subjects (10 males, age: 21-27) with normal vision underwent a resting scan first, then followed by a passive viewing task(task 1) and a one-back matching task(task 2).During task scans, subjects were instructed to see interleaved blocks of two object types (faces, non-face objects such as table, stool, house flower et.al). Control epochs were a fixation "+". Resting-state lasted 6 minutes, two visual tasks lasted 5 minutes 32s. Structural and functional MRI were collected using 3.0 T MR imaging system (Siemens Trio Tim). The fMRI series was collected using a single shot, T2*-weighted gradient-echo echo planar imaging (EPI) sequence (TR/TE=2000/30 ms; 32 slices, 4mm sickness; matrix=64╳64) covering the whole brain with a resolution of 3.75╳3.75mm. Structural images were acquired with a three-dimensional enhanced fast gradient-echo sequence with a thickness of 1mm and a resolution of 1_1mm.

Data analysis Preprocessing was performed on each subject's scan data using SPM5 software (including slice timing, spatial realignment, segmentation of structural data, normalization into standard MNI, re-sampling to 2mm cube voxels, smoothing with FWHM 6mm). For task 2 scan, a standard GLM analysis was performed, face sensitive regions was identified by contrasting face condition with object condition; object sensitive regions were similarly defined by contrasting object condition with face condition. Each individual's most strong and consistent active regions in the occipital-temporal cortex were selected as regions of interest (ROI). After preprocessing steps, each subject's resting scan and task 1 scan were processed in the following way respectively: global proportional scaling was performed to yield whole brain intensity value of 1000; Drifts were de-trended by second-order polynomial detrending; six parameters of head motion, signals in ventricular regions and signals extracted from white matter were removed by linear regression, DCT band-pass filter (0.01-0.08Hz) was performed to retain the low frequency fluctuations signals only. time courses from face sensitive ROI and object sensitive ROI were extracted and spatially averaged separately, these time signals were then used as predictors (regressors) to perform whole brain voxel-by-voxel GLM statistical analysis, statistical parametric t-map was obtained by contrasting the effects of the face ROI's to that of the object ROI's. Finally, multi-subject map was generated by performing a random effect one-sample t test.

Results Task 2 scan identified fusiform face area(FFA) in right lateral pFg in 15 of 19 subjects and object sensitive regions in left medial pFg in 14 of 19 subjects (individual analysis: $p<1e-4$,FDR corrected; number of contingent voxels>20). Low frequency spontaneous fluctuation analysis from resting scan have found that a set of blobs show significant activation by contrasting the effects of FFA to that of object ROI in individual and group level, including right lateral pFg, right IOG, bilateral STS, medial/supper medial frontal gyrus, paracentral gurus, anterior cingulated cortex(ACC) and posterior cerebellum($p<0.01$, number of contingent voxels>20, FDR corrected), while similar low frequency fluctuation analysis from face-object visual task have shown that lateral pFg, IOG, bilateral STS, inferior frontal gyrus (inferior FG), medial frontal gyrus(medial FG),supplementary motor area(SMA),intra-parietal gyrus (IPG) and medial cerebellum have significant low frequency activation. The location of peak active regions in lateral pFG, IOG, bilateral STS under two states varied within 6mm at individual level and 10mm at group level.

Discussion and Conclusion For the first time, we investigated the low-frequency fluctuations of distributed face perception network in resting states and the modulation of this network from resting to visual task. By using 0.01-0.08HZ low-frequency spontaneous fluctuations of BOLD-fMRI signal, we found that right lateral pFg, IOG, bilateral STS, medial/supper medial FG, paracentral lobe, ACC and posterior cerebellum constructed a significantly activated network in resting states, while in viewing task, right lateral pFg, IOG, bilateral STS, inferior FG, medial FG, SMA, IPG and medial cerebellum reflected strong neural activation of low-frequency fluctuations. Our result suggested an intrinsically organized low-frequency network for face perception involving lateral pFg, IOG, bilateral STS and an altered extended network for face perception. Future study will be necessary to investigate the role of these active regions within face perception network under different states.

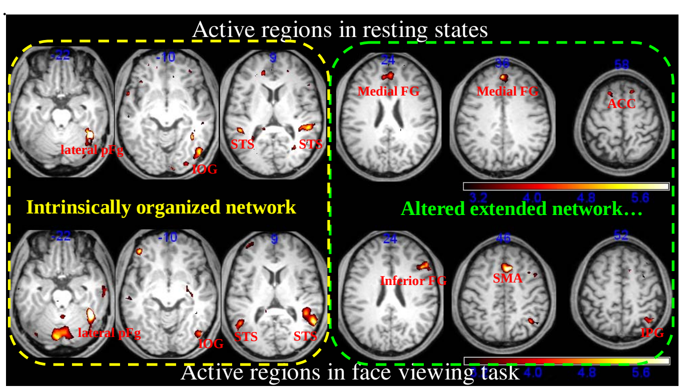

Fig.1 Random effect group analysis of active regions in low frequency resting states (top) and face viewing task (bottom); active regions in lateral pFg, IOG and STS constructed an intrinsically organized network(left, within yellow dotted line) under two states; differed active regions in frontal, parietal lobe as well as cerebellum show altered extended network(right, within green dotted line) .

References [1]James V. Haxby et al.Trends in Cognitive Sciences.2000; 4(6):223-233