Investigation of visual perception functions in children with Down Syndrome : a functional MRI study

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Introduction

Down Syndrome (DS) is the most common genetic cause of mental retardation. Numerous researchers have stressed that neuropsychological profile of DS is characterized by a remarkable deficit in language abilities solely. Recent studies have demonstrated that this DS population features more complex neuro-psychological problems which include deficit in visual perceptual functions as well [1, 2]. Therefore, this research is aimed to use fMRI to investigate the functional and structural networks underlying visual perception in DS. We hope to provide quantified information of brain function deficits to help in implementing more appropriate rehabilitation protocol and special education plans for DS

Method and Material

The participants were 9 DS and 9 normal children. After being granted a green light by Institutional Review Board, all participants have to fill out the agreement prior to entering the experiment. The participants take a behavioral task with two experimental conditions: dismantling picture (the condition D) and full picture (the condition F) conditions [3]. The experiment utilizes a 4-block design task in which each task consists of 2 blocks respectively named "D" and "F" by random. In each D or F block, 8 pictures are presented to the subject for 6 seconds per each by selection from the pool. All participants pressed the button to select the answer for the reconstructed pictures. The answers and the reaction time are recorded through the entire image scan(about 15 min). Scanning is done in a GE SignaHDx 3.0T MRI machine (Milwaukee, WI, USA) at Kaohsiung Medical University Chung-Ho Memorial Hospital. Echo-Planar Imaging (EPI) protocol is used to take the whole brain functional image with the following acquisition parameters: 22×22 cm^2 field-of-view (FOV), 64×64 matrix (3.4×3.4 mm^2 in-plane resolution), 27 ms echo time (TE), 80° flip angle (FA), 4mm slice thickness and 2160 ms repetition time (TR). Moreover, in addition to functional imaging, each participant must be scanned by high-resolution T1-weighted structural images (resolution of about 1 mm^3) and these images are used as the anatomical template of the EPI image. According to the protocol MPRAGE (TR = 2.5s, TE = 4.38ms, FA = 9 °) each scan take about 3 minutes. Whole images are analyzed after image preprocessing, including slice-timing, realignment, coregistration, normalization and smoothing, with Statistical Parametric Mapping (SPM8) software. The activated regions for each condition are chosen through a measure of one-sample *t*-test(p=0.005, cluster size=50 voxels).

Result

From the behavioral task result(Fig1), DS group showed that the correct response rate in the condition D (66%) was lower than that in the condition F (79%) and both reading were lesser than those of normal children (94% in condition D and 99% in condition F). As expected, the reaction time between DS and normal groups demonstrated the similar trend as response rate. From the performance of the fMRI images, normal children showed quite few activated reaction for the contrast between conditions D and F, except the area of visual cortex and motor cortex, in contrast to the DS children, who had more diffused activated areas. These activated regions included sub-gyral, transverse temporal gyrus, middle temporal gyrus, frontal gyrus, superior parietal lobule, fusiform gyrus, lingual gyrus, parahippocampalgyrus, cuneus, precuneus, declive, precentralgyrus, cingulate gyrus, caudate, occipital gyrus, angular gyrus (Fig2).

Discussion

In this study, the major fMRI findings were concluded: (a) Activation in frontal lobe (precentral gyrus) in normal subjects only shows that the subjects have higher cortical functions (motor planning). (b) Activation of posterior cingulate cortex presented in DS group is due to the cognitive (problem-solving) demands of the fMRI tasks. (c) Increased activation of other components of the visual-perceptual network (posterior cingulate cortex and premotor area) indicates the use of compensatory recruitment of cortical regions outside the task-relevant pathway in DS group. (d) More diffused brain areas in DS group might indicate their anomalous processing pattern [4]. (e) The fact that medial frontal gyrus is under-activated shows that DS group has lower capacity in social cognition and emotional processing caused by visual stimuli [5]. (f) The areas of superior parietal lobule and occipital lobes help visuospatial processing, which echoes and match our experimental design in both groups [6].

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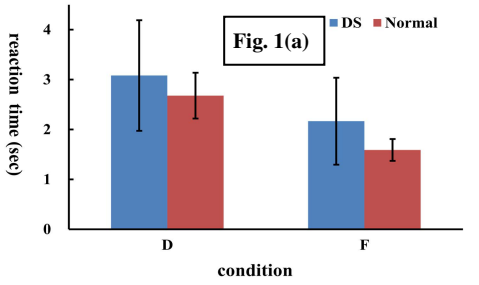

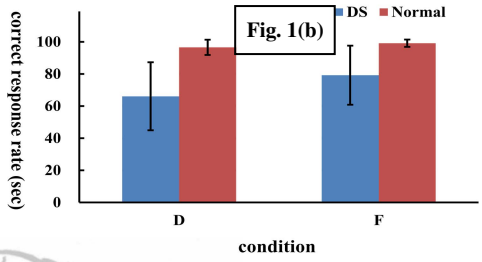

Fig. 2