Localization of cerebral functional deficits in patients with obsessive–compulsive disorder: A resting-state fMRI study

Jingming Hou, Wenjing Wu, Yun Lin, Jian Wang, Daiquan Zhou, Junwei Guo, Shanshan Gu, Mei He, Saud Ahmed, Jiani Hu, Wei Qu, Haitao Li

1. Introduction

Obsessive-compulsive disorder (OCD) is a debilitating neuropsychiatric disorder with an approximate lifetime prevalence of 2–3% (Horwath and Weissman, 2000). This disorder is characterized by persistent intrusive thoughts (obsessions) and/or repetitive behaviors (compulsions). Despite its high prevalence, the exact etiology and pathogenesis of OCD remain unclear.

Dysfunction of orbitofronto-striatal circuits has been the most common finding in the pathophysiology of obsessive–compulsive disorder (OCD) (Menzies et al., 2008; Robbins et al., 2011), thus it is speculated that dysfunction of the orbitofronto-striatal circuits may play a crucial role in the pathophysiology of the disorder. For instance, structural magnetic resonance imaging (MRI) demonstrated abnormalities in some areas including the orbitofrontal cortex (OFC) (Atmaca et al., 2007; Choi et al., 2004; Kang et al., 2004; Pujol et al., 2004), caudate (Robinson et al., 1995; Szaszko et al., 2008), anterior cingulate cortex (ACC) (Szaszko et al., 2004), and thalamus (Atmaca et al., 2007; Gilbert et al., 2000). Functional neuroimaging which have been utilized in the study of OCD mainly included positron emission tomography (PET), single photon emission computed tomography (SPECT) and blood...
oxygenation level dependent (BOLD) functional MRI (fMRI). The majority of PET and SPECT studies of OCD measured the cerebral blood flow (CBF) found functional abnormality in cerebral areas including the OFC, ACC, thalamus and the caudate nucleus (McGuire et al., 1994; Swedo et al., 1989; Whiteside et al., 2004). Meanwhile, a few recent neuroimaging studies have also demonstrated abnormalities in the other brain regions, such as the parietal cortex, cerebellum and occipital (Page et al., 2009; Sanematsu et al., 2010), and dysfunction in these areas may also be involved in the pathogenesis of OCD (Menzies et al., 2008). However, the results obtained in the above functional studies most are task-related, and we couldn’t know whether these areas are also abnormal during the resting state. Until now, little attention has been paid to the brain dysfunction of OCD during the resting state. So it is meaningful to study the abnormal brain areas during resting state in patients with OCD.

It has been suggested that the resting-state fMRI is a promising approach to study psychiatric disease. Resting-state fMRI not only avoids the performance-related confounds for the patients (Callicott et al., 2003), but it is also easier to implement than PET and SPECT because of its lower cost, non-invasiveness and greater availability (Lui et al., 2008; Lui et al., 2009). It has been shown that spontaneous low frequency (0.01–0.08 Hz) fluctuations (LFF) in the BOLD fMRI signal have been suggested to be physiologically meaningful and reflect brain spontaneous neural activity (Goncalves et al., 2006; Laufs et al., 2003; Leopold et al., 2003; Shmuel and Leopold, 2008).

In recent years, resting-state fMRI has been more and more widely applied in psychiatric studies. In the studies of OCD, Some researchers found a lot important and interesting results using resting-state fMRI (Harrison et al., 2009; Jang et al., 2010; Fitzgerald et al., 2011; Sakai et al., 2011). For example, Harrison et al. (2009) found altered functional connectivity in the corticostriatal circuitry especially in the ventrolimbic corticostriatal regions in patients with OCD. Sakai et al., (2011) showed the increased connectivity of the bilateral ventral striatum to the OFC, DLPC and VMNPC in patients with OCD. Taken together with these resting-state functional connectivity results of the above studies, the altered functional connectivity of orbitofronto-striatal circuits seems to be a common finding.

However, most of the resting-state fMRI studies of OCD investigated LFF from the aspect of temporal synchronization (referred to as “functional connectivity”) rather than from the aspect of regional activity during a resting state (Zang et al., 2007). Although the result of abnormal functional connectivity between two remote regions is integrative and comprehensive, it is difficult to draw a conclusion about which region is abnormal from such a study (Huang et al., 2010). The amplitude of LFF (ALFF) is one of the methods used to investigate regional neuronal activity in the resting state. Biswal et al. (1995) confirmed that ALFF was higher in gray matter than in white matter. Furthermore, using the power spectrum method, Kiviniemi et al. (2000) found activation in the visual cortex due to low-frequency fluctuations at about 0.034 Hz, suggesting that ALFF may reflect regional spontaneous neuronal activity. ALFF analysis has been used successfully to detect cerebral dysfunctions in many diseases, including ADHD (Zang et al., 2007), schizophrenia (Huang et al., 2010) and trauma survivors (Lui et al., 2009). To the best of our knowledge, no ALFF studies in OCD existed until now.

Based on the previous functional studies of OCD, we hypothesized that patients with OCD would show increased ALFF in the bilateral OFC, ACC and striatum, and decreased ALFF in the parietal cortex and cerebellum during the resting state. The purpose of this study was to identify brain regions with abnormal ALFF in patients with OCD and to explore the relationship between whole-brain voxel-based ALFF values and clinical characteristics.

2. Materials and methods

2.1. Subjects

A total of 46 right-handed subjects were recruited, including 23 OCD patients and 23 normal controls. Patients and normal controls were recruited at the Department of Clinical Psychology of Southwest Hospital. This study was approved by the local ethics committee, and all patients and normal controls gave written informed consent for their participation in this study. All patients met the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition (DSM-IV) criteria for primary OCD, and were diagnosed by two experienced psychiatrists using the Structured Clinical Interview according to DSM-IV criteria. 18 of the patients were drug-naive, 5 patients had a history of treatment with selective serotonin reuptake inhibitors (fluoxetine 20–40 mg/day; mean duration of treatment 62.3 ± 46.5 days, range 10–180 days). Two of the five patients had stopped medication 14–30 days, and three patients had stopped medication more than a month before entering the study. All patients did not take any medication that might affect the central nervous system for at least 2 weeks prior to MRI scans. The Yale–Brown Obsessive–Compulsive Scale (Y–BOCS) was used to evaluate illness severity (Goodman et al., 1989a, 1989b). In addition, the Hamilton Rating Scale for Depression (Hamilton, 1960) and Anxiety (Hamilton, 1959) was administered to measure the severity of depression and anxiety, respectively. Specifically, no patients in our study met the criteria for major depressive disorder or Tourette syndrome.

The normal controls, who were well matched to the OCD patients with respect to sex, age, height, weight, years of education, and handedness, were recruited by poster advertisement from local community. All controls were screened using Structured Clinical Interview for the DSM-Non-Patient edition (SCID-NP) to confirm the lifetime absence of psychiatric and neurologic illnesses (First et al., 2001). In addition, normal controls were interviewed to ascertain that there was no history of psychiatric illness in any of their first-degree relatives.

Exclusion criteria for patients and normal controls were as follows. Participants who presented a comorbid Axis I diagnosis, an existence of organic brain disorder, a neurological illness, a serious physical disease or a history of drug abuse were excluded. Comorbid depressive and anxious symptoms were not considered as an exclusion criterion, if OCD was the primary clinical diagnosis. Brain magnetic resonance images (T1- and T2-weighted images) were inspected by an experienced neuroradiologist, and no gross abnormalities were found in any of the participants.
2.2. MRI data acquisition

All image data was obtained using a 3 T MR imaging system (TIM Trio, Siemens, Erlangen, Germany) equipped with eight-channel, phase-array head coils. After conventional localizer scan and T2 anatomic scan, resting-state functional images were acquired using an echo-planar-imaging (EPI) sequence with the following parameters: 36 axial slices with a slice thickness = 4 mm and no slice gap, repetition time (TR) = 2000 ms, echo time (TE) = 30 ms, flip angle (FA) = 90°. Magnification (FOV) = 256x256 mm², data matrix = 64x64, resulting in a voxel size of 4x4x4 mm³, total volumes = 240. Participants were instructed to remain relaxed with their eyes closed. For each participant, another high resolution structural T1-weighted anatomical sequence was scanned in a sagittal orientation using a three-dimensional magnetization-prepared rapid gradient-echo (3D MP-RAGE) with the following parameters: TR = 1900 ms, TE = 2.52 ms, FA = 15°, slice thickness = 1 mm, data matrix = 256x256, isotropic voxel 1x1x1 mm³.

2.3. Data processing

Functional MRI data preprocessing and statistical analyses were performed with SPM8 software (http://www.fil.ion.ucl.ac.uk/spm/). The first 10 volumes were discarded to allow the magnetization to reach equilibrium. Then, EPI images were corrected for slice-timing and realigned for head movement correction (subject data with movement more than 1 mm of translation or more than 1° of rotation in any direction was excluded). Afterwards, all of the realigned images were spatially normalized into the Montreal Neurological Institute (MNI) EPI template, and each voxel was resampled to isotropic 3x3x3 mm³. As a final step, the resting state images were spatially smoothed with an isotropic Gaussian kernel (full-width at half-maximum = 6 mm).

ALFF analysis was performed using the REST software (http://resting-fmri.sourceforge.net/). After preprocessing, the linear trend of the time series was removed and band-pass filtering (0.01–0.08 Hz) was performed to reduce the effect of low frequency drift and high frequency physiological noise, such as the respiratory and cardiac rhythms. Next, to acquire the power spectrum, the time series was transformed to a frequency domain using fast Fourier transform (FFT). And then the power spectrum was square-rooted and averaged across 0.01–0.08 Hz at each voxel. This averaged square root was viewed as the ALFF. In order to reduce the global effects of variability across participants, the ALFF value of each voxel was divided by the global mean ALFF value. The standardized ALFF of each voxel then had a value of approximately 1, and this procedure is similar to that used in PET studies (Raichle et al., 2001). In this study, the global mean ALFF was calculated only within the brain, and the background and other tissues outside the brain were removed using the MRCro software package (http://www.psychology.nottingham.ac.uk/staff/crl/mrcro.html).

2.4. Statistical analysis

To investigate the differences in age, gender, disease duration, and years of education between the OCD group and control group, two-sample t-tests were performed on the SPSS18.0 (SPSS Inc., Chicago, IL, USA), and a P<0.05 was deemed significant. One-sample t-test using SPM8, and results were displayed using REST software with a threshold of P<0.01 with multiple comparison corrected by AlphaSim methods (Cox, 1996). The corrected threshold corresponds to Puncorrected<0.001 with a minimum cluster size of 405 mm³. Finally, we also performed a whole-brain voxel-based correlational analysis between ALFF values and clinical characteristics including Y-BOCS score and disease duration. Given the exploratory nature of the study, we adopted a relatively liberal statistical threshold (Puncorrected<0.005 with a minimum cluster size of 270 mm³).

3. Result

23 patients with OCD and 23 normal controls completed the fMRI scans. 2 patients (drug-naive) and 2 controls were excluded because of excessive head motion. The results were present for 21 patients with OCD and 21 normal controls. The demographic and clinical characteristics of subjects are summarized in Table 1. No significant differences were found between the two groups in gender, age, height, weight, education and head motion (P=0.76 for translation; P=0.53 for rotation).

The ALFF maps of both the OCD group and control group are presented in Fig. 1, and the two groups both showed a significantly higher ALFF value than 1 in some common regions such as posterior cingulate cortex (PCC), precuneus, MPFC and bilateral parietal areas. A two-sample t-test showed that, compared to the normal controls, patients with OCD had significantly increased ALFF in multiple areas including bilateral OFC, ACC, as well as decreased ALFF in several brain areas including the parietal and bilateral cerebellum (P<0.01, corrected; Figs. 2–3, Table 2). In addition, the ALFF values in bilateral OFC were positively correlated with total Y-BOCS scores (2-tailed in SPSS, Right OFC: R²=0.513, P=0.001; Left OFC: R²=0.372 P=0.003). After controlling for the influence of comorbid depression and

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<tr>
<th>Table 1</th>
<th>Demographic and clinical characteristics of OCD patients and normal controls.</th>
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<tr>
<td></td>
<td>Characteristics</td>
</tr>
<tr>
<td>Gender (male: female)</td>
<td>10:11</td>
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<tr>
<td>Mean age (years)</td>
<td>27.3±9.9</td>
</tr>
<tr>
<td>Education (years)</td>
<td>11.9±3.5</td>
</tr>
<tr>
<td>Disease duration (months)</td>
<td>64.1±53.3</td>
</tr>
<tr>
<td>HAM-D total score</td>
<td>6.5±5.9</td>
</tr>
<tr>
<td>HAM-A total score</td>
<td>10.2±3.6</td>
</tr>
<tr>
<td>Y-BOCS total score</td>
<td>26.7±6.1</td>
</tr>
</tbody>
</table>

Note: Data are expressed as mean±SD, SD: standard deviation; OCD: obsessive–compulsive disorder; HAM-D: Hamilton rating scale for Depression; HAM-A: Hamilton rating scale for Anxiety; Y-BOCS, Yale–Brown obsessive–compulsive scale.
anxiety, this relationship remained significant in a partial correlation analysis (2-tailed in SPSS, Right OFC: R = 0.661, P = 0.002; Left OFC: R = 0.457, P = 0.049).

4. Discussion

In the current resting-state fMRI studies, we used the ALFF methods to compare the differences between patients with OCD and normal controls. Before attempting to interpret the results in this study, one important question that arises is the nature of ALFF. In the present study, we found both patients with OCD and normal controls showed a significant higher ALFF value than 1 in some regions including PCC, precuneus, MPFC and bilateral parietal areas. This result is somewhat similar to the default mode network (DMN) proposed by Raichle et al., which exhibits the highest blood flow and oxygen consumption in a resting state (Raichle et al., 2001). Several studies (Li et al., 2000; Pelled and Goelman, 2004) have attributed the mechanism of LFF BOLD signal to spontaneous neuronal activity (SNA). More direct evidence came from a study of simultaneously monitoring the functional MRI blood oxygen level-dependent signal and the local field potential (LFP) from the visual cortex of monkeys (Logothetis et al., 2001). It was showed the impulse response function computed from LFP and BOLD signal under resting-state can well predict the response under task conditions, suggesting the spontaneous BOLD signal of resting-state fMRI may share the same underlying electrophysiological mechanism as the task-induced BOLD signal. The combination of EEG and resting-state fMRI can also help our understanding of the nature of LFF. Some studies (Goldman et al., 2002; Moosmann et al., 2003) found there was a negative correlation between alpha activity and the spontaneous BOLD signal during resting state. Hence, based on the aforementioned results, it could be considered ALFF reflects the extent of spontaneous neuronal activity.

In our current study, we found significant ALFF differences between patients with OCD and normal controls using resting-state fMRI. Compared with normal controls, patients with OCD showed increased ALFF mainly in the bilateral OFC and ACC, and decreased ALFF in the bilateral cerebellum and parietal cortex. In addition, the ALFF values in the bilateral OFC were positively correlated with the severity of OCD symptoms.

In recent years, there have been about four studies using resting-state fMRI to investigate the functional connectivity

Fig. 1. Results of amplitude of low-frequency fluctuation (ALFF) maps of patients with OCD (A), and normal controls (B) in resting state (P < 0.01, corrected with Alphasim). The left side of image corresponds to the right side of the brain.
in patients with OCD (Fitzgerald et al., 2011; Harrison et al., 2009; Jang et al., 2010; Sakai et al., 2011). For example, Harrison et al. showed the increased connectivity of the ventral striatum to the OFC and ACC. Sakai et al. also found the increased connectivity between the bilateral OFC and ventral striatum. Jang et al. reported less functional connectivity within the default mode network in the ACC, middle frontal gyrus and putamen compared to controls. Fitzgerald et al. found OCD in the youngest patients were associated with reduced connectivity of dorsal striatum and medial dorsal thalamus to rostral and dorsal ACC, respectively. Taken together with the resting-state functional connectivity results of above studies, although we cannot compare those results directly because they used different seed ROIs, the altered functional connectivity of orbitofronto-striatal circuits seems to be a common finding.

The result of abnormal resting-state of orbitofronto-striatal circuits is integrative, comprehensive and well confirmed by functional connectivity resting-state fMRI, but it is difficult to draw a conclusion about which region is abnormal from such a study. Most of the previous PET and SPECT studies consistently found increased activity within the OFC and ACC (Baxter, 1992; Machlin et al., 1991; Nordahl et al., 1989; Swedo et al., 1989). Using resting-state fMRI, we also found increased ALFF in bilateral OFC and ACC, which were consistent with previous functional findings in OCD studies. Our findings added an expanding literature to the abnormality hypothesis of orbitofronto-striatal circuits using a resting-state fMRI ALFF approach.

In addition, we performed a whole-brain voxel-based correlation analysis and adopted a more exploratory statistical threshold (\( P < 0.005 \), uncorrected). We found increased ALFF values in the bilateral OFC were positively correlated with patients’ total Y-BOCS scores, which were consistent with the result of previous studies. Harrison et al. (2009) reported that the specific strength of functional connectivity between ventral caudate/nucleus accumbens and anterior OFC predicted the total Y-BOCS scores of patients with OCD. Previous PET studies indicated that the metabolism in OFC of patients with OCD could be identified as a potential biomarker of symptom severity (Saxena et al., 1999; Schwartz et al., 1996; Swedo et al., 1992). Structural MRI study also found there were significant correlations between Y-BOCS scores and left OFC volumes, and right OFC volumes (Atmaca et al., 2007). In addition, Chamberlain et al. (2008) detected abnormal activation of the OFC in patients with OCD as well as their unaffected first-degree relatives, suggesting that abnormalities of OFC may reflect an underlying vulnerability marker of illness. All the aforementioned results using a variety of methods
support the hypothesis that the OFC may play a very important role in the pathophysiology of OCD. The OFC is believed to be involved in many functions, including emotional processing and memory, cognitive and behavioral regulation (Evans et al., 2004; Price et al., 1999). OFC dysfunction in OCD has been reported in numerous studies. Nuclear neuroimaging techniques, using PET or SPECT, predominantly to investigate brain functional metabolism during the provocation of obsessive–compulsive symptoms or in the resting state suggest that the OFC metabolic activity in patients with OCD is increased compared to normal controls (McGuire et al., 1994; Rauch et al., 1994). A meta-analysis of PET and SPECT revealed that patients with OCD had abnormalities in the area of OFC (Whiteside et al., 2004). Functional MRI studies using symptom provocation indicate that patients with OCD showed increased activation in the OFC (Adler et al., 2000; Mataix-Cols et al., 2004; Menzies et al., 2008) and it is decreased after successful pharmacotherapy or behavioral therapy (Nabeyama et al., 2008; Nakao et al., 2005). A lot of previous structural neuroimaging studies have also shown that the gray matter volume was reduced in OFC (Atmaca et al., 2007; Choi et al., 2004; Pujol et al., 2004). In line with these functional and structural results, our study found higher ALFF value in the bilateral OFC. Our result confirms the above findings by a new functional parameter with no performance confounds.

The ACC is thought to be important in action-monitoring functions, including executive function, response selection, and conflict monitoring (Ursu et al., 2003; van der Wee et
In a task-state, Ursu et al. (2003) reported in-}


evidence that the diversity of the symptoms, and methodological constraints could be potential confounding factors to group comparison. In future studies, it would be better to estimate these effects within each participant. Furthermore, the table below shows that the scanning environment, so the aliasing physiological noises (as in this study TR=2 s), the respiratory and cardiac cycle artifacts may alias into the resting-state low frequency fluctuations. In this study, patients with OCD and normal controls might have different physiological responses to the scanning environment, so the aliasing physiological noises may be potential confounding factors to group comparison. In future studies, it would be better to estimate these effects by recording respiratory and cardiac cycles during the scanning.

### Table 2

<table>
<thead>
<tr>
<th>Brain Region</th>
<th>Side</th>
<th>Cluster Size</th>
<th>MNI Coordinate</th>
<th>Peak</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increased ALFF in OCD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACC (BA 24,32)</td>
<td>L/R</td>
<td>133</td>
<td>-18 -9 -30</td>
<td>5.12</td>
<td></td>
</tr>
<tr>
<td>OFC (BA 11)</td>
<td>L</td>
<td>97</td>
<td>-30 49 -10</td>
<td>4.31</td>
<td></td>
</tr>
<tr>
<td>OFC (BA 11)</td>
<td>R</td>
<td>46</td>
<td>27 51 -9</td>
<td>4.55</td>
<td></td>
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<tr>
<td><strong>Decreased ALFF in OCD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerebellum</td>
<td>L</td>
<td>33</td>
<td>-23 -83 -40</td>
<td>5.08</td>
<td></td>
</tr>
<tr>
<td>Cerebellum</td>
<td>R</td>
<td>30</td>
<td>-20 -81 -39</td>
<td>4.96</td>
<td></td>
</tr>
<tr>
<td>Parietal (BA 7)</td>
<td>L</td>
<td>27</td>
<td>11 -61 63</td>
<td>3.83</td>
<td></td>
</tr>
</tbody>
</table>

Note: BA: Broadmann area; L: left; R: right; ACC: anterior cingulate cortex; OFC: orbitofrontal cortex (P<0.01, corrected with Alphazm).

So far, most consideration has been given to the involvement of orbitofronto-striatal circuits in the pathophysiology of OCD. However, our results also showed changed spontaneous neuronal activity in parietal cortex and cerebellum, which were not fully assessed in previous studies. The parietal cortex is traditionally considered to play a role in attention and visual–spatial processes (Cabeza and Nyberg, 2000). In addition, parietal cortex is also involved in various executive functions, including planning, switching and working memory (Sohn et al., 2000; van den Heuvel et al., 2003). Menzies et al. (2008) have reported that the cognitive impairments in some patients with OCD may be related to dysfunction of parietal cortex. Previous structural MRI studies have found abnormalities in parietal cortex in OCD patients compared with healthy control subjects. For example, Valente et al. (2005) found decreased grey matter in the right parietal cortex in patients with OCD. Carmona et al. (2007) reported decreased white matter volumes in the right parietal. van den Heuvel et al. (2009) showed there was a negative correlation between parietal white matter volume and the washing dimension, meanwhile, the parietal grey matter volume was negative to the symmetry dimension. In this present study, we also found reduced ALFF in the parietal cortex. All of these structural and functional imaging findings suggest that functional abnormality of parietal cortex may also play an important role in the pathophysiology of OCD.

In neuroimaging study on OCD, increasing attentions have now been paid to the cerebellum. The cerebellum has been found to play a role in some higher cognitive functions, including attention, verbal learning and memory, and cognitive planning (Allen et al., 1997; Daum and Ackermann, 1995; Kim et al., 1994). A few task-related fMRI have reported decreased activation in the cerebellum in patients with OCD, and after clinical improvement, the cerebellum exhibited with increased activation (Nabeyama et al., 2008; Nakao et al., 2005). Moreover, it was reported that the pre-treatment activation in the right cerebellum had a positive correlation with the improvement in the Y-BOCS score during the symptom provocation task (Sanematsu et al., 2010). In the present study, we found reduced ALFF in the bilateral cerebellum. To the best of our knowledge, no previous functional MRI researches had directly located the functional abnormality of cerebellum during resting-state in patients with OCD, however, it was captured in our study for the first time using the ALFF approach.

The current study has several limitations. First, some patients with OCD have a history of serotonergic antidepressant medication, and although these patients had a minimum two week medication washout prior to MRI scans, we couldn’t completely rule out the influence of medicine to brain function. Further studies using drug-naïve patients are needed to confirm our preliminary results. Second, given the low sample rates (as in this study TR = 2 s), the respiratory and cardiac cycle artifacts may alias into the resting-state low frequency fluctuations. In this study, patients with OCD and normal controls might have different physiological responses to the scanning environment, so the aliasing physiologic noises may be potential confounding factors to group comparison. In future studies, it would be better to estimate these effects by recording respiratory and cardiac cycles during the scanning. Third, the patients in the present investigation are heterogeneous in symptom dimensions, and some previous
studies (van den Heuvel et al., 2009) suggested that there are distinct neural mechanisms under different symptom dimensions in OCD, however, as the sample size is limited, we cannot further divide our patients into different groups. In addition, HAMD and HAMA scales were not acquired for the control group in the present study, and although no patients and controls in our study met the criteria for major depressive disorder, we still could not completely exclude the possibility that our results were influenced by participants’ current comorbid symptoms. Further investigations are warranted to confirm our preliminary results after controlling for participants’ comorbid depression and anxiety ratings on the HAMD and HAMA scales. In conclusion, the present study observed the abnormal spontaneous activities in patients with OCD by analyzing resting-state fMRI data, including increased ALFF in the bilateral OFC and ACC as well as decreased ALFF in the bilateral cerebellum and parietal cortex. Our findings suggest that the abnormal spontaneous activity of these brain regions may implicate the underlying pathophysiology in patients with OCD. Future experiments are expected to combine different modalities to provide more information about the disorder.

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This study was not provided by any funding.

Conflict of interest
All authors declare that they have no conflicts of interest.

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Appendix A. Supplementary data
Supplementary data to this article can be found online at doi:10.1016/j.jad.2012.01.022.

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