***Supplementary Materials***

**Altered Dynamic Amplitude of Low-Frequency Fluctuations in Patients with Postpartum Depression**

**The patient inclusion and exclusion criteria**

The patients met the following inclusion criteria: (1) met the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition unipolar depression (DSM-V); (2) Hamilton Depression Scale (HAMD) score >20 (M, 1967); (3) Edinburgh Postnatal Depression Scale (EPDS) score ≥12 (L et al., 1987); (4) right-handed; (5) first onset without any treatment; (6) depression onset during pregnancy or new-onset postpartum (N et al., 2005); and (7) no MRI examination contraindications and abnormalities in MRI structure imaging. The exclusion criteria included the following: (1) patients and first-degree relatives have suffered from mental illness in the past or present; (2) other types of mental illness in addition to PPD; (3) serious physical illness at present or in the past; (4) long history of alcoholism or drug dependence; (5) history of brain tumor or trauma; (6) hormonal contraceptives; (7) left-handed; and (8) complications, such as hypertension, diabetes, eclampsia, heart disease, or postpartum hemorrhage, during pregnancy or childbirth.

**The HCs inclusion and exclusion criteria**

The inclusion criteria were as follows for HCs: (1) HAMD score < 8; (2) EPDS score < 3; (3) no mental illness; (4) not taking antidepressants or other antipsychotics. The exclusion criteria are the same as those for the PPD group.

**Data preprocessing**

The rs-fMRI data preprocessing were carried out using data Processing and Analysis for Resting-State Brain imaging (DPARSF; <http://www.restfmri.net/forum/DPARSF>) (Chao-Gan et al., 2016).The first 10 time points were removed to stabilize the status of the MRI signal and allow subjects to adapt to the scanning condition. The subsequent analysis was carried out for the last 165 time points. Slice timing and head movements were carried out on the remaining data to correct differences. Only participants with head motion less than 2.0 mm in the x, y or z direction and less than 2.0° rotation about each axis were included. On the basis of this criterion, four patients with PPD were excluded. The resulting images were spatially normalized to the standard Montreal Neurological Institute (MNI) EPI template. And each voxel was resampled to 3 mm × 3 mm × 3 mm. Several covariates such as the Friston-24 head-motion parameters, white matter signal, cerebrospinal fluid signal and whole brain signal were regressed by using multiple linear regression methods. A 6 mm half-width smoothing kernel was used to spatially smooth the image. Linear trend and band-pass filtering (0.01-0.08) were performed to remove signal drift and physiological noises such as breathing and heartbeat.

**The dALFF calculation**

The DPABI toolkit was used to calculate the dALFF value (Yan et al., 2017). Sliding window is an important parameter to capture dynamic spontaneous neural activity. Appropriate window length is very important for dynamic analysis. According to previous studies, the minimum window length should not be less than 1/fmin (Jiao et al., 2019; Qiu et al., 2018), because a short window length may increase the risk of false volatility (Leonardi and Ville, 2015), while a long window will lose its dynamics, where fmin is defined as the minimum frequency of time series. Therefore, a window with window width of 50 TRs (Li et al., 2019) and step length of 1 TR were selected for dynamic interception of fMRI time signals. First, the complete time series of each subject was divided into windows with a specific length of time. The time series of each participant was divided into 116 windows, and then the ALFF value in each window was calculated to generate a set of ALFF maps for each participant. Each window data were first filtered, and then all filtered voxels were converted from time domain to frequency domain by using fast Fourier transform for power spectrum calculation. The square root of each frequency of all power spectra in the range of 0.01-0.08 Hz was calculated to obtain the ALFF map, and then the ALFF value was divided by the mean value of the whole brain to obtain the standardized ALFF map. The dALFF map of each participant is obtained by connecting the ALFF values of all windows. Subsequently, variance was calculated to evaluate the time variability of ALFF. Finally, for each participant, the dALFF variability of each voxel was further converted to z-scores.

**Clustering analysis**

K-means algorithm was performed on the dALFF values of all participants in the two groups to evaluate the occurrence state of dALFF. The k-means algorithm aggregates information with similarities into “k” groups, ensuring that the sum of squares within clusters is minimal (Wen-Ying et al., 2019; Zhang et al., 2018). The Manhattan distance (L1 distance) was used as a similarity measure in clustering. To reduce the computational demands and to diminish redundancy between windows, following a previous study (Allen et al., 2014), we used the subject exemplars as a subset of windows with local maxima in dALFF variance to perform k-means clustering with varying numbers of clusters k (2–10). The optimal number of clusters k=4 was determined based on the Davies-Bouldin criterion as suggested by a recent work (M et al., 2020). The resulting four cluster centroids were used as starting points to cluster all dALFF data into four clusters. The final resulting cluster centroids were regarded as dALFF states at the group level. Group differences were assessed for the following properties (1) mean dwell time: average number of consecutive windows assigned to a state; (2) fraction time: the proportion of windows assigned to a state; and (3) number of transitions: overall number of transitions between different states.

**Validation results**

The findings based on the sliding window length of 30 and 70 TRs were similar to the main results reported above. In validation analyses, the dALFF variance of the left cerebellar regions also decreased. However, in the length of the 70 TRs window, the dALFF variance of the MFG\_R, PreCG\_R, and SFG\_R were increased. The dALFF states were also clustered into four categories, but the proportion distribution of the four states was not consistent with the main experiment. Results of all validation analyses are presented in Supplementary Materials (Figs. S1–S5 and Table S1–S3).

**References**

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**Table S1. Results of group comparisons in variance values of dALFF (Window width = 30TR & Step = 1TR)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Clusters | voxels | Peak MNI coordinate | Peak MNI coordinate region | Structure | Sphere (L/R) | Brain Regions/Network | t-values |
| 1 | 268 | 21, -60, -30 | Cerebelum\_6 |  | R |  | -3.9259 |
|  |  |  |  | Cerebelum\_8 | R | Cerebellum\_Inferior/CB |  |
|  |  |  |  | Cerebelum\_6 | R | Cerebellum\_Superior/CB |  |
|  |  |  |  | Cerebelum\_Crus1 | R | Cerebellum\_Superior/CB |  |
| 2 | 209 | 9, -75, -27 | Cerebelum\_Crus1 |  | R |  |  |
|  |  |  |  | Cerebelum\_6 | L | Cerebellum\_Superior/CB | -4.8157 |
|  |  |  |  | Cerebelum\_6 | R | Cerebellum\_Superior/CB |  |
| 3 | 315 | 33, 0, 72 | Precentral |  | R |  |  |
|  | 118 |  |  | Precentral | R | Precentral gyrus/SM | -4.033 |
|  |  |  |  | Postcentral | R | Postcentral gyrus/SM |  |
|  |  |  |  | Frontal\_Mid | R | Middle frontal gyrus/CC |  |
|  |  |  |  | Rolandic\_Oper | R | Rolandic operculum/CC |  |
| 4 | 106 | -36, -12, 57 | Precentral |  | L |  |  |
|  |  |  |  | Precentral | L | Precentral gyrus/SM | -4.1732 |
|  |  |  |  | Postcentral | L | Postcentral gyrus/SM |  |

CB, Cerebellar network; CC: Cognitive-control network; SM: Sensorimotor network; Frontal\_Mid: Middle frontal gyrus;

Rolandic\_Oper: Rolandic operculum.

**Table S2**. **Results of group comparisons in variance values of dALFF (Window width = 70TR & Step = 1TR)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Clusters | voxels | Peak MNI coordinate | Peak MNI coordinate region | Structure | Sphere (L/R) | Brain Regions/Network | t-values |
| 1 | 356 | 9 -75 -27 | Cerebelum\_Crus1 |  | L |  | -4.5327 |
|  |  |  |  | Cerebelum\_Crus1 | L | Cerebellum\_Superior/CB |  |
|  |  |  |  | Cerebelum\_6 | L | Cerebellum\_Superior/CB |  |
|  |  |  |  | Cerebelum\_Crus2 | L | Cerebellum\_Inferior/CB |  |
| 2 | 194 | 18 6 72 | Frontal\_Sup |  | R |  |  |
|  |  |  |  | Precentral | R | Precentral gyrus/SM | 3.7829 |
|  |  |  |  | Frontal\_Sup | R | Superior frontal gyrus, dorsolateral/CC |  |
|  |  |  |  | Supp\_Motor\_Area | R | Supplementary motor area/CC |  |
|  |  |  |  | Frontal\_Mid | R | Middle frontal gyrus/CC |  |

CB, Cerebellar network; CC: Cognitive-control network; SM: Sensorimotor network

**Table S3. Results of group comparisons in variance values of dALFF (Window width = 50TR & Step = 2TR)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Clusters | voxels | Peak MNI coordinate | Peak MNI coordinate region | Structure | Sphere (L/R) | Brain Regions/Network | t-values |
| 1 | 125 | 15 -66 -21 | Cerebelum\_6 |  | R |  | -4.1617 |
|  |  |  |  | Cerebelum\_6 | L | Cerebellum\_Superior/CB |  |
|  |  |  |  | Cerebelum\_6 | R | Cerebellum\_Superior/CB |  |
| 2 | 186 | 57 0 27 | Precentral |  | R |  |  |
|  |  |  |  | Precentral | R | Precentral gyrus/SM | -3.5221 |
|  |  |  |  | Postcentral | R | Postcentral gyrus/SM |  |
|  |  |  |  | Rolandic\_Oper | R | Rolandic operculum/CC |  |

CB, Cerebellar network; CC: Cognitive-control network; SM: Sensorimotor network; Rolandic\_Oper: Rolandic operculum.



**Fig.S1.** The flowchart for the exploration of dALFF. (a) Collect each subject's time point and be divided into the fixed length of time window; (b) Calculate the variances of its dALFF; (c) Cluster the dALFF to 4 states using the k-means cluster method, and compares the group differences (between PPD and HCs) when the dALFF state appears.

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**Fig. S2**. The validation results with 30 TR sliding window length and 1 TR step size. The variances of dALFF value of different brain between the HCs and PPD group.

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**Fig. S3**. The validation results with 50 TR sliding window length and 2 TR step size. The variances of dALFF value of different brain between the HCs and PPD group.



**Fig. S4**. The validation results with 70 TR sliding window length and 1 TR step size. The variances of dALFF value of different brain between the HCs and PPD group.



**Fig S5**. Group differences in dALFF states.

(a) Differences of dALFF states in 30 TR window length and 1 TR step size.

(b) Differences of dALFF states in 50 TR window length and 2 TR step size.

(c) Differences of dALFF states in 70 TR window length and 1 TR step size.