The Brain Activity Atlas for Working Memory

http://www.brainactivityatlas.org

This package contains a series of maps which characterizes the brain activities for working memory task.

Localizer paradigm

The n-back task was used to define working memory activation. It is one of the most common tasks in working memory studies, involving the storage and manipulation of information (Wager & Smith, 2003; Yaple et al., 2019). In our experiment, participants were required to perform an n-back task while inside the MRI scanner. In the 2-back condition, they were required to press a button when the current stimulus matched the stimulus from two trials back; in the 1-back condition, participants pressed a button if the current stimulus matched the immediately preceding stimulus. The n-back task consisted of two block-design functional runs, each of which lasted 168 s. Each run included four block sets, where the 1-back and 2-back conditions were intermixed. Each block set consisted of a 16-s fixation period, a 4-s instruction period, and three 20-s blocks of faces, scenes, and objects. Each block presented 10 gray-scale images, each lasting 2 s, from the same category. All face images were adult Chinese faces, showing only a roughly oval shape without hair. Scene images were common landscapes, such as mountains, lakes, and trees. Object images were images of cars in daily life, without any background. The order of blocks in each run was pseudorandomized across participants.

Image acquisition

Functional and anatomical MRI images were collected using a Siemens Trio 3T whole-body scanner with a 12-channel phased-array head coil at Imaging Center for Brain Research, Beijing Normal University, China. For functional imaging, T2*-weighted images were acquired with gradient-echo, echo-planar-imaging sequence with the following parameters: repetition time (TR) = 2000 ms, echo time (TE) = 30 ms, flip angle = 90°, in-plane resolution = 3.1 × 3.1 mm. Whole brain data were obtained using 30 contiguous interleaved 4.8-mm axial slices. Structural images were acquired with a 3D T1-weighted magnetization-prepared rapid acquisition gradient echo sequence for spatial normalization (TR = 2530 ms, TE = 3.39 ms, inversion time = 1100 ms, flip angle = 7°). Foam pillow and extendable padded head clamps were used to restrain head motion, and earplugs were used to attenuate scanner noise.

Activation analysis

Functional data were analyzed using the fMRI Expert Analysis Tool (FEAT), from the Oxford Center for Functional MRI of the Brain Software Library (FSL, http://www.fmrib.ox.ac.uk/fsl). Preprocessing consisted of motion correction, spatial smoothing with a Gaussian kernel (6-mm full-width at half-maximum), grand-mean intensity normalization, and high-pass temporal filtering with a cutoff of 120 s. In the first-level analysis, functional data were regressed by time series of each condition in n-back task with a general linear model, including six parameters from the motion correction as covariates. The time series of each condition was created by convolution of the boxcar kernel with a gamma hemodynamic response function. In the second-level analysis, two runs from each participant were combined using a fixed-effect analysis. The functional data from each participant were first aligned to the individual's structural images, and then to the Montreal Neurological Institute (MNI) standard template and resampled at 2×2×2 mm resolution. The 2-back > 1-back contrast was used to identify brain activity associated with working memory, and the resulting statistical map (*z*-score) from each participant was used to delineate subject-specific functional brain activation associated with working memory.

Probabilistic activation map (PAM)

The Z-statistic images from the second-level analysis were used to generate the probabilistic activation map (PAM). Specifically, the individual Z-statistic image for the contrast of 2back versus 1back were thresholded ($z > 2.3$, uncorrected) and binarized. The binary images across participants were then averaged, thereby creating a PAM that represents, at each voxel, the percentage of participants who showed activation for 2back versus 1back. It provides us the information for the spatial distribution of activation.

Subject-specific ROI (SSR)

There were seven working memory regions in both hemispheres in each participant, including the frontal pole (FP), middle frontal gyrus (MFG), frontal eye field (FEF), superior parietal lobule (SPL), insular (INS), precuneus (PCUN), anterior cingulate cortex (ACC). A semi-automated process was used to delineate subject-specific regions. First, the subject-specific activation map threshold at $z > 2.3$ ($p < 0.01$, right-tailed, uncorrected) with the contrast of 2-back > 1-back. Second, the watershed algorithm was employed to partition the activation map into small parcels (Meyer, 1994) to avoid subjectivity in determining the boundary between regions-of-interest (ROIs). Then, subject-specific ROIs were manually selected in these parcels by two raters, based on group-level functional reference map and macro-anatomical landmark. Finally, to avoid biases from raters, after being independently delineated by two raters, ROIs were double-checked and refined by discussion across raters. If the raters failed to reach an agreement, the map was evaluated by another rater and discussed until a consensus was reached. The FreeROI tool was used to delineate ROIs in this procedure (Zhen et al., 2015; http://www.brainactivityatlas.org/).

Probabilistic ROI Map (PRM)

A probabilistic atlas (or map) was created for each ROI, by calculating the frequency of a respective SSR being present at a given position across all subjects. The map coded the occurrence probability of each voxel being located in the ROI, and thus provided a voxel-wise description for interindividual variability in the location and extent of that ROI.

Maximum-probability ROI Map (MPRM)

A maximum-probability ROI map (MPRM) was constructed to integrate the multiple probabilistic ROI maps into one map, and to characterize the spatial relations among SSRs. Specifically, for each voxel, we compared its values from each probabilistic map, and assigned that voxel to the ROI which showed the highest probability at the voxel.

Details for Files

BAA-WM-2backvs1back-PAM-2mm: Probabilistic activation map defined by 2back vs. 1back in resolution of 2mm.

BAA-WM-2backvs1back-lACC-PRM-2mm: Probabilistic region map for left ACC defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-lFEF-PRM-2mm: Probabilistic region map for left FEF defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-lFP-PRM-2mm: Probabilistic region map for left FP defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-lINS-PRM-2mm: Probabilistic region map for left INS defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-lMFG-PRM-2mm: Probabilistic region map for left MFG defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-lPCUN-PRM-2mm: Probabilistic region map for left PCUN defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-lSPL-PRM-2mm: Probabilistic region map for left SPL defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-rACC-PRM-2mm: Probabilistic region map for right ACC defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-rFEF-PRM-2mm: Probabilistic region map for right FEF defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-rFP-PRM-2mm: Probabilistic region map for right FP defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-rINS-PRM-2mm: Probabilistic region map for right INS defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-rMFG-PRM-2mm: Probabilistic region map for right MFG defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-rPCUN-PRM-2mm: Probabilistic region map for right PCUN defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-rSPL-PRM-2mm: Probabilistic region map for right SPL defined by subject-specific ROI (2back vs. 1back) in resolution of 2mm.

BAA-WM-2backvs1back-MPRM-thr20-2mm: Maximum probability map (thresholded at 0.2) for working memory regions defined by subject-specific ROI in resolution of 2mm.

BAA-WM-2backvs1back-MPRM-thr30-2mm: Maximum probability map (thresholded at 0.3) for working memory regions defined by subject-specific ROI in resolution of 2mm.