The Change of an Effective Connectivity over Working Memory Loads: an fMRI Study of Face and Location Working-Memory Tasks

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Background: Brain strategy for a location and a face matching tasks under a heavy load is an interesting subject.

The aim of the present study: To assess the changes in the functional integration of the working memory network for each task while performing two visuospatial n-back tasks (face-matching and location matching) with three load levels (1-, 2-, and 3-back tasks).

Introduction

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Methods

Subjects
Sixteen normal right-handed subjects (10 males and six females). The mean age was 16.9 years (range, 15-18 years; standard deviation, 1.2 years).

Task

Data Analysis
1. Realignment with SPM2
2. Normalization to MNI template
3. Smoothing using a Gaussian kernel of 8 mm FWHM
4. Activation map construction with display slices routine (P < 0.0001)
5. Extraction of the coordinates for middle frontal gyrus (MFG, right and left), inferior frontal gyrus (IFG, right and left), medial frontal gyrus (MedFG), superior parietal lobule (SPL, left), and inferior parietal lobule (IPL, right) with a local maxima search
6. Build the union of ROIs from a face and a location activation map (each ROI is a sphere of 4 mm radius)
7. Extracting the time series of mean BOLD signal value using MarsBar
8. A session specific linear detrend and normalization with zero mean and unit variance
9. A task-related eigenseries was extracted for each region using the principal component analysis (PCA)
10. Model generation with an automated search method using AMOS 7.0
11. Build the effective connectivity diagram for each kind of task and difficulty level with the structural equation modeling (SEM).

Statistical criteria to accept the model were set at goodness-of-fit index (GFI) > 0.9 and root mean square error of approximation (RMSEA) < 0.1

Results

We can see the following results from Fig. 3.
• At 1-back task, right hemisphere is dominant for both contexts.
• A circuit switched from the right to the left hemisphere during the face matching task at 2-back task.
• Processing circuit for location matching was bilateral at 2-back task.

Results

Conclusion

• In 1-back task, a fast and prompt visual imagery rehearsal was used in the right hemisphere.
• At 2-back task, articulatory rehearsal was utilized in the left hemisphere for a stable and robust performance.
• A distributed and parallel brain use was needed for the heavy load task.
• This study suggests an efficient use of both an imagery and an articulatory rehearsals for the heavy load 2-back tasks.