"Dual-Use" fMRI in children: assessing language and visuospatial functions with one task

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Introduction

Performing functional magnetic resonance imaging (fMRI) studies in children is still challenging, particularly due to issues involving cooperation once inside the scanner. Motion is an important confound in such studies [1], and is heavily dependent on the time spent in the scanner. The objective of the current study was to investigate whether a "dual-use" approach to analyzing data from one task might be an alternative to using two tasks.

Subjects & Methods

Two fMRI tasks were investigated: in the letter task [2], the active condition consists of a concrete object that is visually presented, and the subject has to decide if the vowel "I" (always pronounced [ee] in German) is present in the name if the object (if so, a button press is required). The control condition consists of two complex unnamable images (fractals), and the subject has to decide if the smaller one fits "like the piece of a puzzle" into the larger one (if so, a button press is again required). While the contrast active > control is known to induce left-frontal activation, the contrast control > active was as yet unused. The visual search task [3] was developed to investigate predominantly right-hemispheric visuo-spatial functions and consists of a complex figure (Rey-Osterrieth figure) which is always shown twice. In the control condition, the subject has to decide if a (small) part of the figure is missing on one side (if so, a button press is required). In the control condition, the overall orientation of the two figures has to be judged; if they are different, a button press is required. Both tasks were implemented as block designs with a 30s block duration and 5 blocks of each condition.

For the current study, 43 children were recruited from the community, 24m, mean age 12.03 +/- 2.6 years, 38 were right-handed, 4 were left-handed, and 1 was ambidextrous, according to the Edinburgh handedness inventory. Of those, all children performed the visual search task, while all but one child performed the letter task. Institutional review board approval was obtained, and informed consent (parents) and assent (children) was given. MR scanning was performed on a 1.5T MR scanner (Avanto, Siemens, Erlangen) using a 12-channel head coil. EPI images were acquired with TR/TE = 3000/40 ms, 40 slices of 3 mm thickness, matrix = 64x64, resulting in a voxel size of 3x3x3 mm. An anatomical T1-weighted 3D-dataset was also acquired with TR/TE=1300/2.92 ms, 176 slices of 1 mm thickness, matrix = 256x256, resulting in a voxel size of 1x1x1 mm. Data processing was done in SPM8 (FIL, UC London) running in Matlab (Mathworks, Natick) and included denoising, fieldmap-based EPI unwarping/realignment, and spatial normalization employing the unified segmentation framework [4] which was based on custom-generated pediatric reference data [5]. After the removal of global trends, Gaussian smoothing was performed with FWHM = 9 mm. Following single-subject analyses employing the general linear model [6], parameter estimates were entered into a random-effects analysis, where age (in months), gender, and handedness were used as covariates of no interest. Significance was assumed at $p < .01$, FWE-corrected for multiple comparisons. Results are rendered on the custom-generated GM map.

Results

Imaging data from 3 children performing the letter task had to be discarded due to motion exceeding one voxel size. The active > control condition in the letter task induced left-inferior-frontal activation, as before ([2]; data not shown here). The control > active condition induced right-dominant posterior-parietal activation (Fig. 1, a,b). The visual search task induces posterior-parietal as well as occipital activation in the active > control condition (Fig.1, c,d).

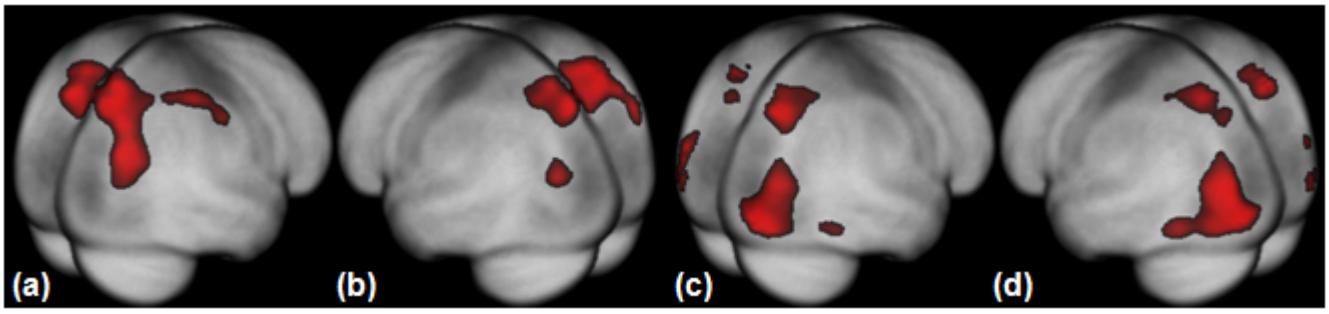

Figure 1: Activation pattern of the letter task (a,b) and the visual search task (c,d)

Discussion

Both tasks induce similar activation patterns, and especially the high-parietal regions show a large overlap between areas activated in the one and the other task. This potentially corresponds to a pattern recognition and/or pattern matching process which is inherent in both tasks. While further analyses regarding the contribution of the overlapping and non-overlapping brain regions are underway, the additional analysis of the control > active condition in an already-established functional MRI task seems to offer an interesting alternative to using two distinct tasks. Combining a motor with a cognitive paradigm has been done before [7] but the assessment of two so distinct cognitive domains in one task would seem to be a novel approach. Prospectively, the design of (mainly, but not only) pediatric fMRI tasks may benefit from attempting to include such a dual-use approach.

References

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