Mapping of task-relevant activation in human posterior parietal cortex for processing spatial and non-spatial stimulus characteristics

D. A. Poggel[1,2], D-S. Kim[1], J. F. Rizzo[2,3], and L. J. Toth[1]

[1]Center for Biomedical Imaging, Boston University Medical School, Boston, MA, United States, [2]Center for Innovative Visual Rehabilitation, Boston VA Medical Center, Boston, MA, United States, [3]Massachusetts Eye and Ear Infirmary, Harvard Medical School, Boston, MA, United States

Introduction:
Posterior parietal cortex (PPC) is regarded as a sensorimotor association area involved predominantly in processing spatial information. In monkeys, well-defined subregions of PPC support saccade planning and other spatial visuo-motor functions (lateral intraparietal, LIP) and reaching movements (medial intraparietal, MIP). Toth & Assad (2002) showed that area LIP is activated in a delayed saccade task not only when the task rule requires spatial processing but also when the task-rule is based on a non-spatial stimulus characteristic, e.g. its color, while target location is ignored. We investigated the role of human PPC in a similar spatial vs. non-spatial task. Our goal was to map activation in human PPC in response to higher cognitive functions such as task instruction.

Methods:
Eleven healthy subjects (5 male, average age: 29.3 years) participated in an fMRI experiment. On a visual display a cue (a red or green circle) was presented for 500ms either to the left or to the right of a fixation mark. Both stimulus color and location were randomized across trials. After a 1000ms delay period, the fixation cross disappeared which was the go-signal for the response. Before each block of 16 trials, the subject received either a "space" instruction (i.e. to press the left button in response to a left stimulus, and the right for a right stimulus, or vice versa) or a "color" instruction (i.e. left button for a green stimulus, right button for a red stimulus, or vice versa). Eight blocks were presented in one run, and the experiment consisted of six runs. BOLD fMRI was measured using a Philips Intera 3T machine (field-echo EPI sequence (T2* contrast) with TR=2500msec, 35 slices, 3mm, TE=35msec, FOV 230x230, 128x128 data matrix). In addition T1-weighted high-resolution structural images were acquired (MP-Rage; TR= 7.44, TE= 3.4, flip angle= 8.0, inversion time TI= 0; 120 axial slices, 256 x 256 reconstructed resolution, FOV = 240 x 240). Data were analyzed with Brain Voyager software (Version 1.7, Brain Innovation, Maastricht, Netherlands) using a General Linear Model (GLM) approach and event-related and ROI analysis tools for single subjects and across the sample. Trials were sorted according to stimulus location (left vs. right visual field), stimulus color (red vs. green), response side (left vs. right hand), and instruction (space vs. color task-rule). Activated regions were plotted on the Talairach-space anatomical surface and/ or the inflated reconstructed surface.

Results and Discussion: Sorting trials by side of the visual stimulus presentation yielded contralateral visual cortex activation in single subjects (figure 1A) and across subjects (figure 2A). Sorting trials by response side yielded strong activation of primary motor cortex regions in all subjects (1B, 2B). The location of activated areas for the visual and motor control conditions was consistent across subjects. Sorting trials by stimulus color (red vs. green) yielded no activation anywhere in the brain (1C, 2C), as expected, and served as a control experiment. Sorting by task-rule yielded adjacent, separable activation in medial PPC for both task-rules (1D, 2D). The exact position of active areas within PPC was highly variable across subjects.

Conclusions: Medial areas of human PPC are reliably activated in a task-dependent manner, even when the rule requires ignoring the spatial aspects of the stimulus. Thus, PPC networks allow flexible processing of stimulus material. However, these networks are highly individualized and possibly reflect individual differences in underlying functional anatomy. Functional localizer tasks for human parietal lobe areas have been notoriously difficult to find compared with occipital/temporal localizer tasks. We speculate that this may be due to higher individual variation within parietal lobe, and now plan to look for correlated individual variation in other imaging modalities.

Acknowledgements: This work was supported by NIH NS44825 (DSK) and EY014588 (LJT).

References:
Toth, L. J., & Assad, J. A. (2002). Dynamic coding of behaviourally relevant stimuli in parietal cortex. Nature, 415(6868), 165-168.

Figure 1 Single-subject data

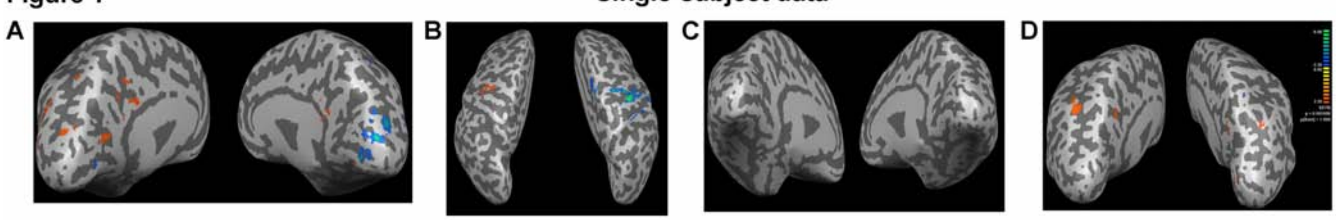

Figure 2 Group data