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MODULATION OF SPECIFIC BRAIN ACTIVITY BY VERY SUBTLE GEOMETRICAL PERCEPTUAL RELATIONSHIPS OF THE MANGINA-TEST: A FUNCTIONAL MAGNETIC RESONANCE IMAGING STUDY IN YOUNG HEALTHY ADULTS

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The Mangina Diagnostic Tool of Visual Perception (Mangina-Test) (Mangina, 1998) provides a neuropsychometric measure of varying degrees of "Analytical-Specific Visual Perception", i.e., the ability to identify simple stimuli inserted (masked) into more complex ones according to their exact geometrical properties. Stimuli dealing with the exact discrimination of size and dimension are related more to mathematical abilities (MA), while those dealing with direction and spatial orientation more to abilities in reading and reading comprehension (RCA). Some stimuli are mixed since deal with both of the above features combined. In another fMRI investigation (this Symposium), we determined the neural correlates of the Mangina-Test. Here we aim at assessing how brain activity is differentially modulated by the discrimination of very subtle category-specific perceptual relationships.

MR images (GE 1.5T) were acquired in 12 young healthy subjects while they performed a computer-adapted version of the Mangina-Test and had to press a button as soon as they

identified a simple stimulus inserted (masked) within a complex one. Overall, 16 MA, 16 RCA and 6 mixed stimuli were presented. Functional brain response was modelled for each trial separately, accounting for the individual response time (RT) and was measured by the subtended area. One-way ANOVA was applied to investigate differential brain responses between stimulus categories ($p<0.05$).

All subjects were able to adequately accomplish the task. RT was not significantly different among stimulus categories. MA stimuli specifically engaged the bilateral fusiform gyrus, extrastriate cortex, inferior and posterior parietal area, precentral gyrus and the dorsolateral prefrontal cortex. Brain response to RCA stimuli was significantly higher in bilateral inferior frontal/insula, the angular gyrus and the middle/posterior cingulate as compared to MA stimuli. On the other hand, when compared to mixed stimuli, RCA stimuli related brain responses were significantly higher in ventral and dorsal occipital extrastriate cortex, as well as, in posterior parietal area. More specifically, mixed stimuli engaged the insula, middle cingulate, and medial precuneus as compared to the other stimuli, and additionally the angular gyrus as compared to MA stimuli only.

Results show that in the Mangina-Test, the exact discrimination of very subtle perceptual relationships between geometrical stimuli, distinctly modulates cerebral activity, so that category-specific brain responses can be related to identifiable cognitive abilities. Activation of parietal cortex for MA stimuli is consistent with previous studies of number processing, as well as, the engagement of the angular gyrus and inferior frontal/insula for RCA stimuli which is specific to language functions.

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Reference:

Mangina, C.A. (1998). Manual for the Mangina Diagnostic Tool of Visual Perception: for Diagnosing Specific Perceptual Learning Abilities and Disabilities (Third Edition, Revised and Expanded). Lawrence Erlbaum Publishers. New Jersey, USA.

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NEURAL CORRELATES OF "ANALYTICAL-SPECIFIC VISUAL PERCEPTION" AS INVESTIGATED BY THE MANGINA-TEST: A FUNCTIONAL MAGNETIC RESONANCE IMAGING STUDY IN YOUNG HEALTHY ADULTS

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Keywords: MANGINA-TEST, ANALYTICAL-SPECIFIC VISUAL PERCEPTION, fMRI

The Mangina Diagnostic Tool of Visual Perception (Mangina-Test) (Mangina, 1998) provides a neuropsychometric assessment of varying degrees of learning abilities and disabilities by measuring "Analytical-Specific Visual Perceptual skills". In this investigation, we used Functional Magnetic Resonance Imaging (fMRI) to determine the neural correlates of the Mangina-Test.

Anatomical and functional MR images (GE 1.5T) were recorded from 12 young healthy subjects. A computer-adapted administration of the Mangina-Test was adopted with the simultaneous presentation of a simple and a complex geometrical stimulus. Volunteers had to press a button as soon as they had precisely identified the simple stimulus within the complex one, as required in the original test. Stimuli were classified into four levels of difficulty (12 very easy, 14 easy, 8 difficult, and 6 very difficult) and presented in random order across subjects. Stimuli duration was self-paced (max length 30 s), and a blank screen appeared in the interstimulus intervals.

Functional brain response was modelled for each trial separately accounting for the individual response time (RT) and the subtended area was computed to quantify brain activity related to each stimulus. One-way ANOVA was applied to investigate the interaction between brain activity and levels of difficulty (FDR-corrected $p<0.05$).

All subjects adequately accomplished the task and RT increased across the levels of difficulty. During the Mangina-Test administration, volunteers recruited occipito-temporal and occipito-parietal areas, inferior parietal lobule (IPL), angular gyrus, supplementary motor area, inferior frontal, insular, and prefrontal cortex (PFC). Brain activity in the ventral occipito-temporal cortex, IPL, precentral and dorsolateral PFC, frontal eye field (FEF), and dorsal precuneus significantly increased for the most difficult stimuli. In contrast, the superior temporal and angular gyrus, anteriomedial PFC, medial precuneus, and cingulate recruitment was significantly higher for the easiest levels.

In this investigation, we determined the neural correlates of the "Analytical-Specific Visual Perceptual processes" involved in the Mangina-Test. Our findings support the existence of a distributed functional neural network that links prefrontal cortex to occipito-temporal and occipito-parietal regions, and its activity correlated with the level of task difficulty, and thus, with the attentional and visual analytical perceptual processing resources needed.

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