Cortical contributions to perceptual and symbolic reasoning using a one-dimensional Raven's progressive matrices task

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Thomas M. Morin,[1,2,3] Allen E. Chang,[2,3] and Chantal E. Stern [1,2,3]

1 Graduate Program for Neuroscience, Boston University; 2 Center for Systems Neuroscience, Boston University; 3 Cognitive Neuroimaging Center, Boston University

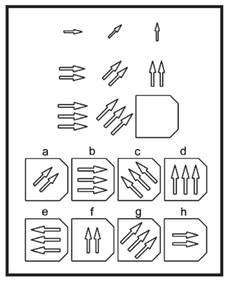
Background

The Raven's Progressive Matrices (RPM) task is widely used by psychologists as a test of non-verbal abstract reasoning ability[1,2]. The task involves deducing and applying rules to identify a probe stimulus that correctly fills in the blank.

Computational models of the RPM task are of great interest to researchers in artificial intelligence and symbolic processing[3,4,5].

We developed a simplified, one-dimensional version of the RPM task suitable for testing during an fMRI scan and for future computational modeling. Our task was focused on the deduction and application of sequence rules, and included both symbolic and perceptual reasoning conditions.

Cognitive control network activity is thought to support higher order cognitive function, including abstract reasoning during the RPM task[6,7]. Previous work in our lab identified several regions of prefrontal cortex that are involved in the deduction and application of sequence rules[8].



Example of a traditional Raven's Progressive Matrices problem.[5]

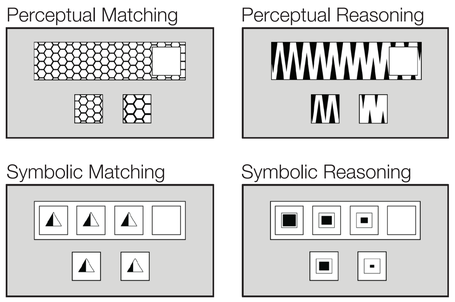
Aims:

1) Examine fMRI activity patterns for symbolic and perceptual reasoning behavior.

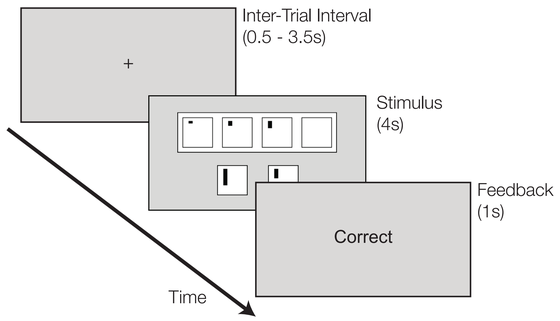
2) Examine functional network contributions to symbolic and perceptual reasoning behavior.

Methods: One-Dimensional Raven's Progressive Matrices Task

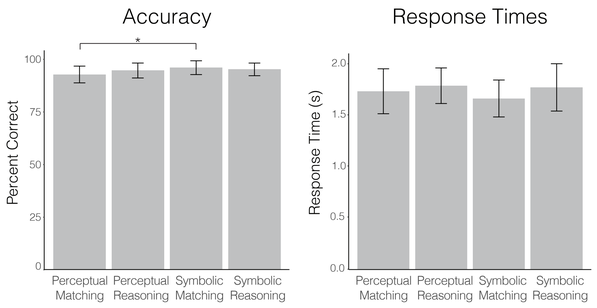
Conditions



Trial Structure



Behavioral Results



To isolate reasoning-related activity from time-on-task and general task difficulty, we extensively piloted the task to balance accuracy and response times across conditions.

The graphs to the left summarize group behavioral data from the fMRI study (n = 27).

* p < 0.05, Bonferroni Corrected
Error Bars = 95% C.I.
n = 27

References

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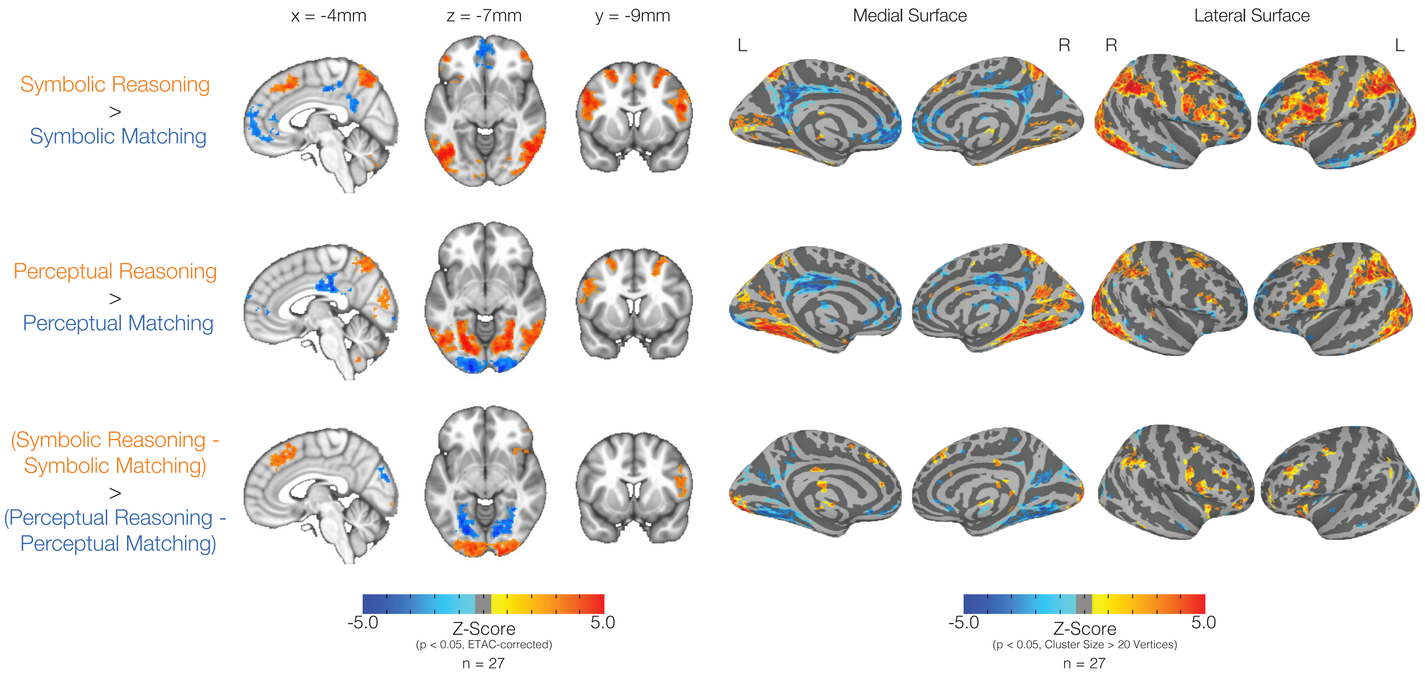
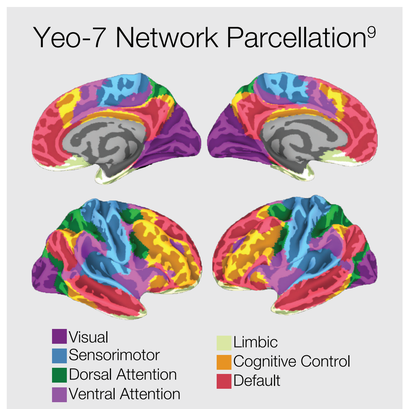
Contact

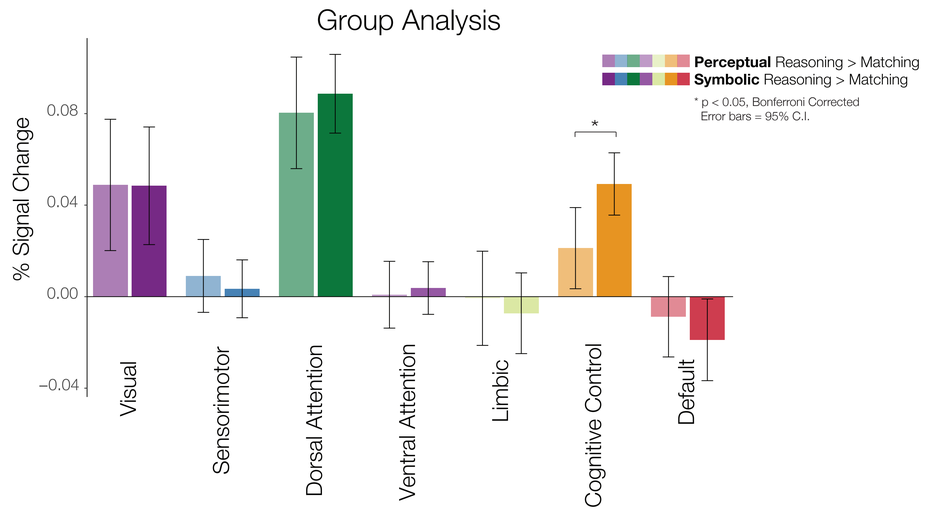
Thomas Morin
tommorin@bu.edu
@ThomasMorin1
www.tmmorin.com

Results: Frontoparietal Contributions to Symbolic and Perceptual Reasoning Behavior



Results: Functional Network Contributions to Reasoning Behavior





Summary & Conclusions

1) We observed reasoning-related increases in activity in frontoparietal cortical regions. Notably, this activation is greater for symbolic reasoning than for perceptual reasoning.

2) Results suggest that frontoparietal cortical regions, and the cognitive control network in particular, are preferentially activated by abstract reasoning about sequences, especially when those sequences are symbolic in nature.