# An fMRI Investigation of Symbolic Processing Using a **One-Dimensional Raven's Progressive Matrices Task**

# Thomas M. Morin,<sup>1,2,3</sup> Allen E. Chang,<sup>1,2,3</sup> and Chantal E. Stern<sup>2,3</sup>

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<sup>1,2</sup>. 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<sup>3,4,5</sup>.

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.

Frontoparietal network activity is thought to support hinger order cognitive function, including abstract reasoning during the RPM task.<sup>6,7</sup> Previous work in our lab identified several regions of prefrontal cortex that are involved in the deduction and application of sequence rules.<sup>8</sup>

#### Questions:

- 1) Can we design a simplified version of the Raven's Progressive Matrices task suitable for fMRI?
- 2) Which brain regions contribute to reasoning behavior during the one-dimensional Raven's Progressive Matrices task?

# Methods: One-Dimensional Raven's Progressive Matrices Task



### **Behavioral Results**



 $\Rightarrow \beta$ 

Example of a traditional Raven's Progressive Matrices problem.<sup>5</sup>

Accuracy Symbol Texture Symbol Rule Rule Uniform Condition n = 20



# Summary & Preliminary Conclusions

#### References



## Results: Fronto-parietal Contributions to Reasoning Behavior

1) We observed reasoning-related activation associated with deducing a sequence rule in frontoparietal cortical regions. Notably, this activation is greater when subjects are reasoning about a symbolic sequence rather than a texture-like sequence.

2) Preliminary results suggest that frontoparietal cortical regions are preferentially activated by abstract reasoning about sequences, especially when those sequences are symbolic in nature.

1. Raven, JC. British Journal of Medical Psychology (19412) 2. Raven, J. Cognitive Psychology. (2000) 3. Carpenter, Just, & Shell. Psychological Review. (1999) 4. Rasmussen & Eliasmith. Intelligence. (2014) 5. Raudies & Hasselmo. Bio. Inspired Cog. Arch. (2017) 6. Golde, et al. Neurolmage. (2010) 7. Christoff, et al. Neurolmage. (2001) 8. Melrose, et al. Brain Research. (2007)

#### Acknowledgements

Supported by: Office of Naval Research MURI N00014-16-1-2832 Office of Naval Research DURIP N00014-17-1-2304

We would like to thank the Jay Bohland and Shruthi Chakrapani at the Cognitive Neuroimaging Center, and members of the Cognitive Neuroimaging Lab who contributed to this study.

#### Contact

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