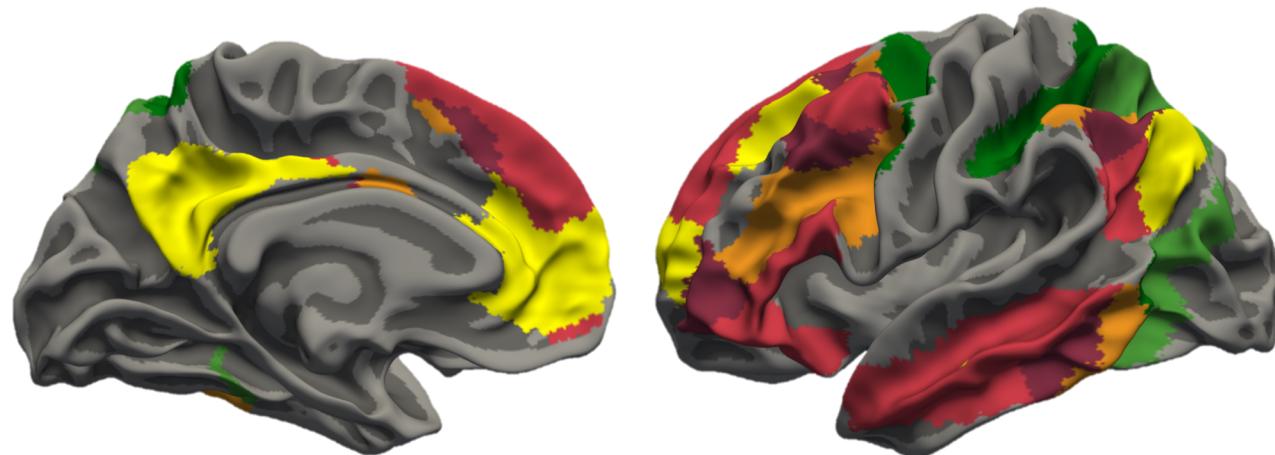
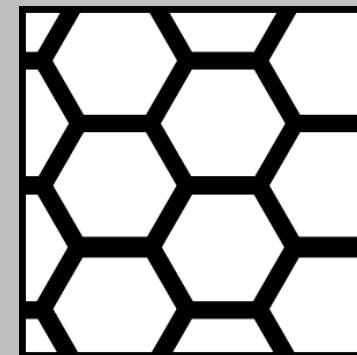
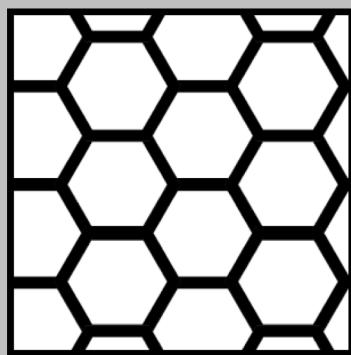
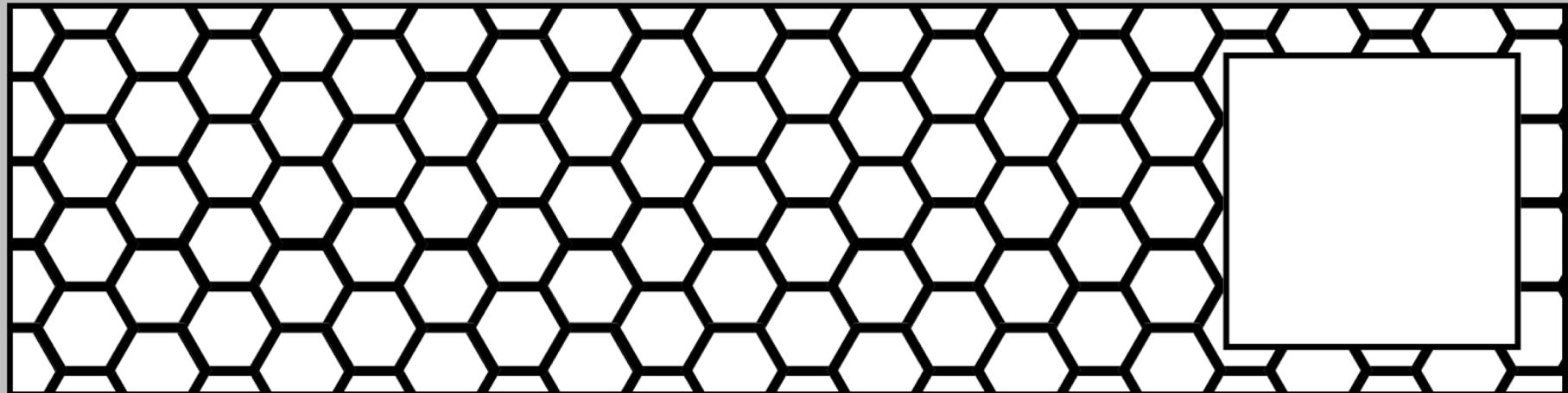


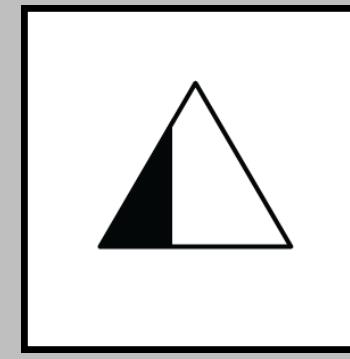
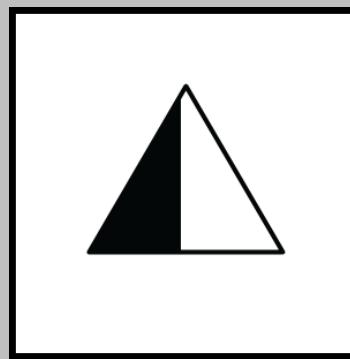
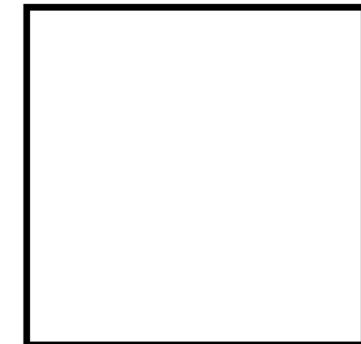
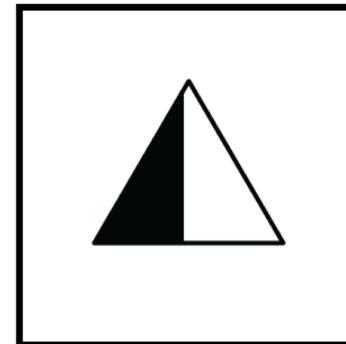
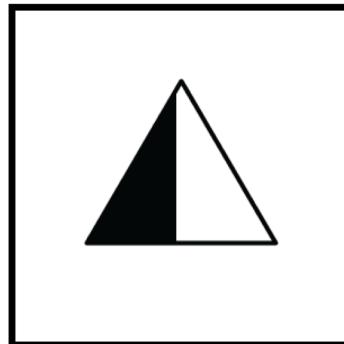
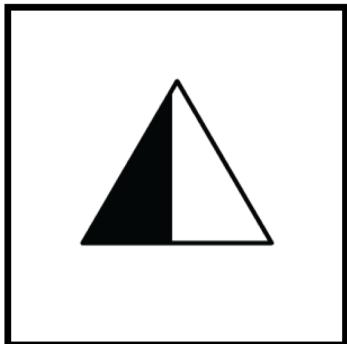
# Contributions of Frontoparietal Control Network to Abstract Reasoning

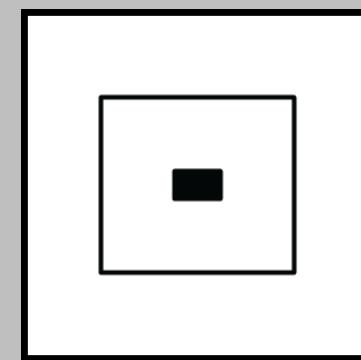
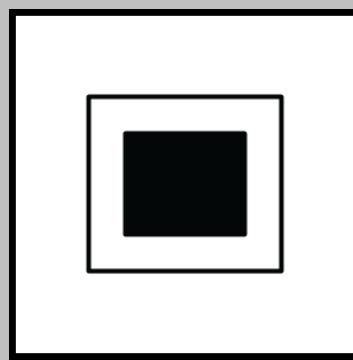
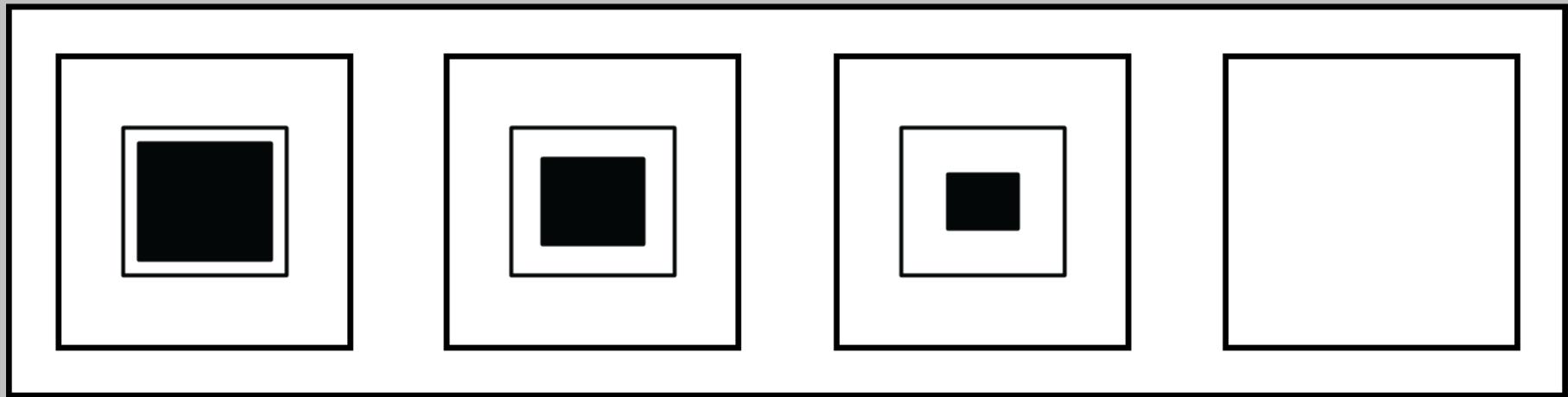


Tom Morin  
GPN Retreat 2019





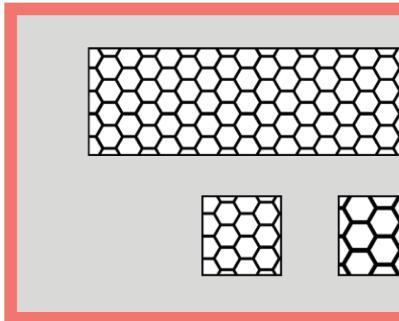




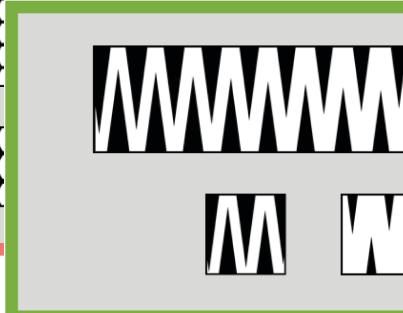
# Raven's Progressive Matrices Task

- Neuropsychological test of:
  - Fluid Intelligence
  - Relational Reasoning
  - Symbolic Processing
- Several Problem Types:

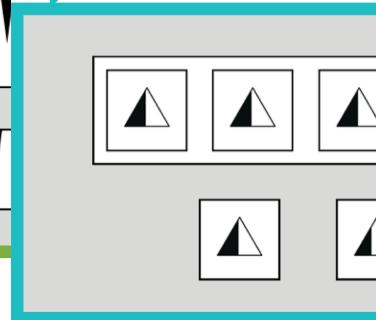
Texture Uniform



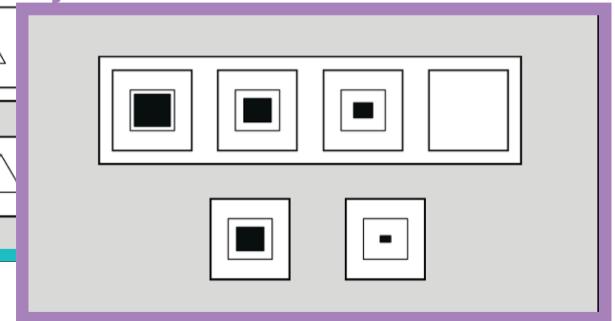
Texture Rule



Symbol Uniform



Symbol Rule



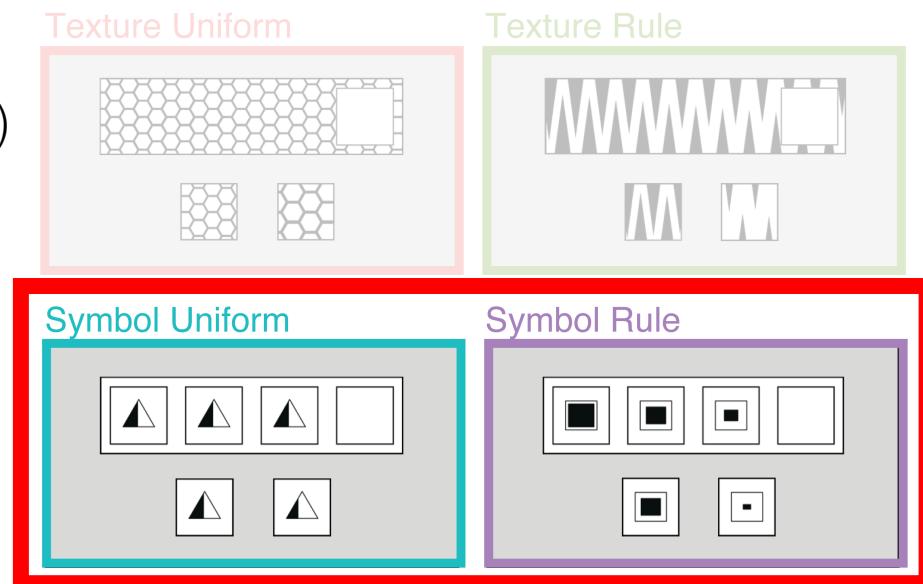
# Previous Work on the Raven's Progressive Matrices Task

## Computational Models

- Carpenter, Just, & Shell (1990)
- Kunda, McGreggor, & Goel (2013)
- Rasmussen & Eliasmith (2011, 2014)
- Lovett & Forbus (2017)
- Raudies & Hasselmo (2017)
- Hasselmo (*Preprint*, 2018)

## fMRI Studies

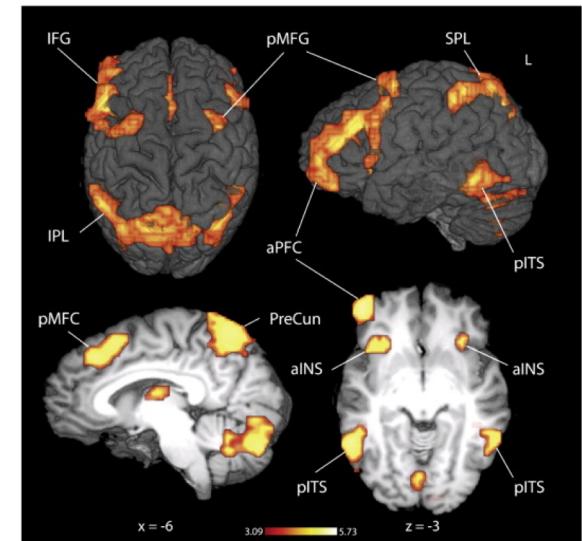
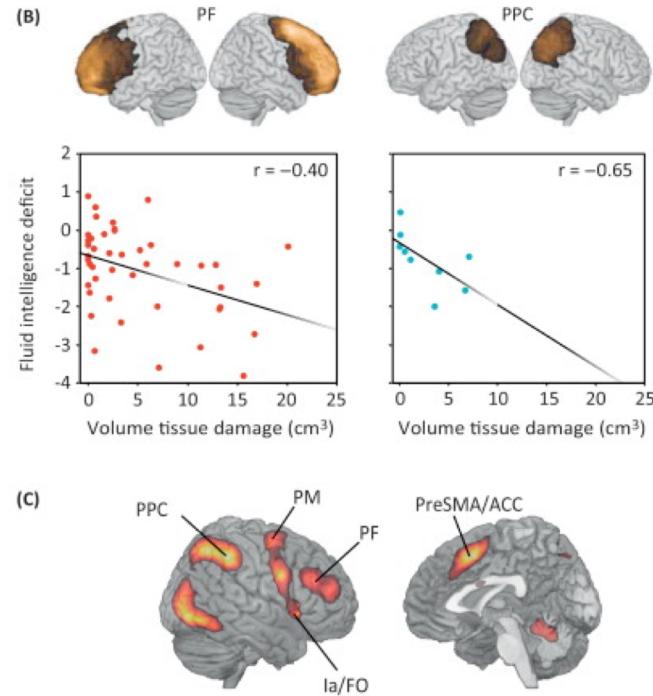
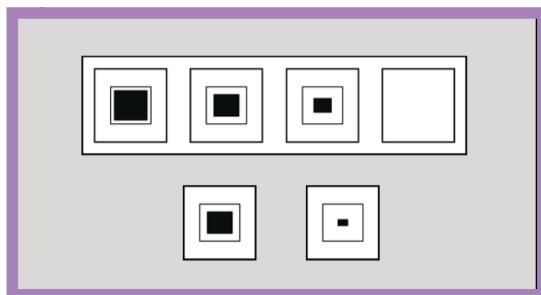
- Prabhakaran et al (1997)
- Christoff et al. (2001)
- Melrose, Poulin, & Stern (2007)
- Golde, Cramon, & Schubotz (2010)



# Frontoparietal Activity Contributes to Relational Reasoning

Common Modelling Approach:

1. Deduce the visuospatial relationship between stimuli (*Parietal*)
2. Apply that rule to simulate what comes next (*Prefrontal*)



Golde et al. 2010

Genovesio, Wise, & Passingham; 2014

# Motivation

## Question:

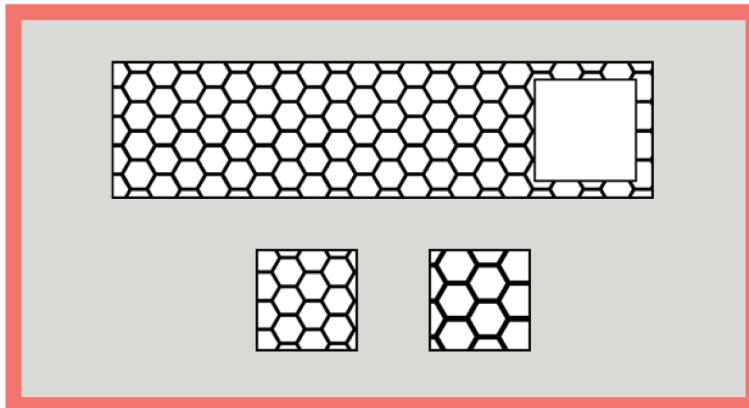
How does perceptual reasoning (texture stimuli) differ from symbolic reasoning (symbol stimuli)?

## Hypothesis:

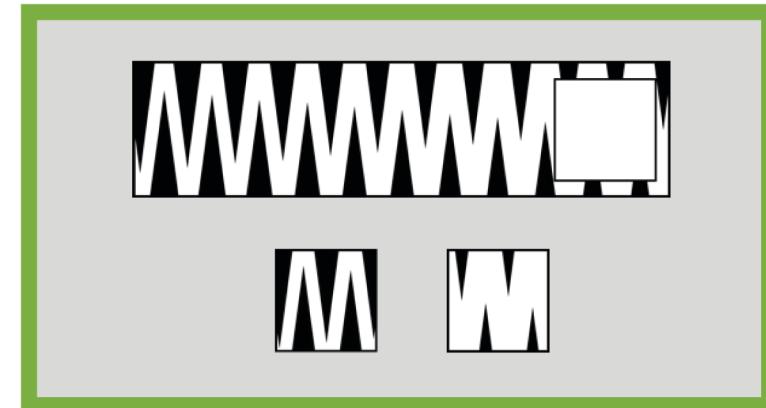
- Both types of reasoning recruit frontoparietal regions.
- Perceptual reasoning may also bring in ventral visual regions.

# Task Conditions

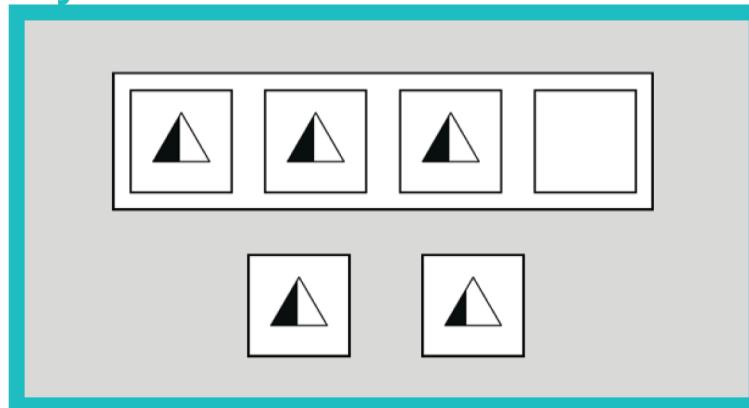
Texture Uniform



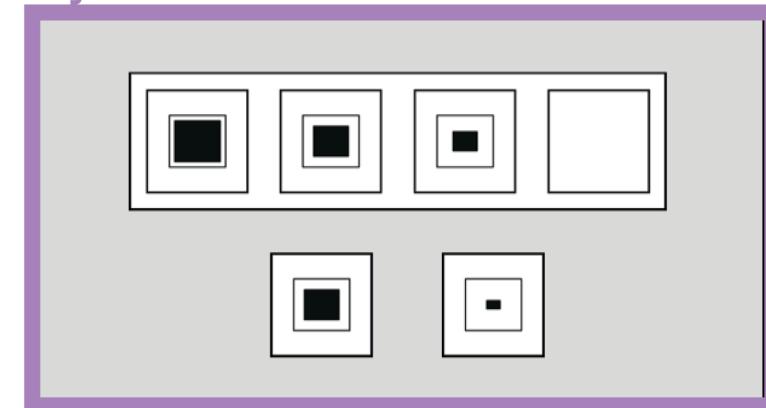
Texture Rule



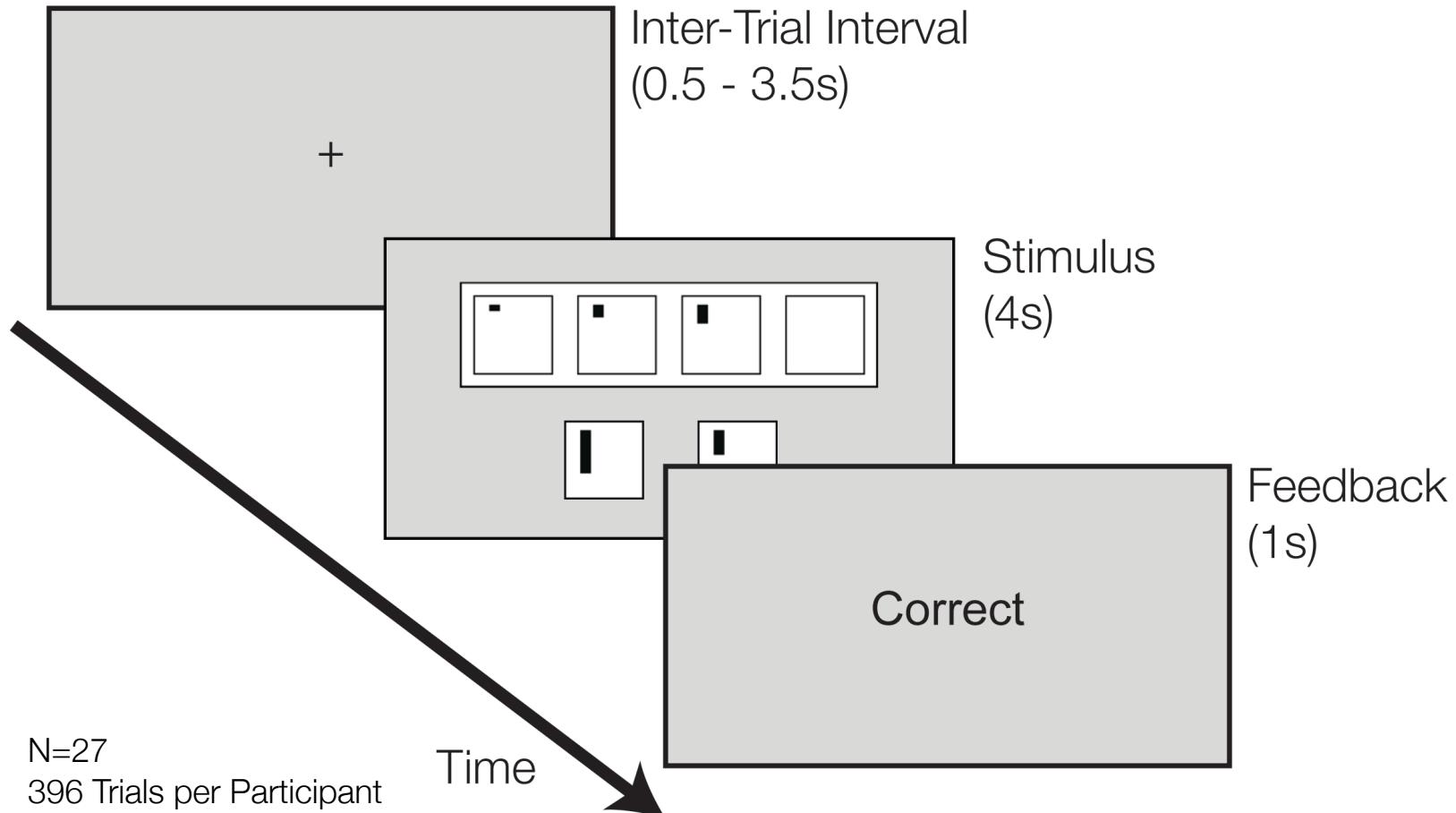
Symbol Uniform



Symbol Rule

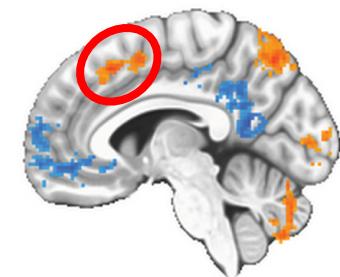
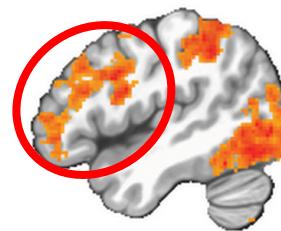
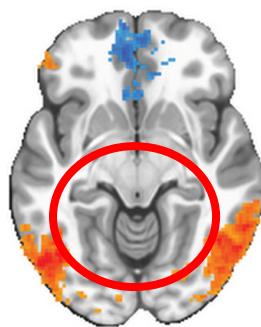


# Sample Trial

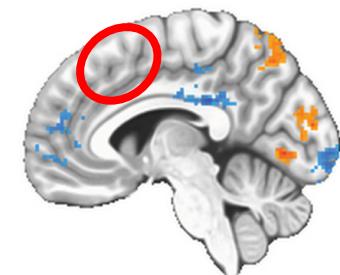
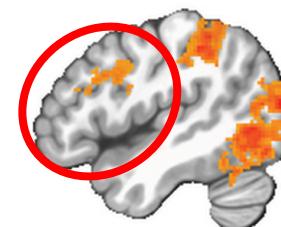
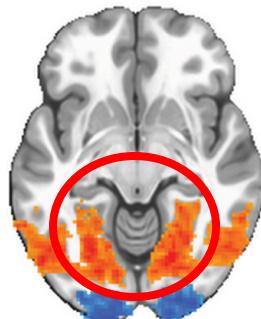


# Activity During Symbolic and Perceptual Reasoning

Symbol Rule  
>>  
Symbol Uniform



Texture Rule  
>>  
Texture Uniform



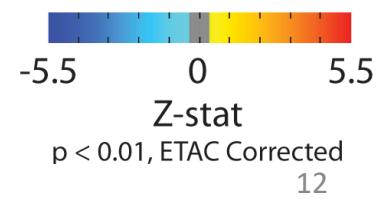
$z = -9\text{mm}$

$v = -7\text{mm}$

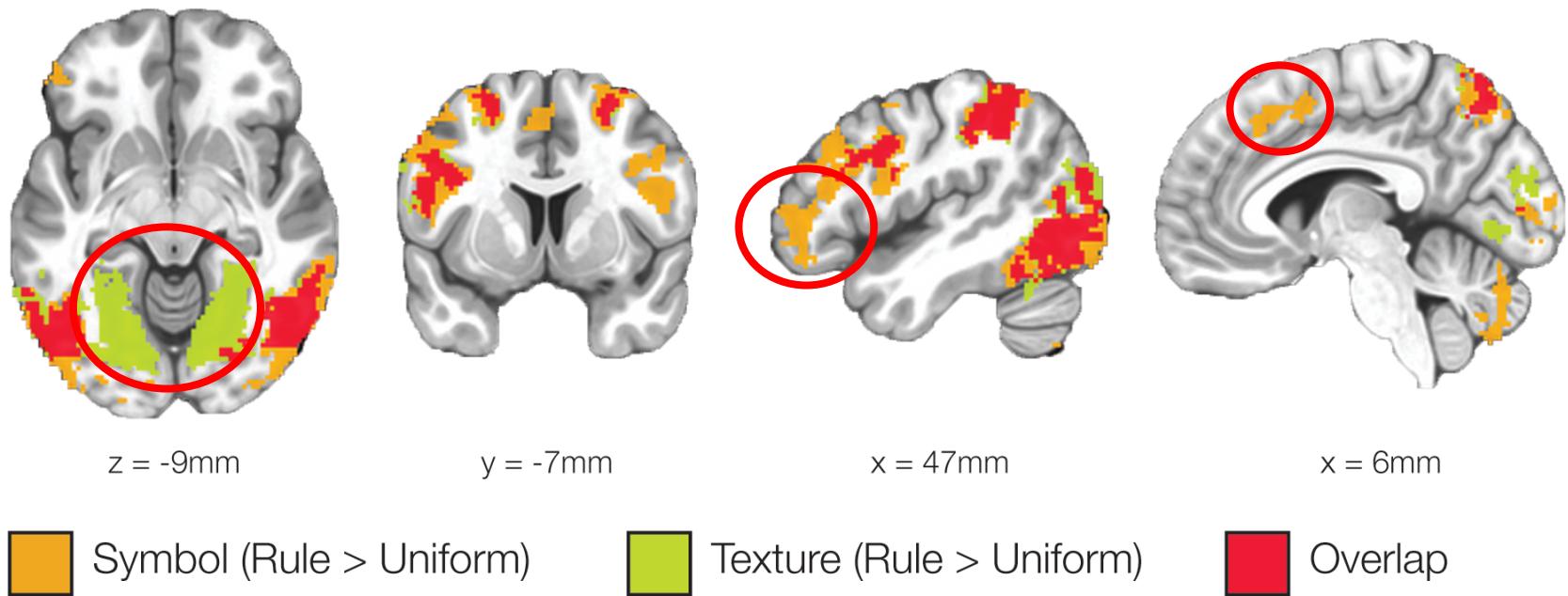
$x = 47\text{mm}$

$x = 6\text{mm}$

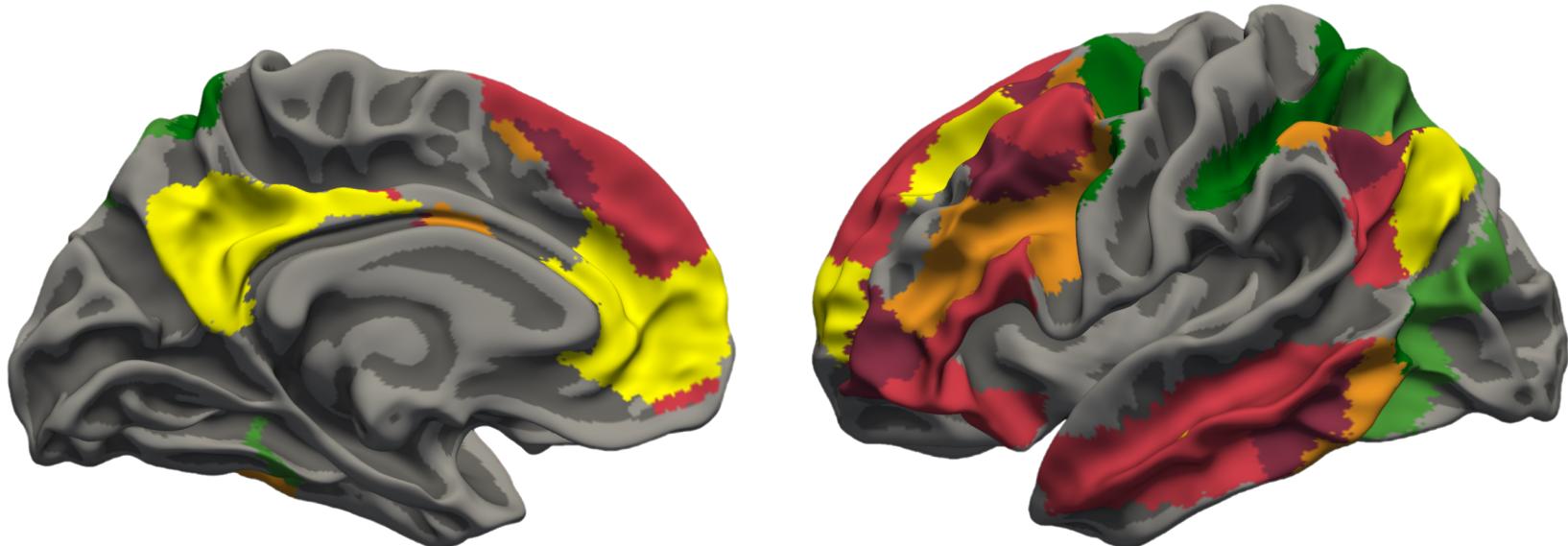
$n = 27$



# Key Differences Between Symbolic and Perceptual Reasoning Activity



# Examining Network Activity Across Symbolic and Perceptual Reasoning



17 Network Parcellation  
Yeo et al. 2011



Dorsal Attention

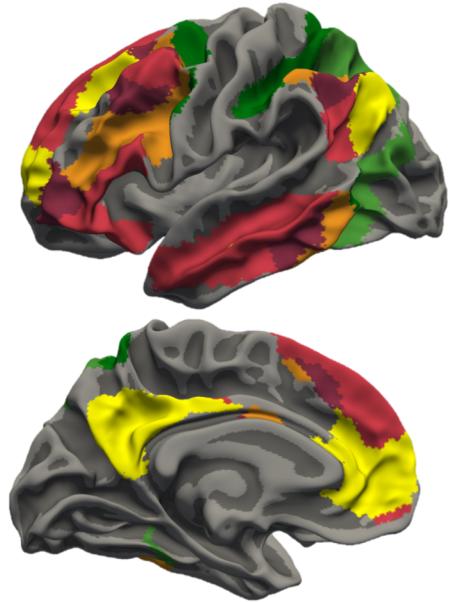


Cognitive Control

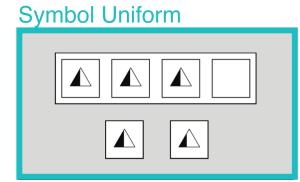
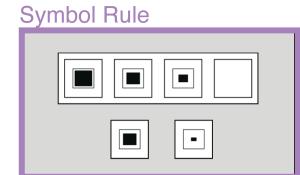
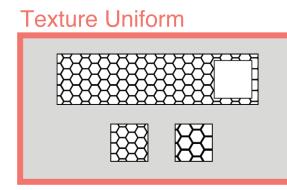
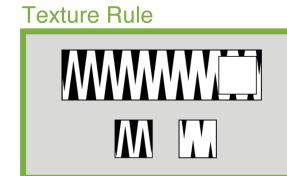
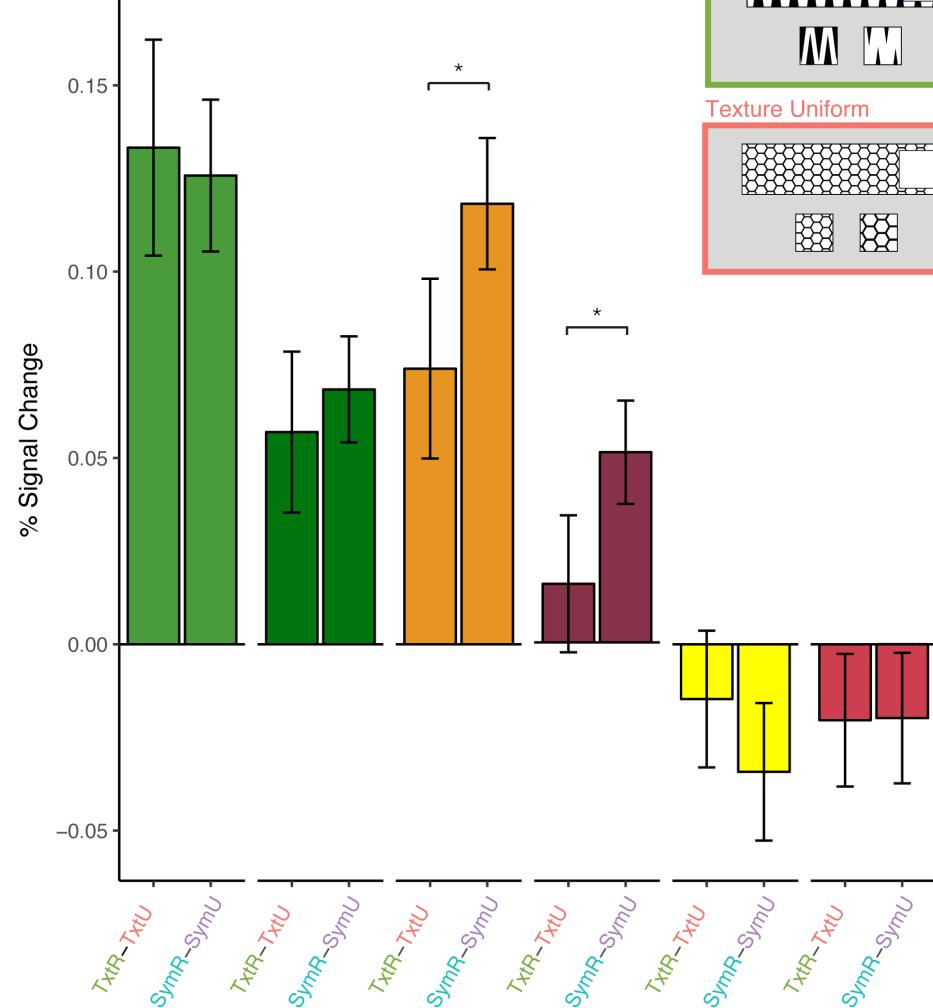


Default Mode

# Differential Cognitive Control Network Activation

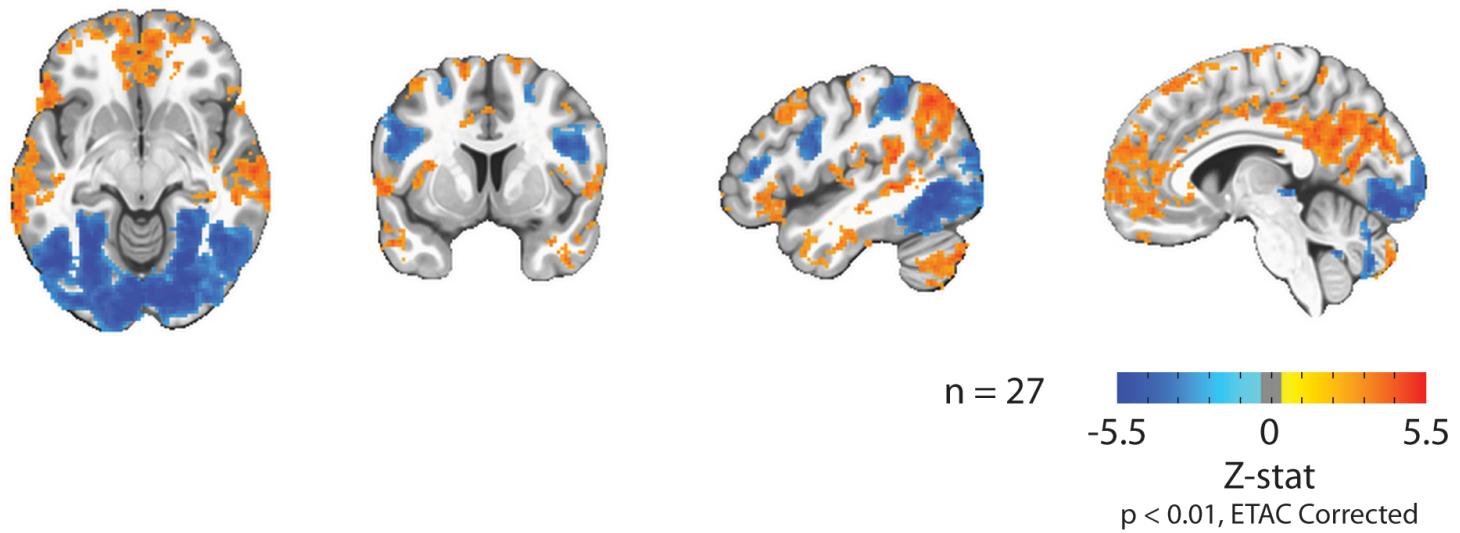


- Dorsal Attention
- Cognitive Control
- Default Mode

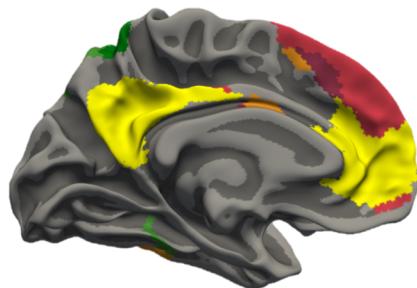
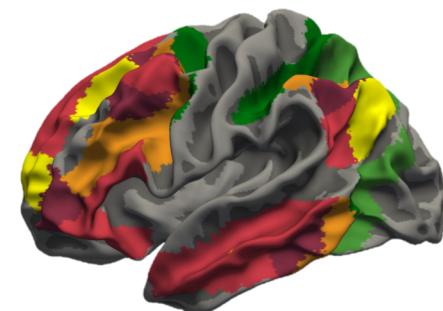


# Symbolic vs. Perceptual Activity Patterns

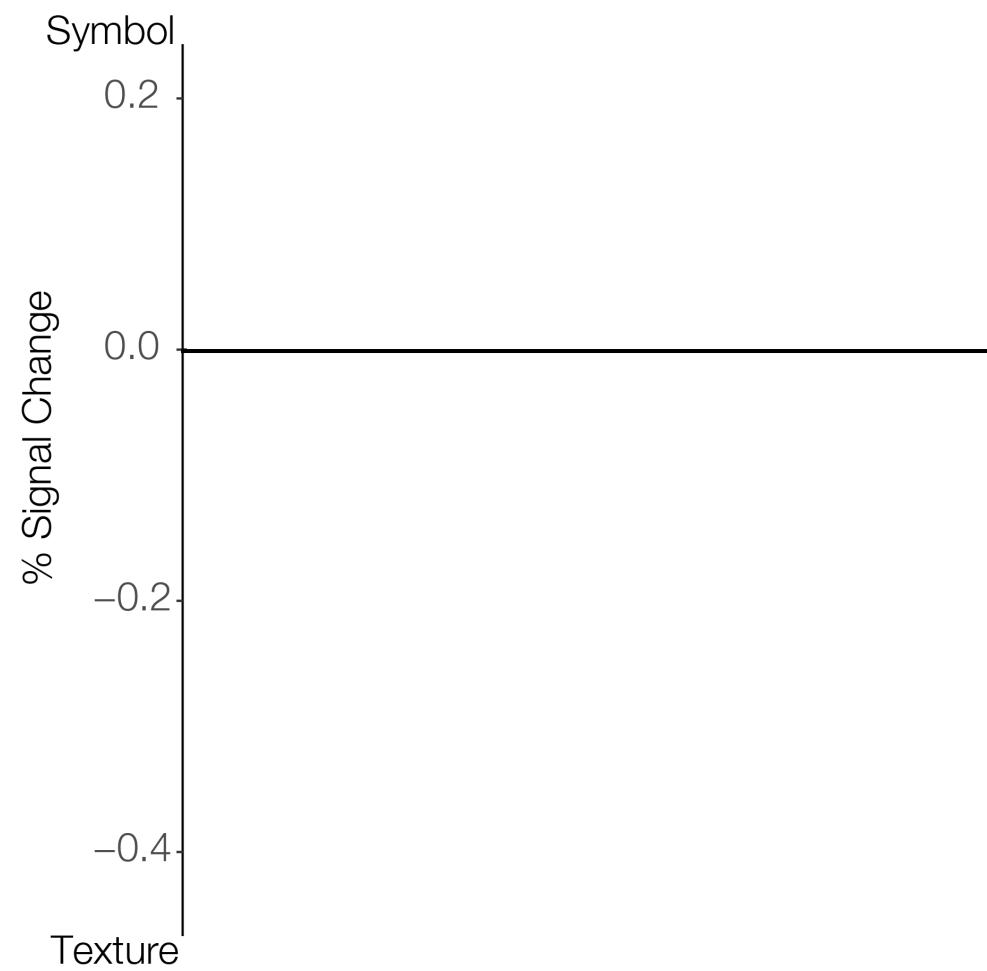
Symbol  
>  
Texture



# Differential Activation of CCN Subdivisions



- [Green square] Dorsal Attention
- [Orange square] Cognitive Control
- [Yellow square] Default Mode



# Implications

- Future computational models might consider the additional ventral-visual processing involved in perceptual reasoning
- Processing of symbolic stimuli may draw on long-term representations (schemas)

# Future Directions

- How does functional connectivity differ between conditions?
- What role do subcortical structures play in this task?
- Are there separate functions for the various nodes of the frontoparietal control network?

# Thank You!



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