Where are the ACT-R modules in the brain?

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ACT-R Workshop
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Methods

- Model-based fMRI analysis
- Five previously published studies
- Meta-analysis
Model-based fMRI Analysis
BOLD response

local field potentials

observed BOLD response

Hemodynamic Response Function

![Graph showing the hemodynamic response function. The x-axis represents peristimulus time (s) ranging from 0 to 30, and the y-axis represents % signal change ranging from 0 to 0.15. The graph shows a peak at around peristimulus time 5 s.](image)
Classical fMRI analysis

BOLD response in an aural voxel

stimulus function: sound (on/off) ⊗ HRF
Classical fMRI analysis

which voxels correspond to the stimulus function?
Model-Based Analysis

which voxels correspond to the stimulus function?

linear model per voxel

which voxels correspond to the model predictions?
Model Predictions

Declarative Memory Retrievals

Trial 1 - Condition A
Trial 2 - Condition B

Demand

0  2  4  6  8

Scans (1 scan = 2 sec)
Line up Model and Data

Data

Trial 1  Trial 2  Trial 3

Key-press  Key-press  Key-press

Model

M  Trial 1  Trial 2  M  M  Trial 3

Lined-up model

M  Trial 1  Trial  M  M  Trial 3

M = module activity
Model-Based Analysis

linear model per voxel

which voxels correspond to the model predictions?
The Five Studies
Paired Associates
(Anderson, Byrne, Fincham, & Gunn, 2008)

Figure 1. A comparison of the procedures in the Paired and Generated conditions.
# Visual & Aural Fan

*(Sohn, Goode, Stenger, Jung, Carter, & Anderson, 2005)*

## Visual Trial

<table>
<thead>
<tr>
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<th>Fixation</th>
<th>Visual Stim</th>
<th>Visual Stim</th>
<th>Visual Stim</th>
<th>Respond</th>
<th>Fixation</th>
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<td>Verb</td>
<td>Object</td>
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1.5 s 0.6 s 0.6 s 0.6 s 2.7 s 9.0 s

## Auditory Trial

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<th>Aural Stim</th>
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</table>

1.5 s 0.6 s 0.6 s 0.6 s 2.7 s 9.0 s
Algebra
(Stocco & Anderson, 2008)

Figure 1. Design of our experiment. The two series of panels represent two possible trial types. Equations could be numeric or parametric (not depicted).
Fig. 1. The 28.5-s structure of an fMRI trial. In this instance, it shows that the instruction can either be a word (e.g., AT) or a number (e.g., 23).
Multitasking
(Borst, Taatgen, & Van Rijn, 2011)
## Correlations in Predictions

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<tr>
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<td>Decl. Memory</td>
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</table>

**Visual & Aural Fan**

**Visual & Aural Fan**

### Trial 1 - Condition A

**Declarative Memory Retrievals**

![Declarative Memory Retrievals](image1.jpg)

### Trial 2 - Condition B

**Problem State Updates**

![Problem State Updates](image2.jpg)

**Model Activity**

- Model Activity
- Model Activity convolved with HRF
Results
Aural

Meta. $p < 1 \times 10^{-7}, \geq 250 \, \text{vox/cluster}$
Manual

$p < .001$

Meta: $p < 1 \times 10^{-7}$, $> 250$ vox/clusters
Visual

$p < .05$

Visual & Aural Fan Paired Associates

Visual & Aural Fan Paired Associates

Meta: $p < 1 \times 10^{-7}$, $> 250$ vox/clusters

Visual

Information Proc.

Multitasking

Algebra
Problem State

Meta: $p < 1 \times 10^{-7}$, $> 250$ vox/clusters
Declarative Memory

\[ p < .05 \]

Meta: \( p < 1 \times 10^{-7}, > 250 \text{ vox/clusters} \)
Meta Overview

Aural

Visual

Manual

Problem State

Decl. Memory
Meta Overview

Aural

-20 -8 +4 +16 +28 +40 +52 +64

Visual

-20 -8 +4 +16 +28 +40 +52 +64

Manual

-20 -8 +4 +16 +28 +40 +52 +64

Problem State

-20 -8 +4 +16 +28 +40 +52 +64

Decl. Memory

-20 -8 +4 +16 +28 +40 +52 +64
Fronto-Parietal Control Network

(e.g., Cabeza et al., 2003; Cole & Schneider, 2007; Dosenbach et al., 2007; Spreng et al., 2010; Vincent et al., 2008)
New ACT-R ROIs?
Thank you!