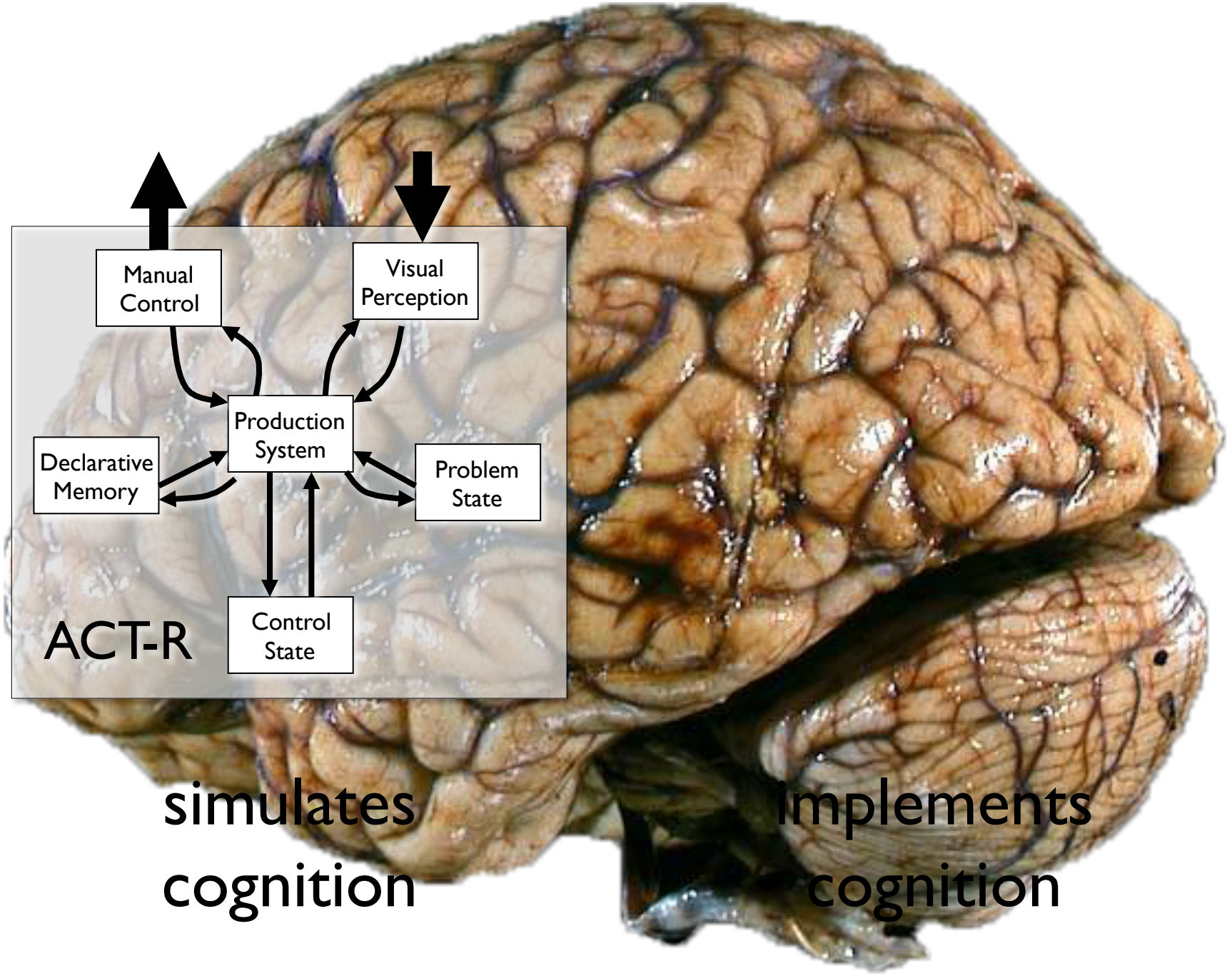
How to give ACT-R a brain?

Jelmer Borst

university of groningen

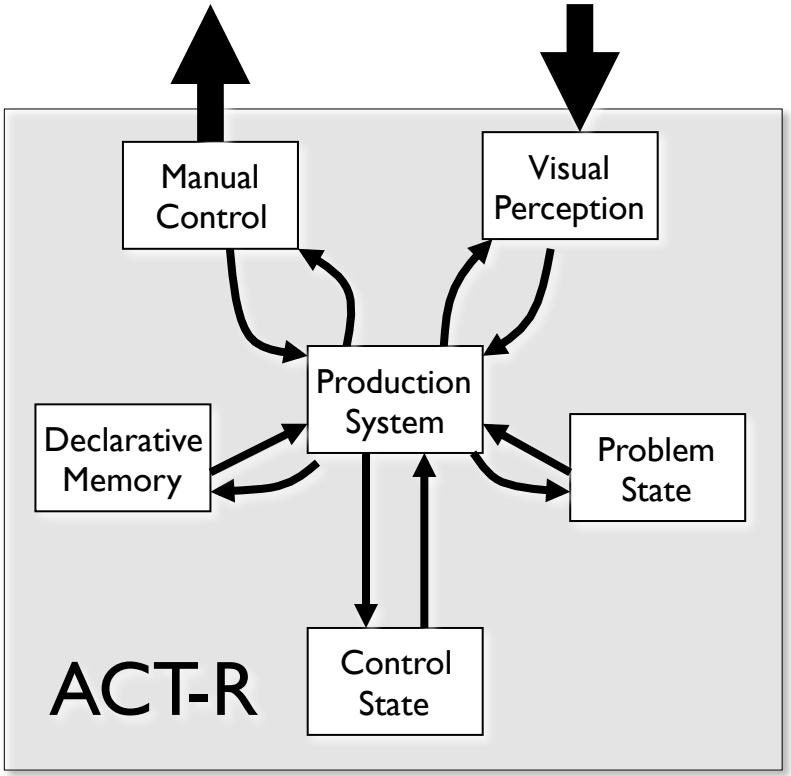
Post-Graduate Summer School

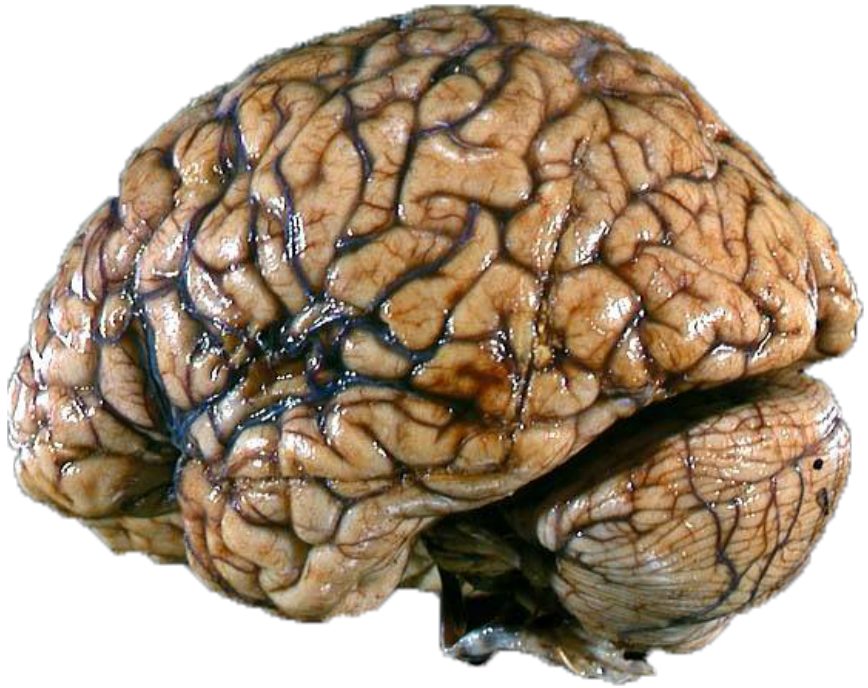
July 19, 2011



simulates cognition

implements cognition



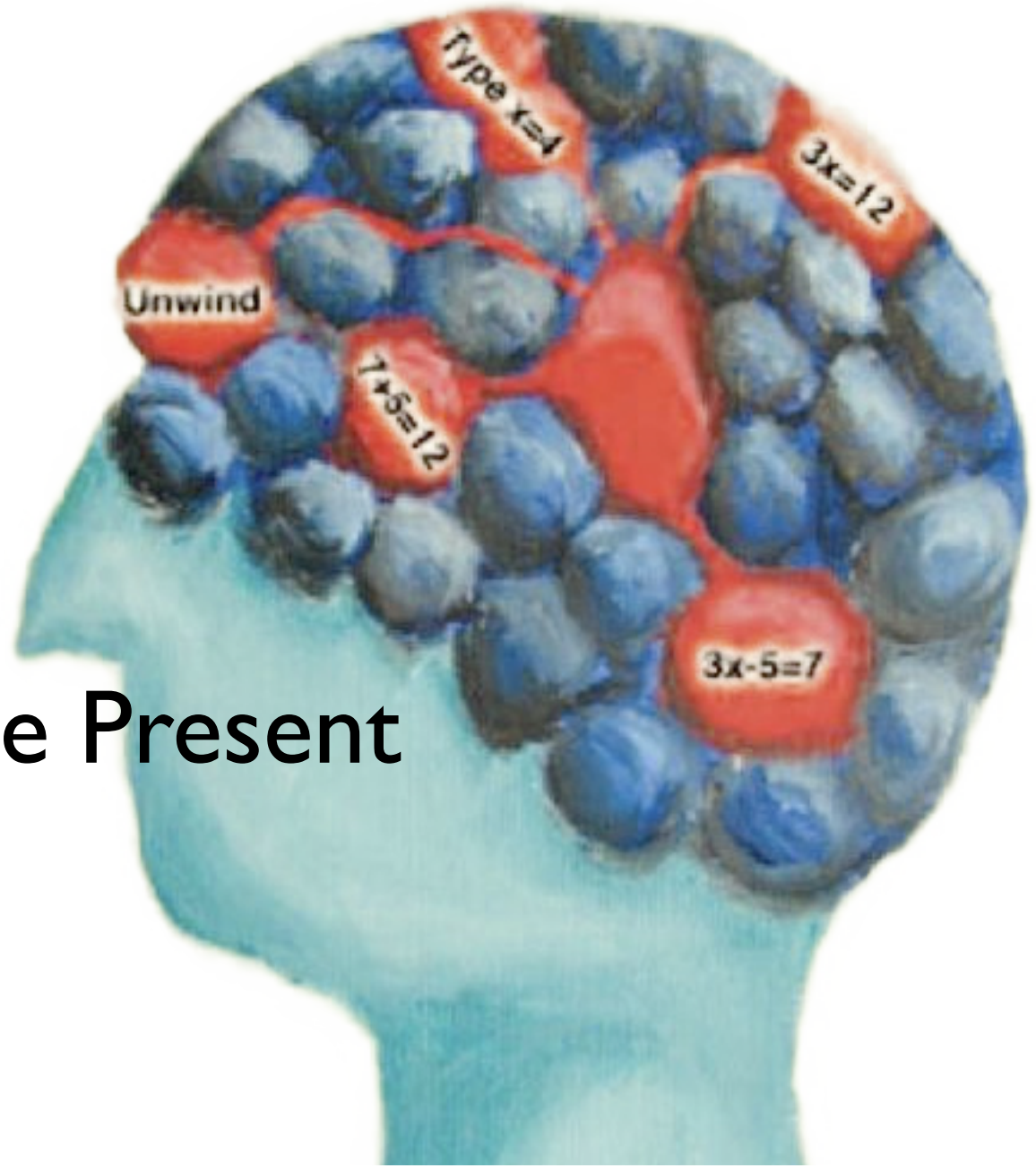


simulates cognition

cognition

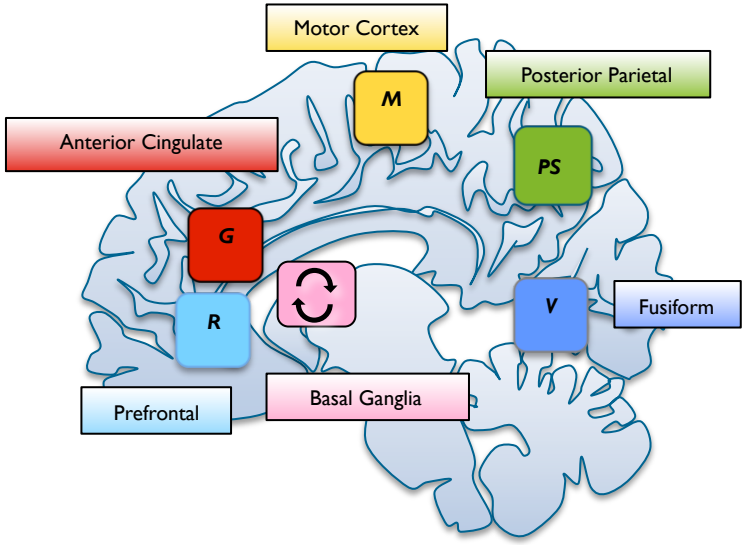
implements cognition

The Present

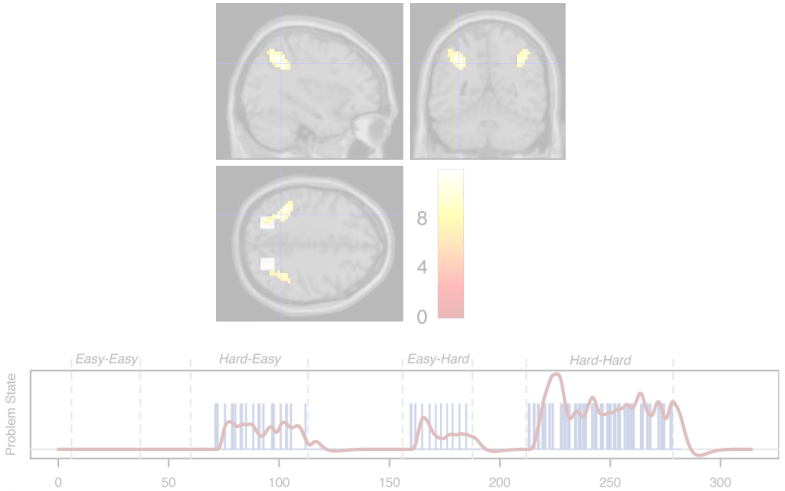


State-of-the-Art

Confirmatory: ROI Analysis

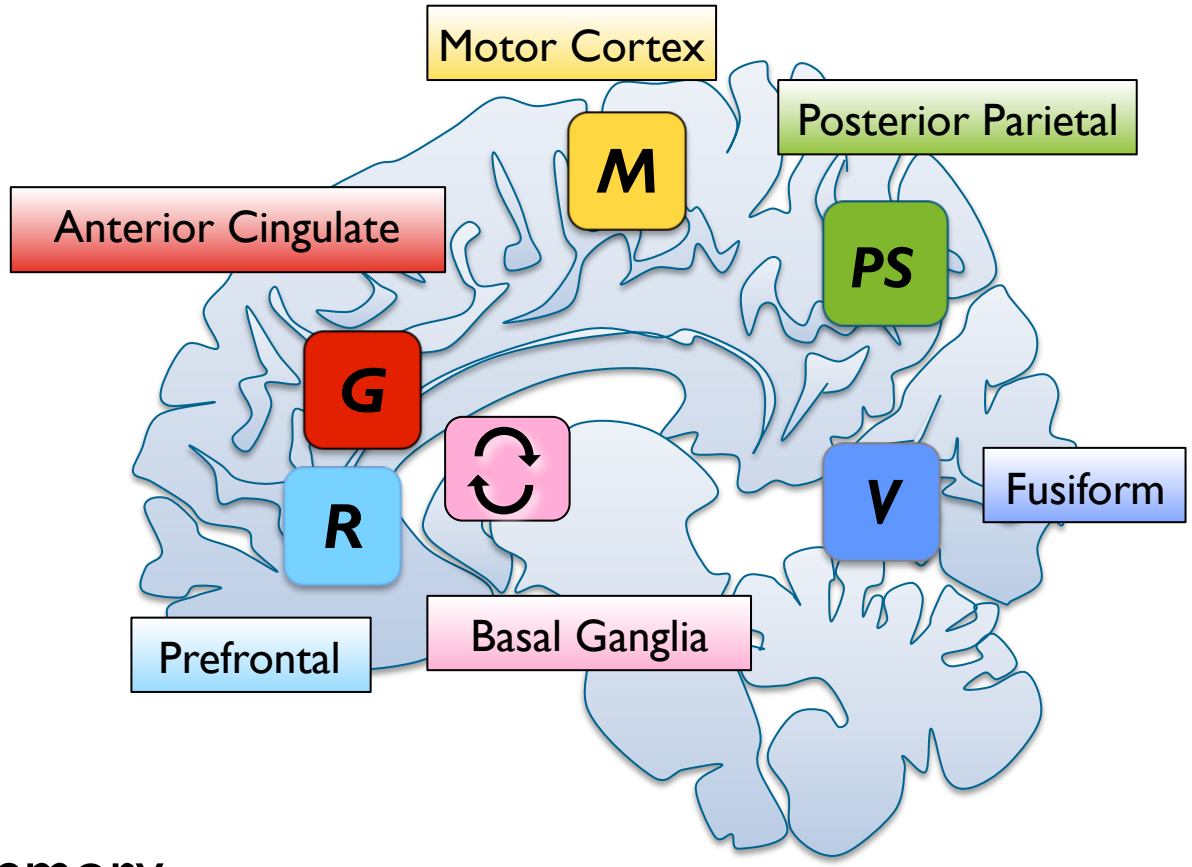


Exploratory: Model-Based Analysis



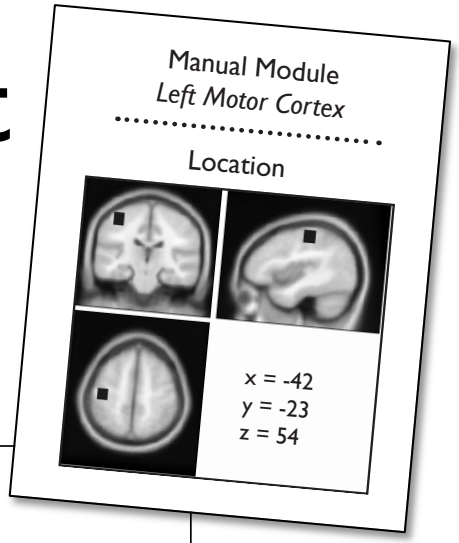
Regions-of-Interest

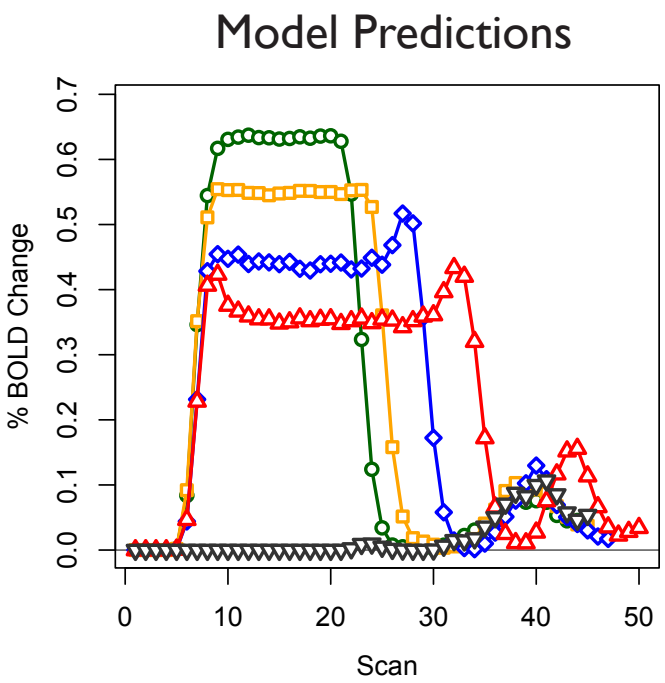
- **G** Goal
- **M** Manual
- **V** Visual
- **PS** Problem State
- **R** Declarative Memory
- Procedural Memory

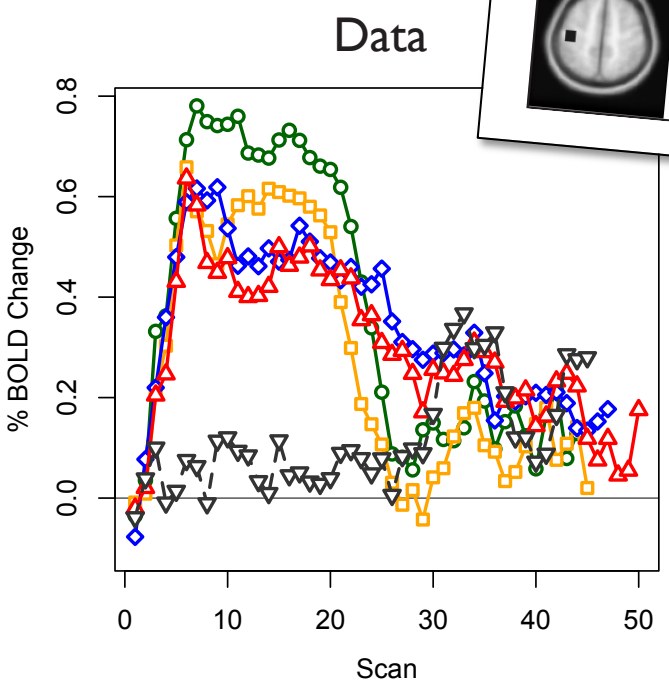


courtesy of Andrea Stocco

Regions-of-Interest







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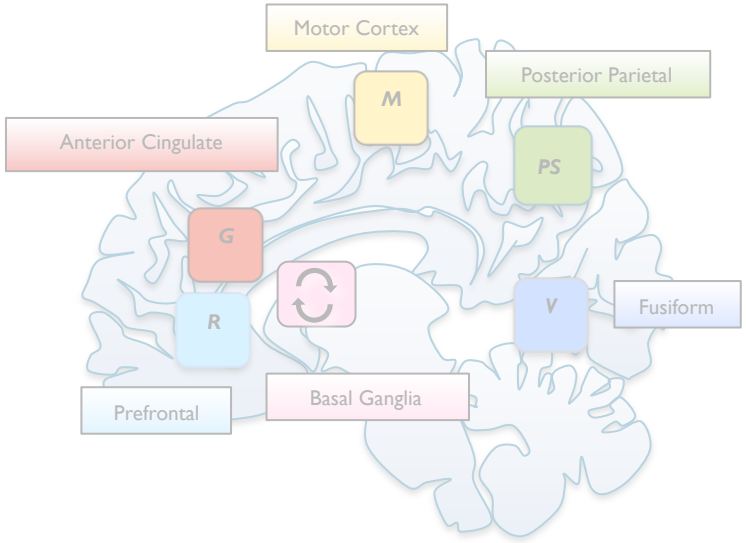
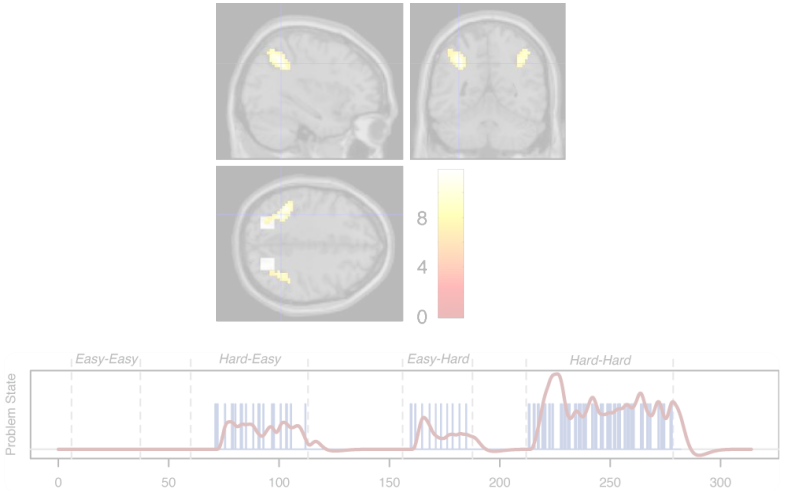
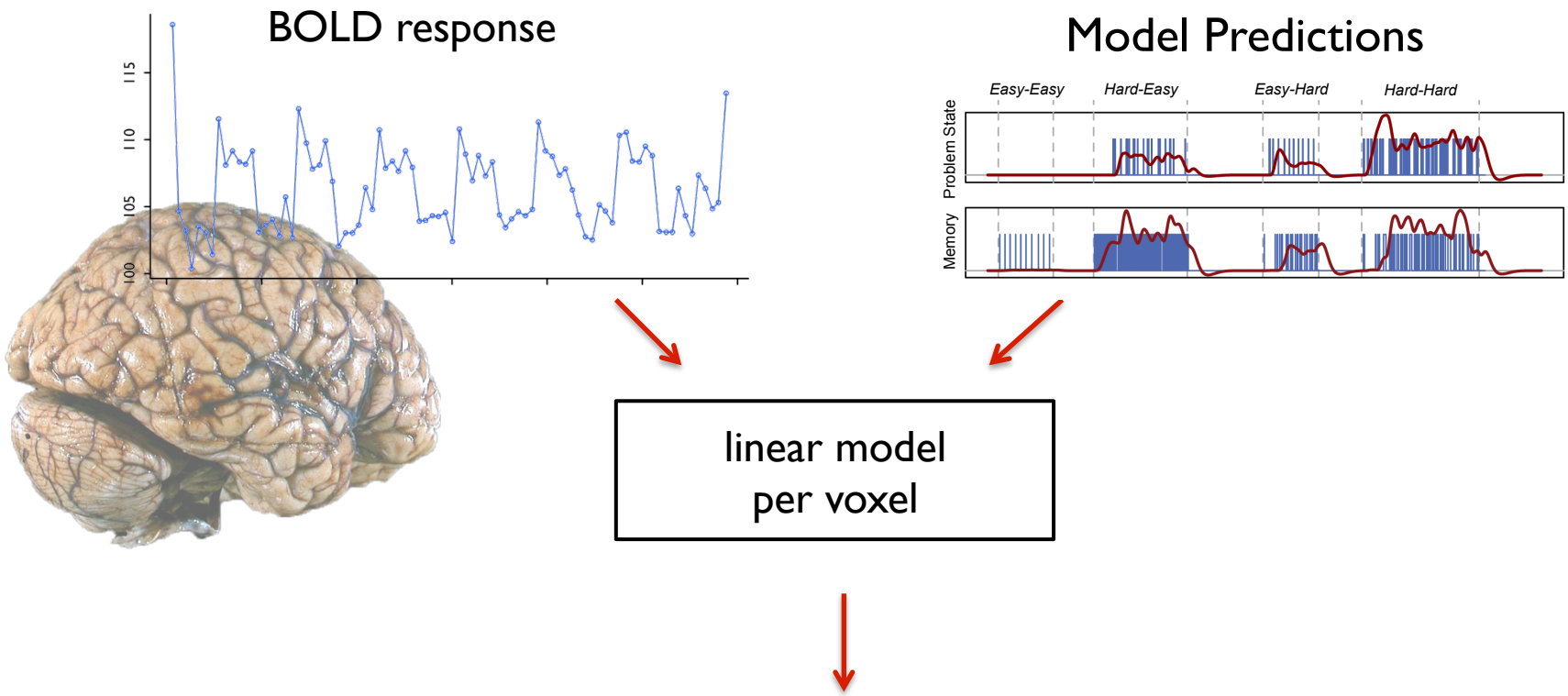


Exploratory: Model-Based Analysis

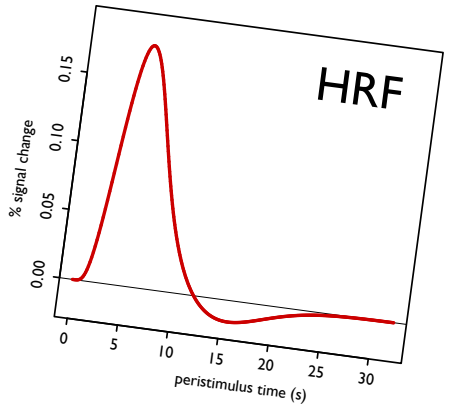


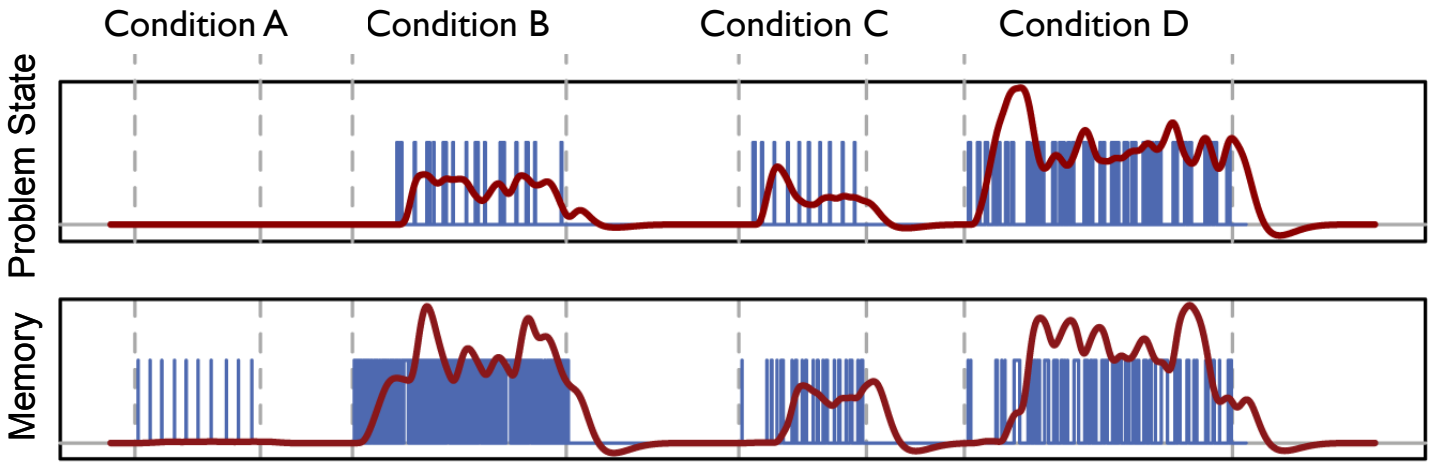
Model-Based fMRI Analysis



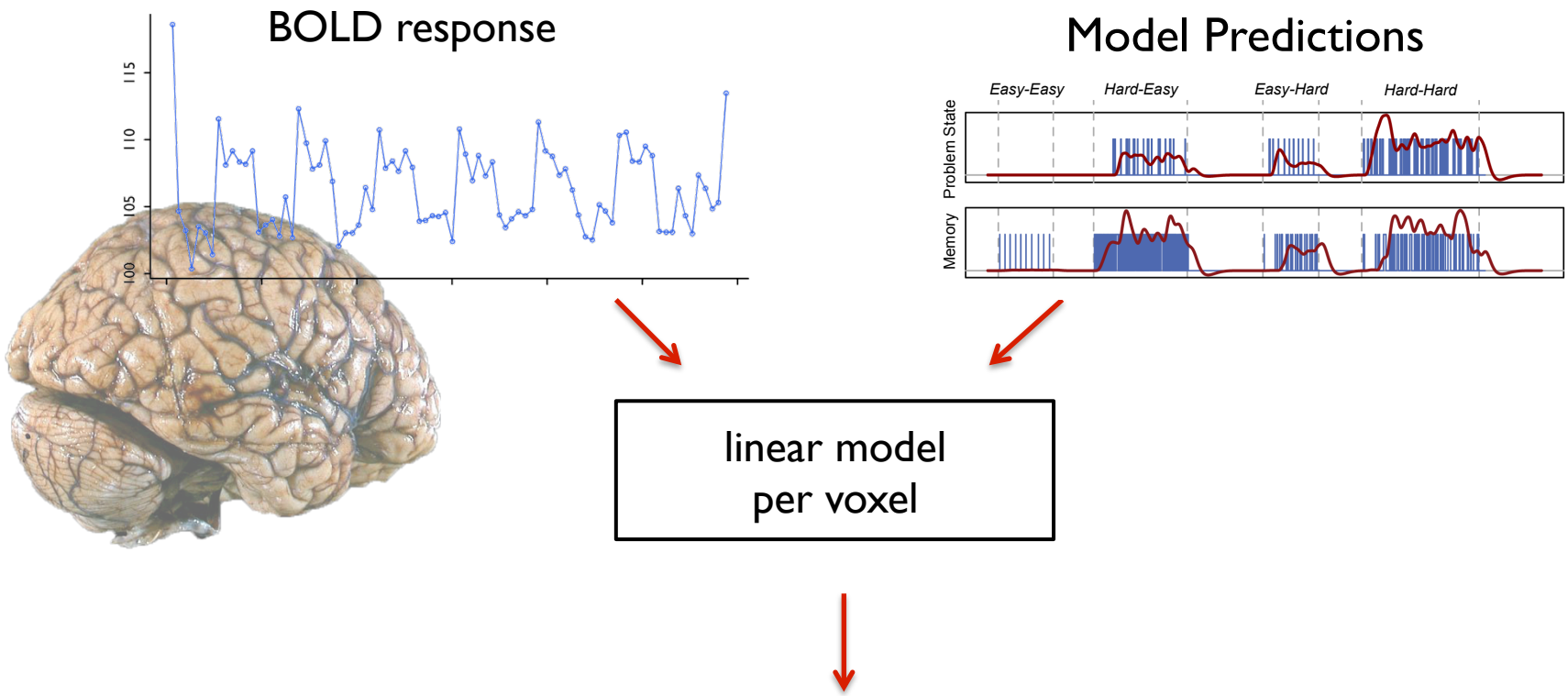
which voxels correspond to the model predictions?

Model Predictions



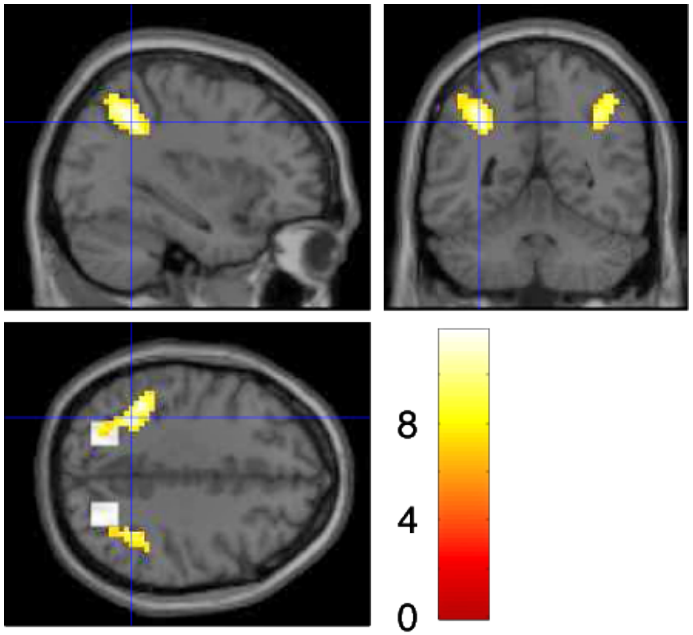


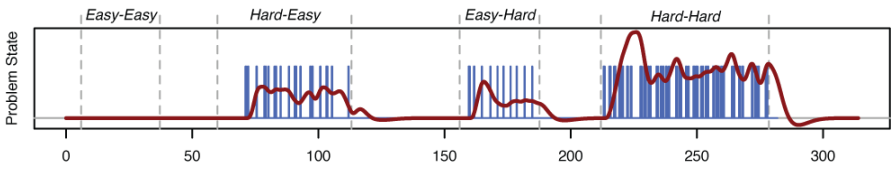
Model-Based fMRI Analysis



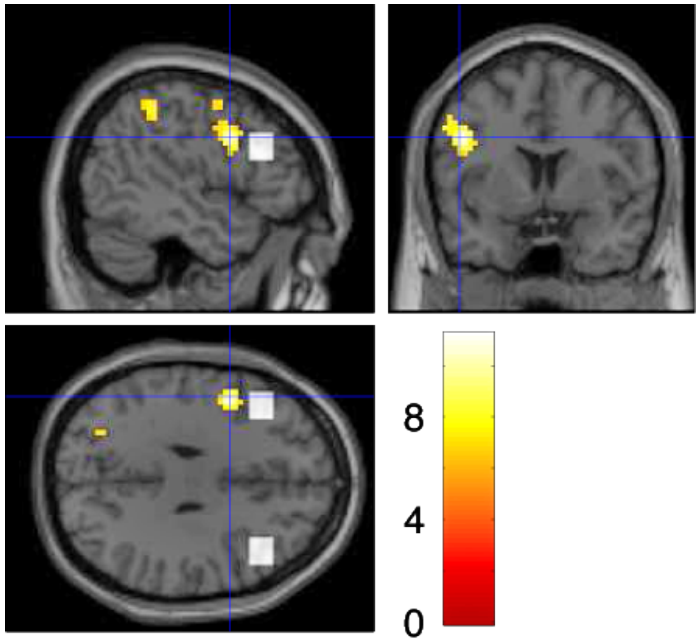
which voxels correspond to the model predictions?

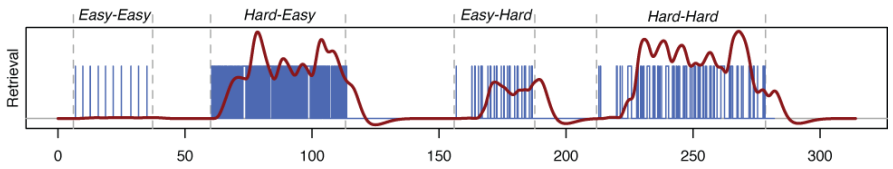
Problem State/ Imaginal





Declarative Memory

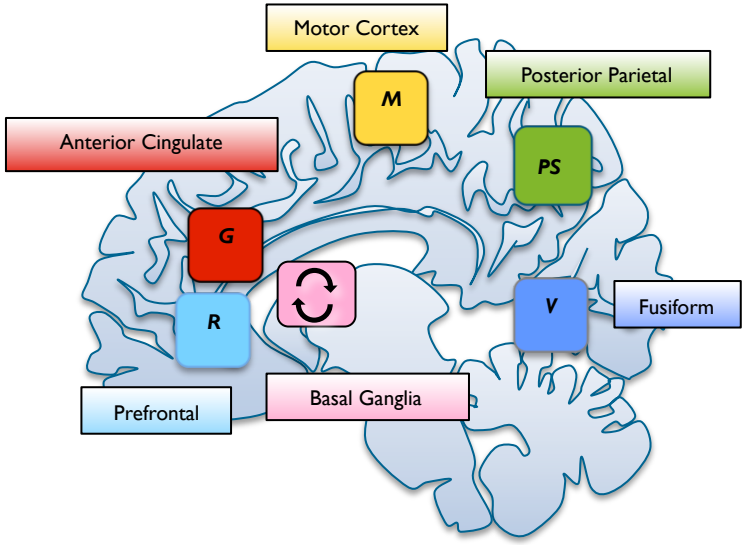




(Borst et al., 2011, *NeuroImage*)

State-of-the-Art

Confirmatory: ROI Analysis



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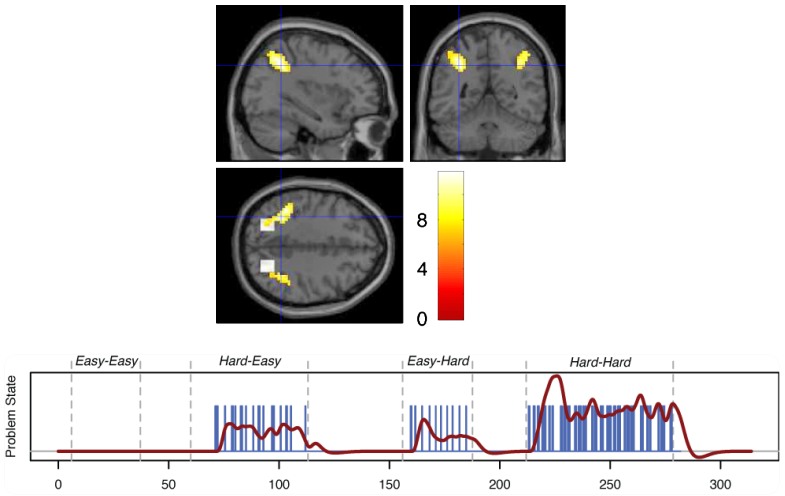
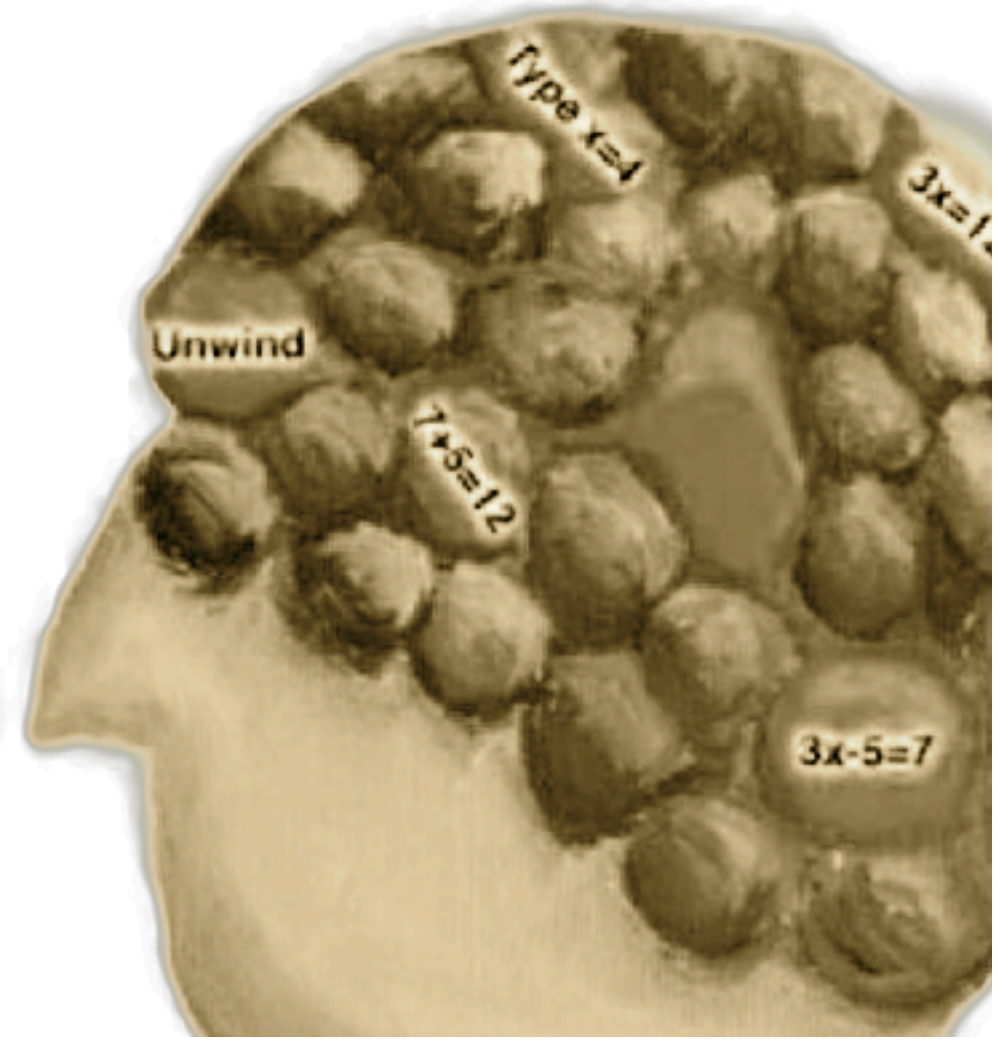
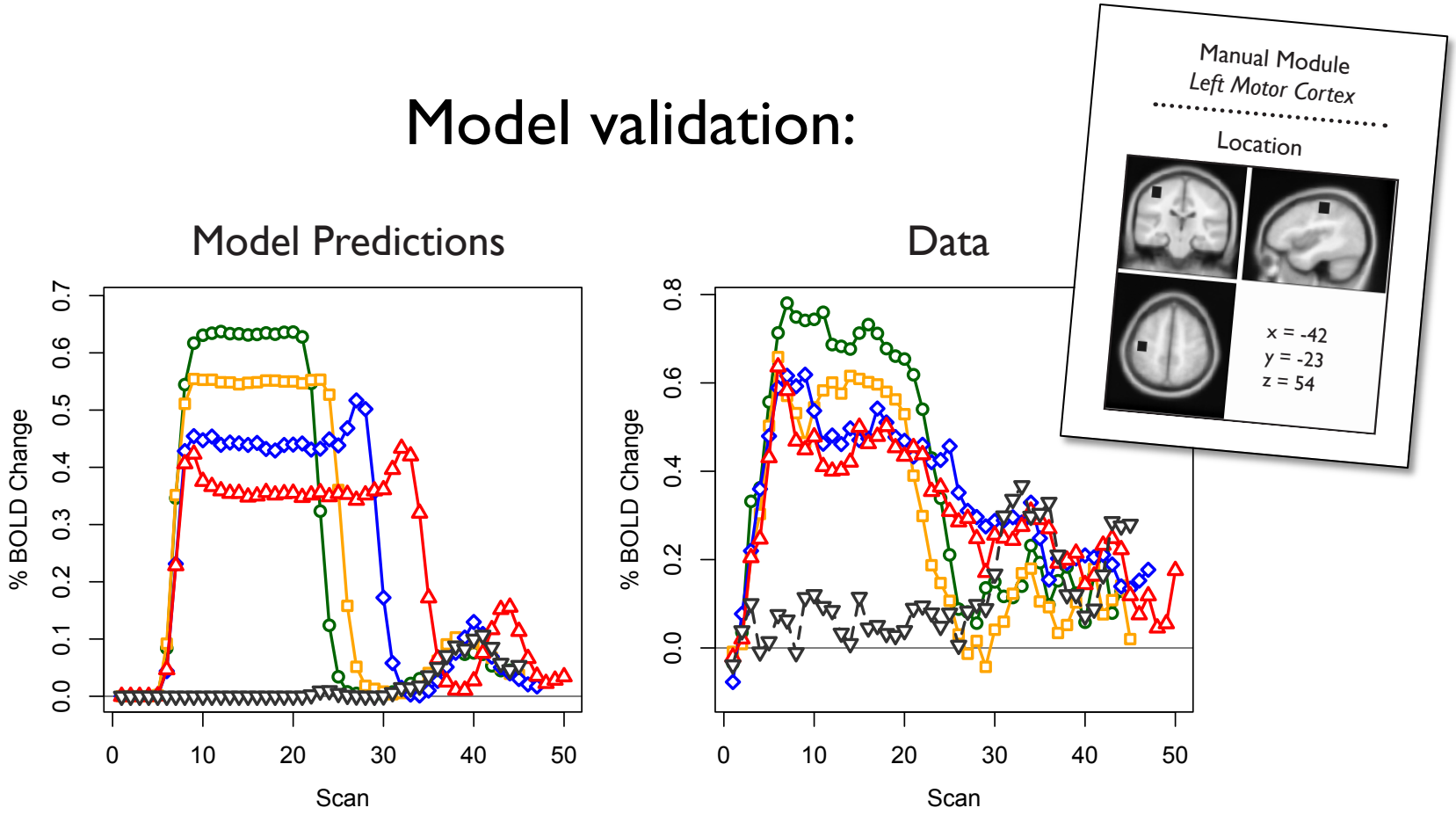


The Past



What did neuroscience give ACT-R?

Model validation:



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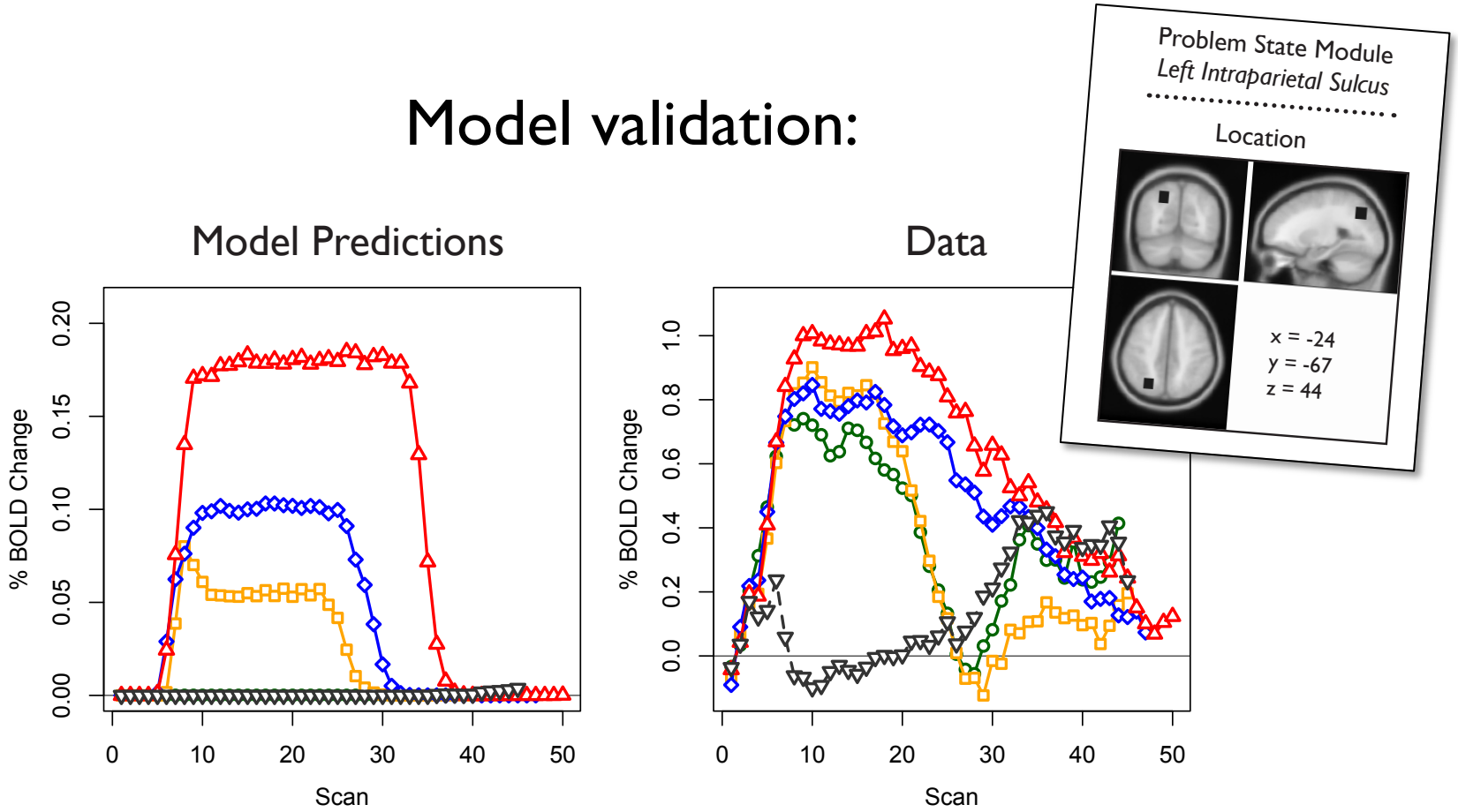

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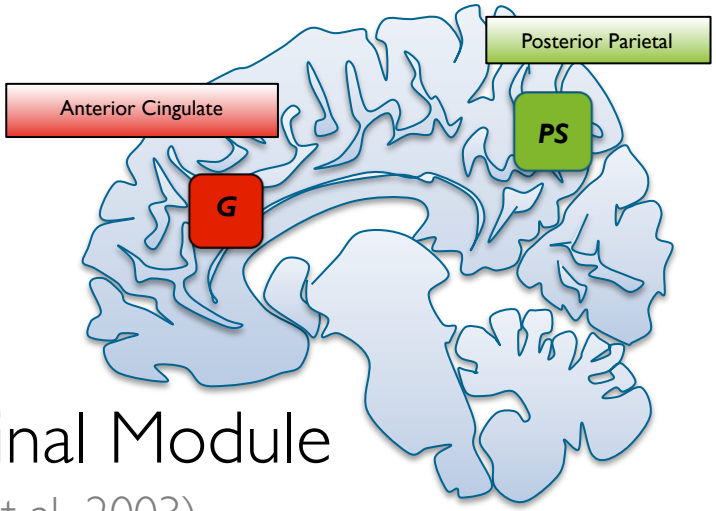
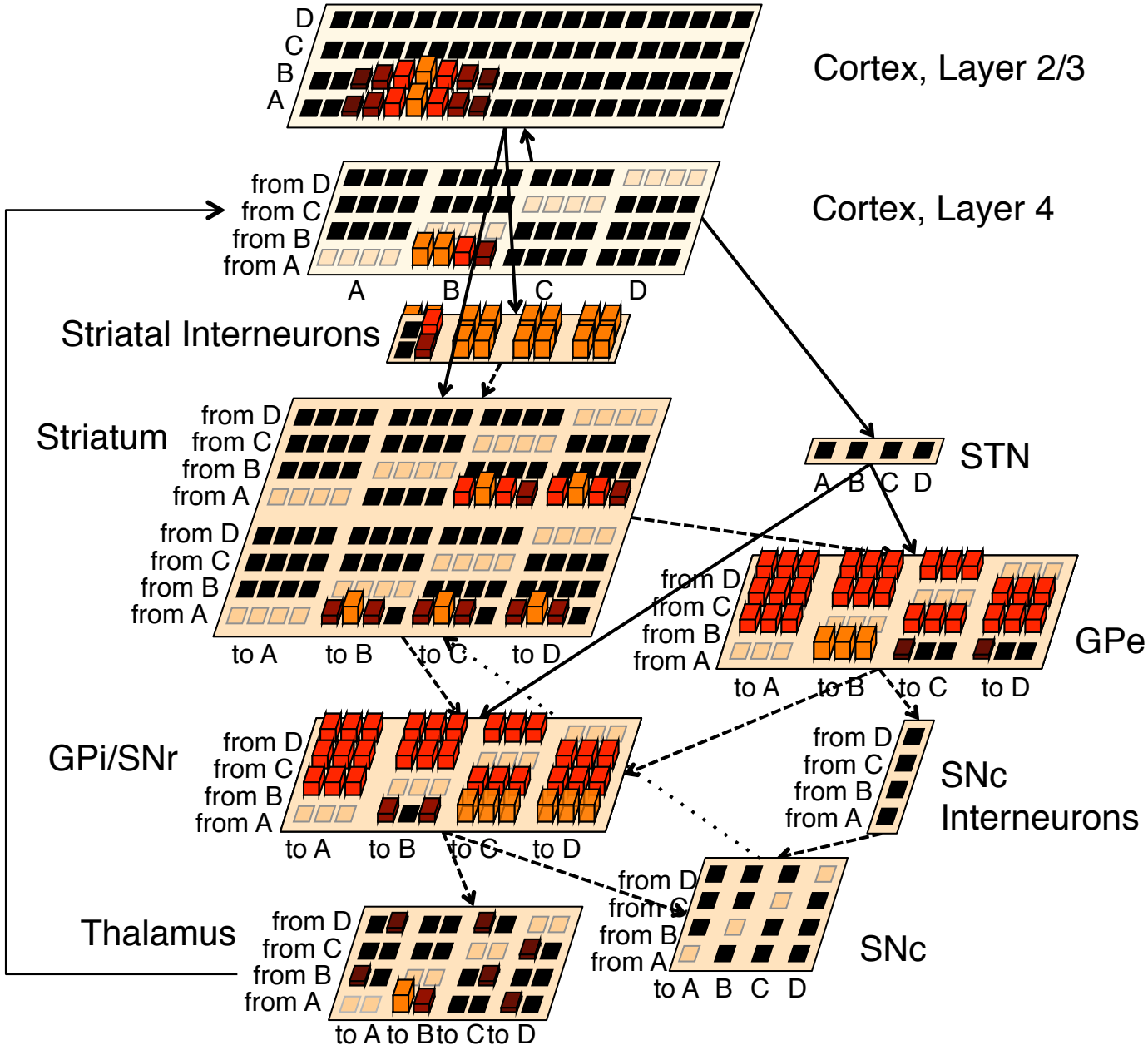


- Model validation
- New constraints:
  - Separate Problem State/Imaginal Module
    (Anderson et al., 2004, Cogn. Neurosci.; Qin et al., 2003)
  - Andrea Stocco's Basal Ganglia model:
    Limit on number of variable bindings in procedural module

Andrea's Model



Stocco, Lebiere, & Anderson, 2010, *Psych. Review*

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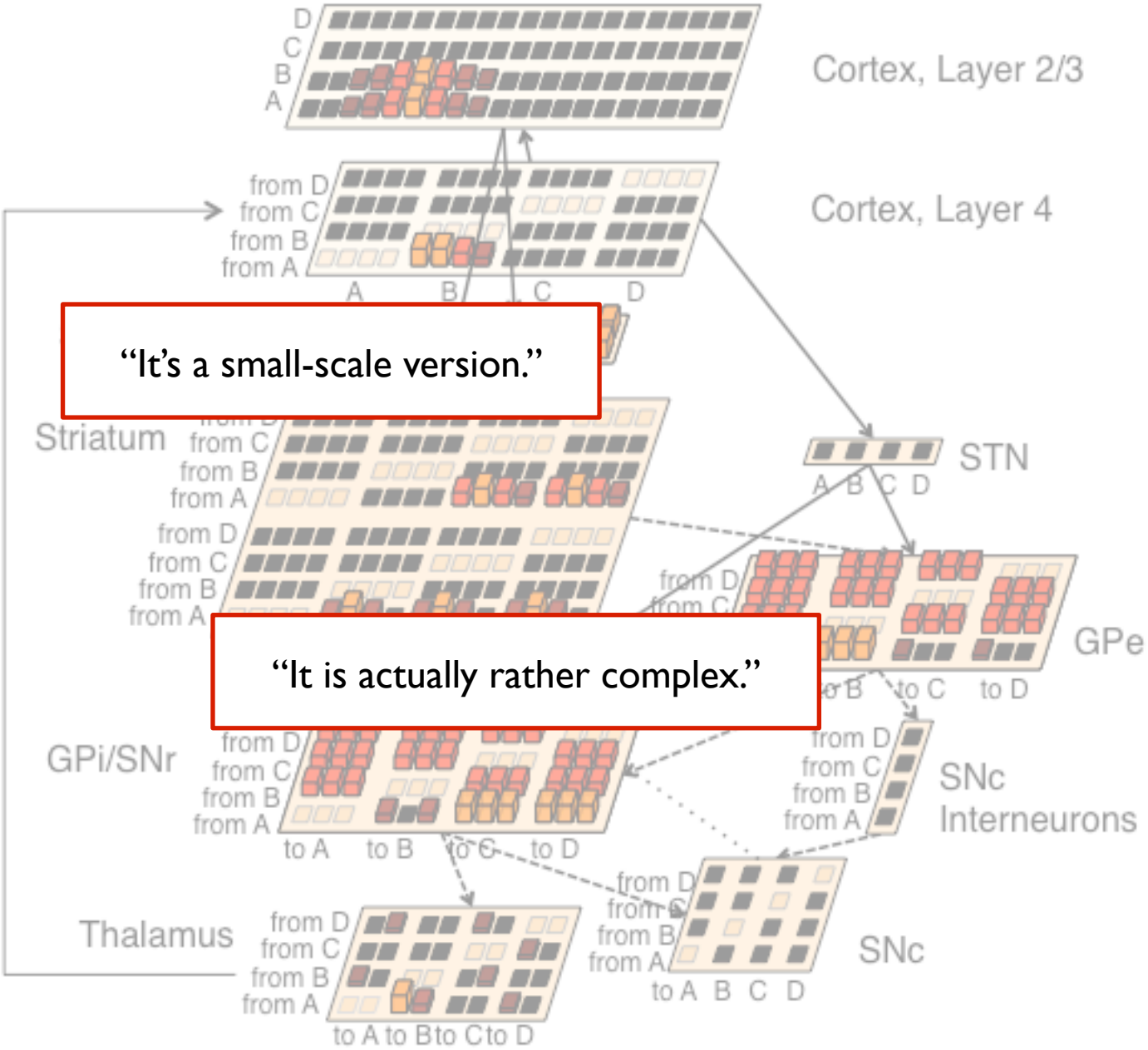

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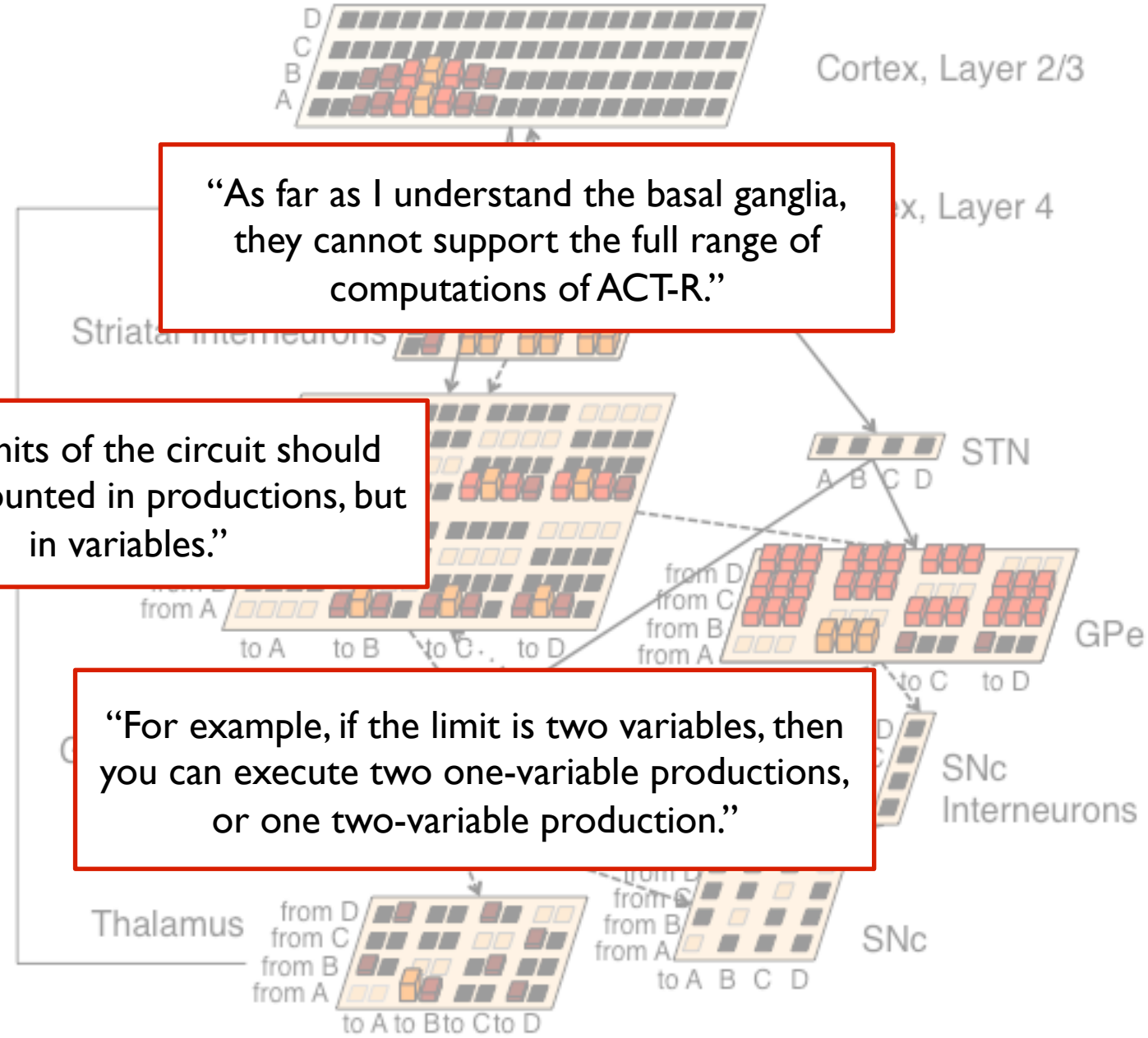

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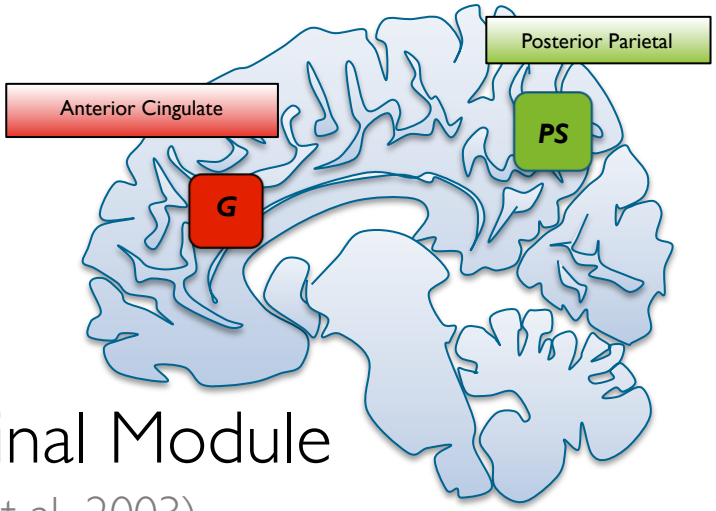

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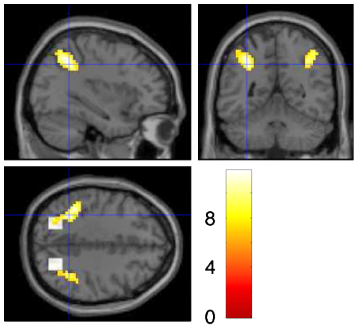
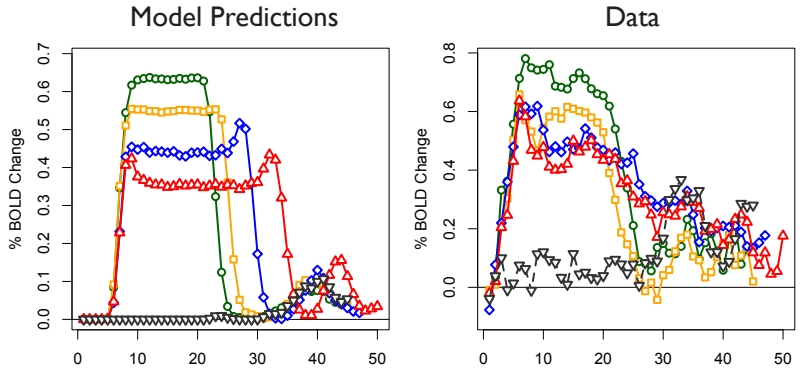
What did ACT-R give neuroscience?

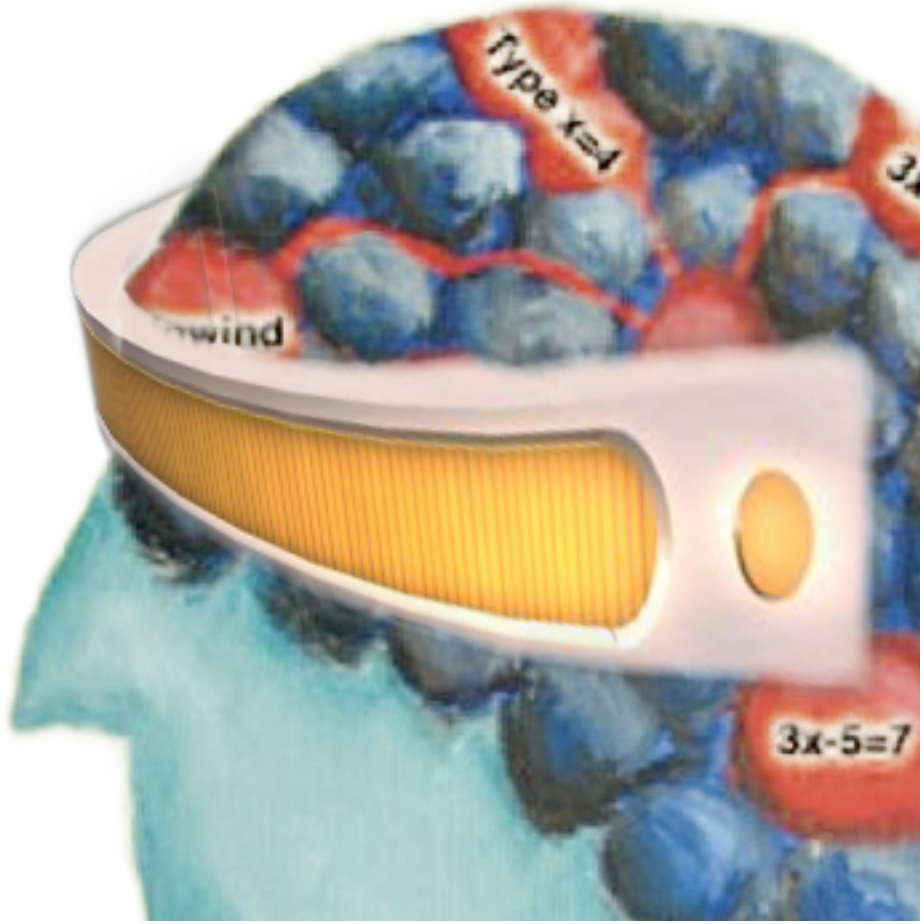
> "If the mind happens in space at all,
> it happens somewhere north of the neck."
> (Fodor, 1999)

- Functional interpretation of fMRI data (model-based)
- Explaining complex fMRI data (ROI)





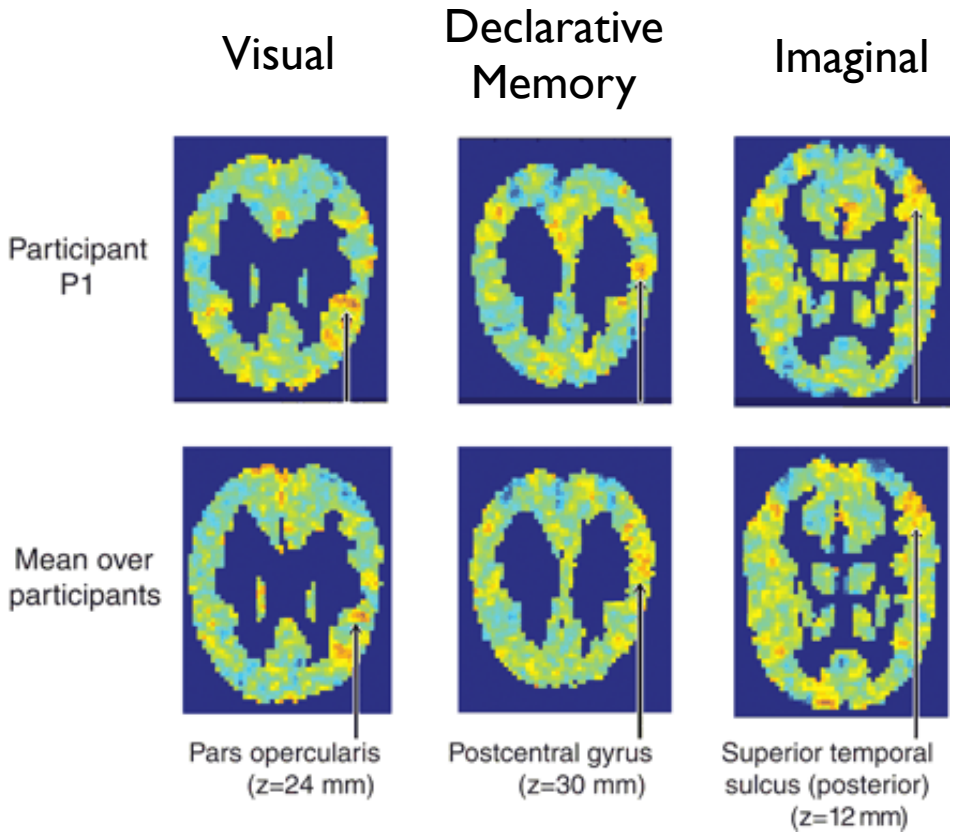
The Future



How to improve neuroscience for ACT-R?

- Model-based multi-voxel pattern analysis, 'mind-reading'

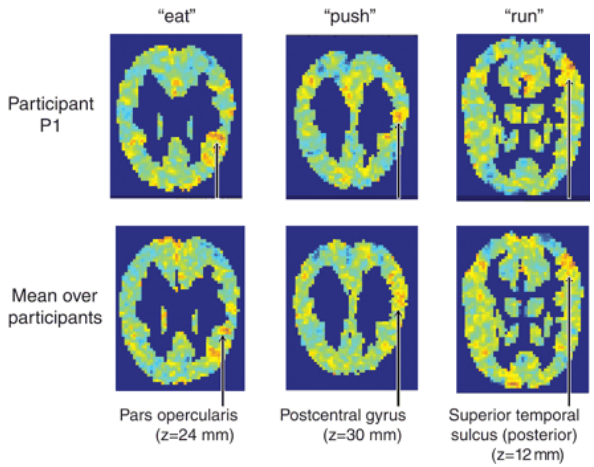
Multi-Voxel Pattern Analysis



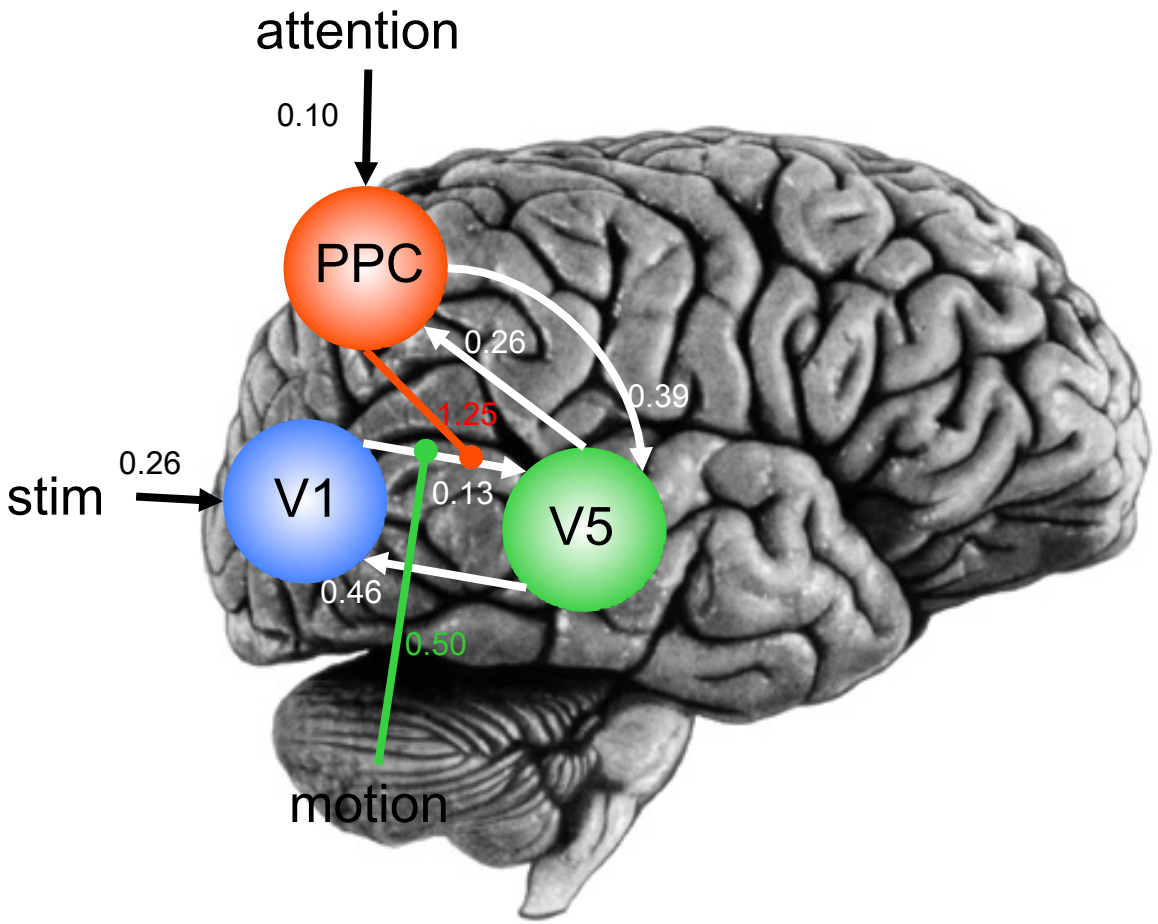
Mitchell, et al., 2008, *Science*

How to improve neuroscience for ACT-R?

- Model-based multi-voxel pattern analysis, 'mind-reading'
- Dynamic Causal Modeling (DCM)



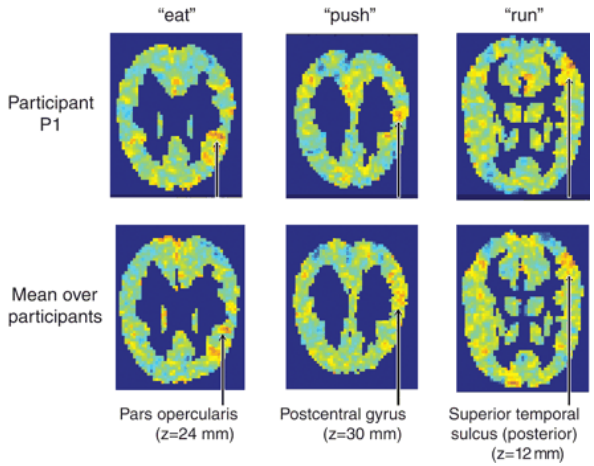
Dynamic Causal Modeling

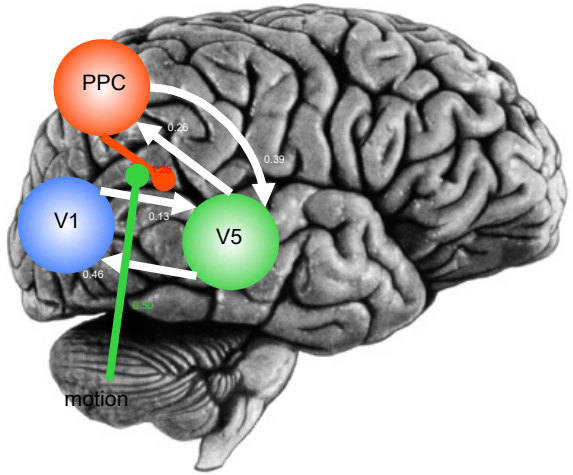


Stephan et al. 2008, *NeuroImage*

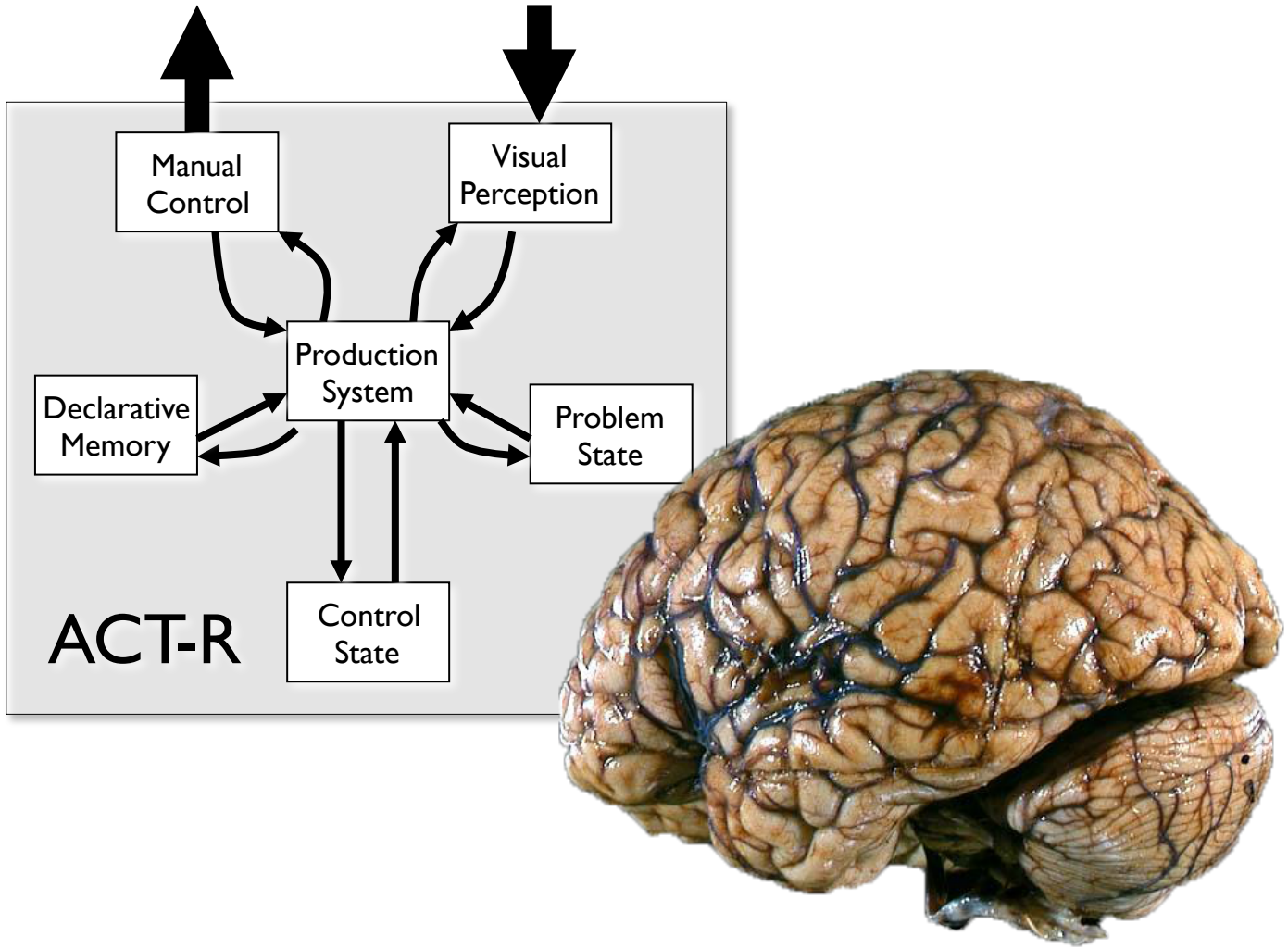
How to improve neuroscience for ACT-R?

- Model-based multi-voxel pattern analysis, 'mind-reading'
- Dynamic Causal Modeling (DCM)
- EEG/MEG?
- Other techniques?

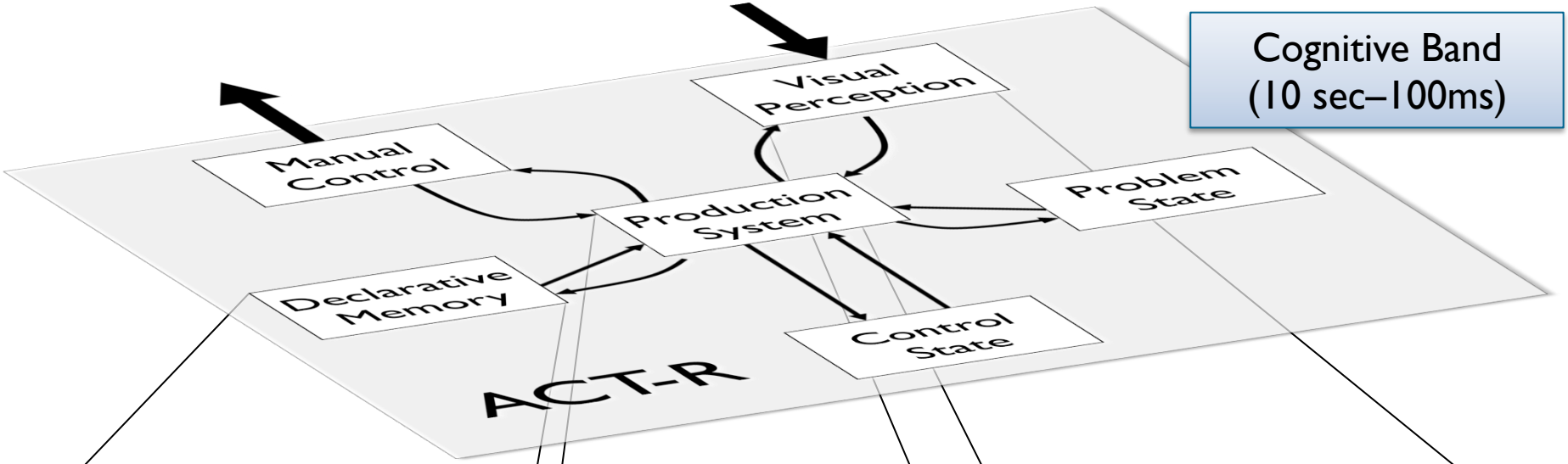




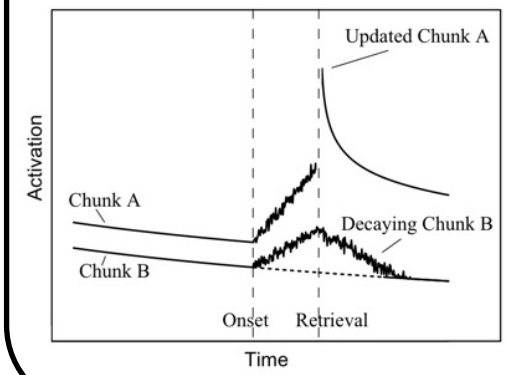
How to improve ACT-R for neuroscience?



Cognitive Band
(10 sec–100ms)



RACE/A



Van Maanen et al., in press, *Cogn Sci*

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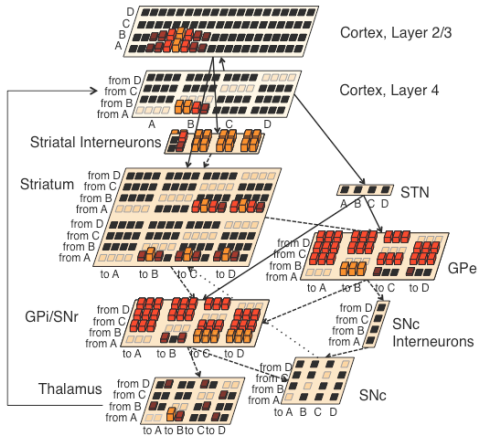
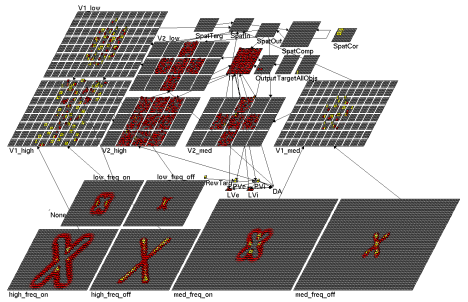


Stocco et al., 2010, *Psych Rev*

Leabra/SAL

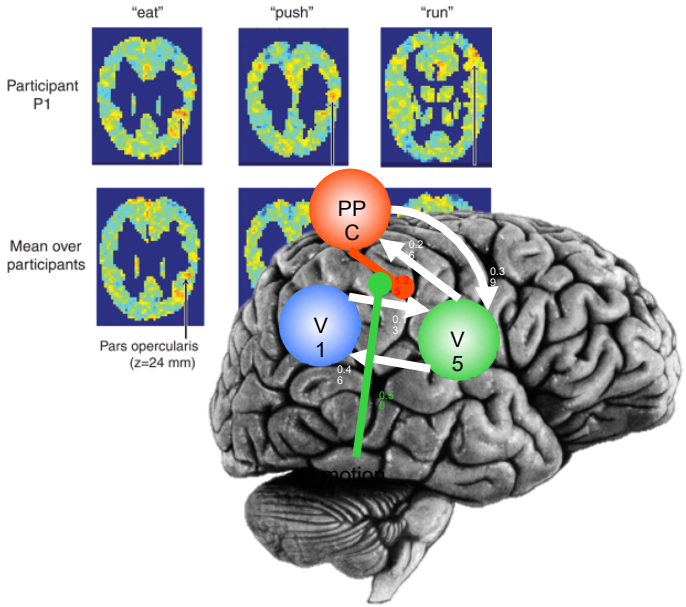


Jilk et al., 2008, *J Exp Theor AI*

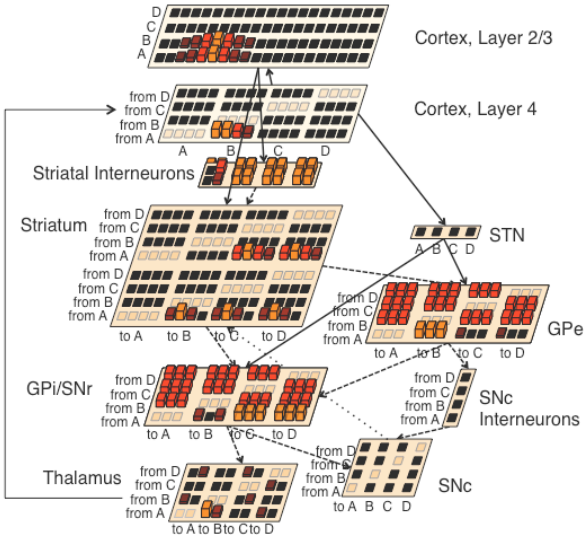
Biological Band
(10 ms–100µs)

Conclusions

More powerful neuroscience methods



Multi-level ACT-R modules



Thanks!