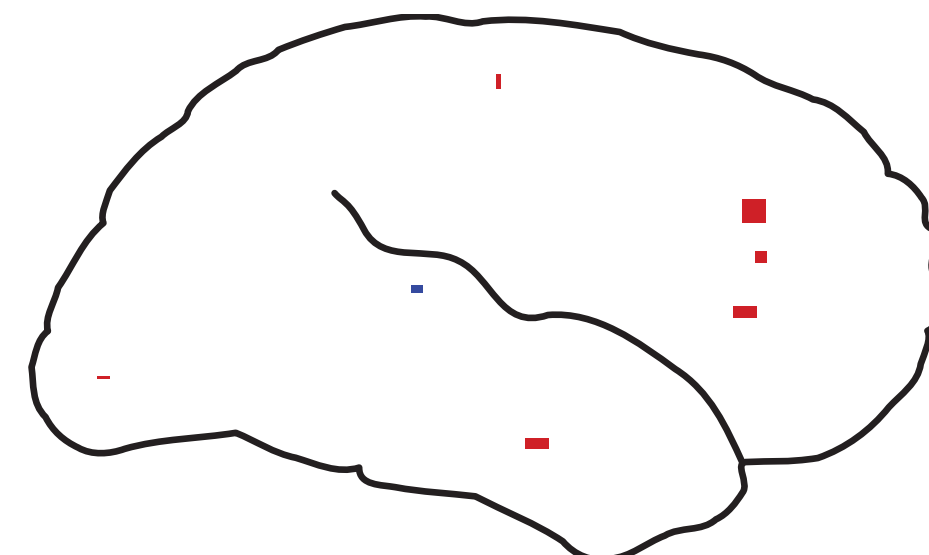


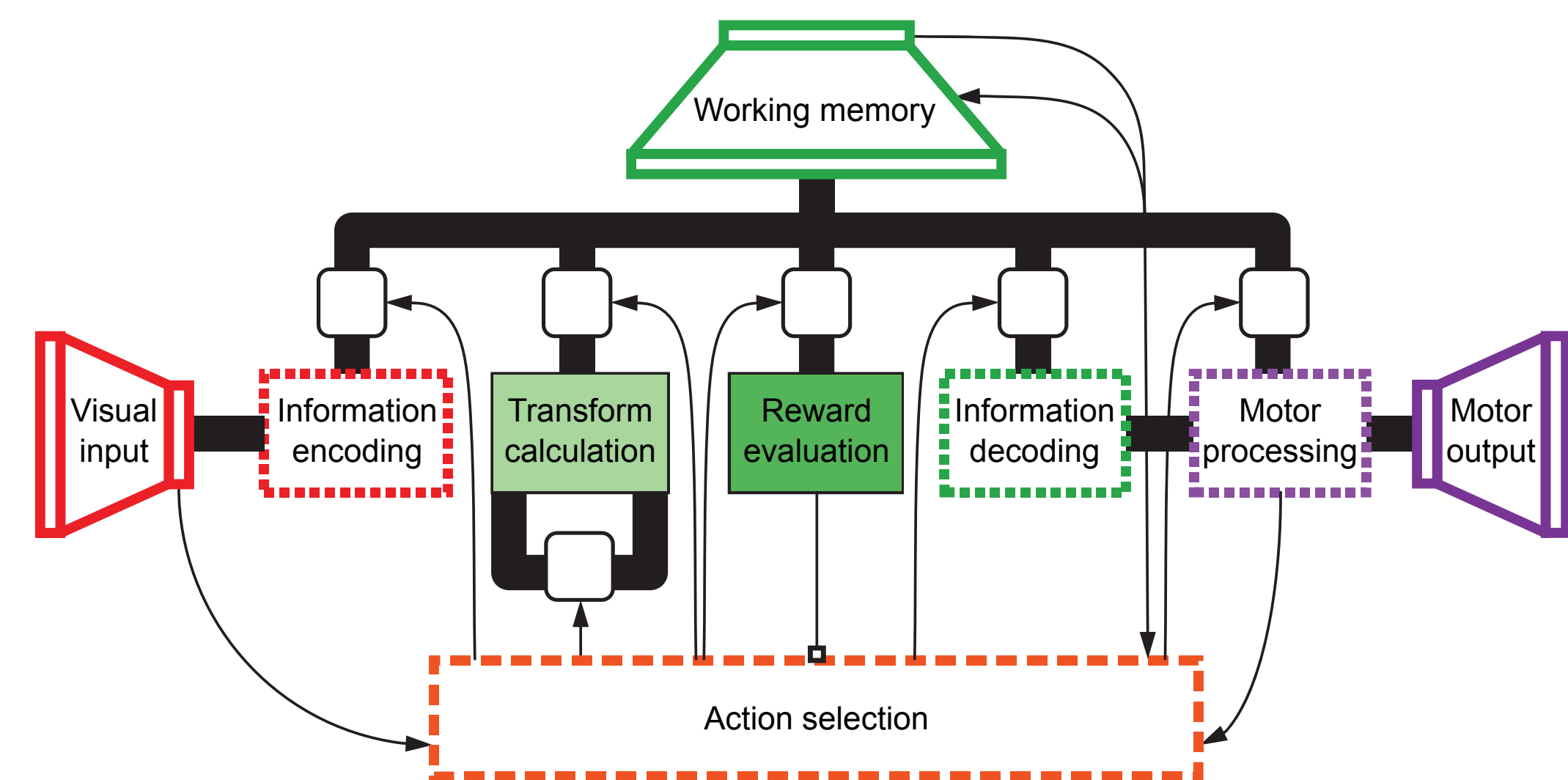
Spaun: A Large-Scale Model of the Functioning Brain

Trevor Bekolay, Terrence C. Stewart, Xuan Choo, Travis DeWolf, Yichuan Tang, Daniel Rasmussen, Chris Eliasmith

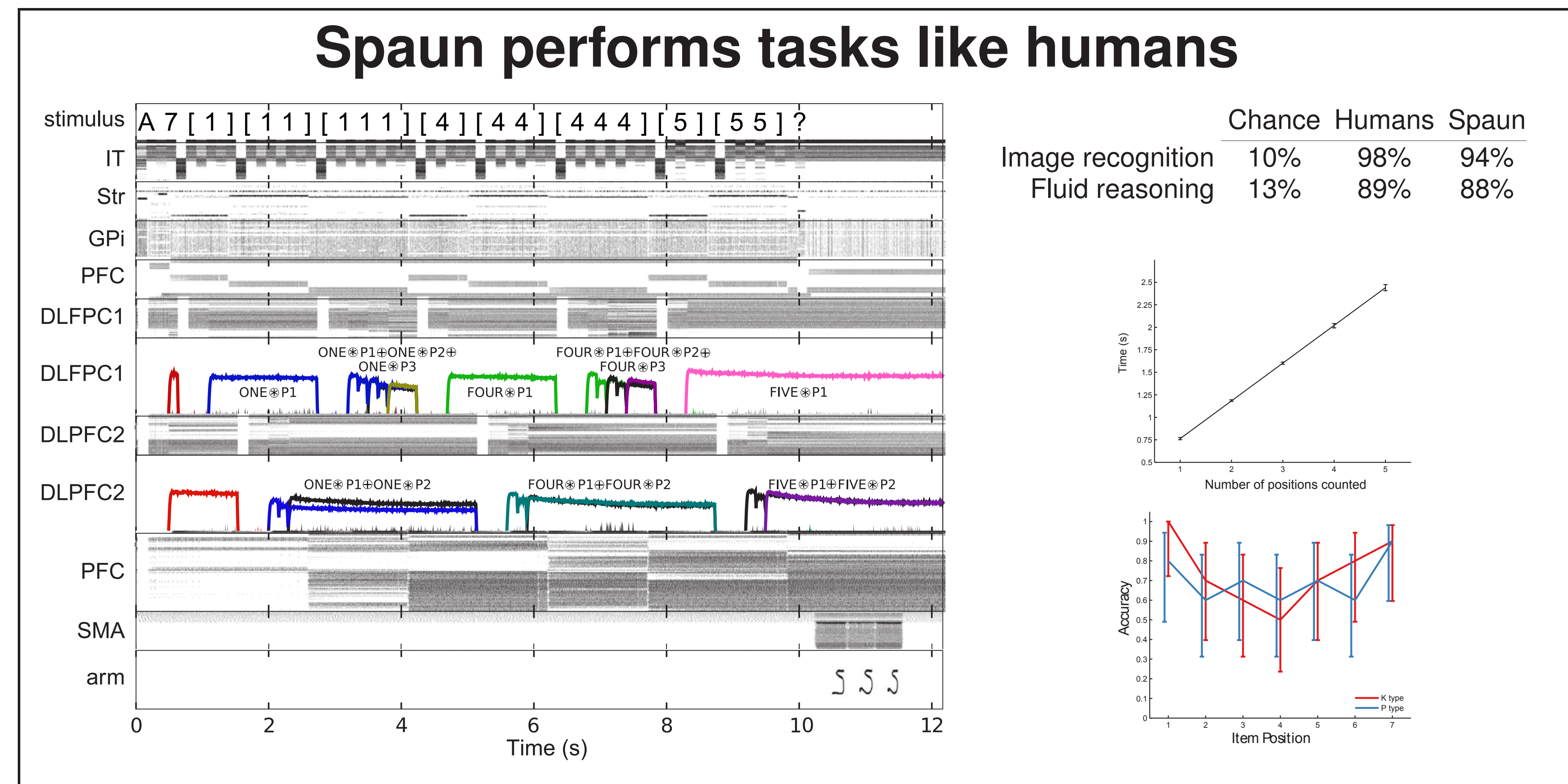
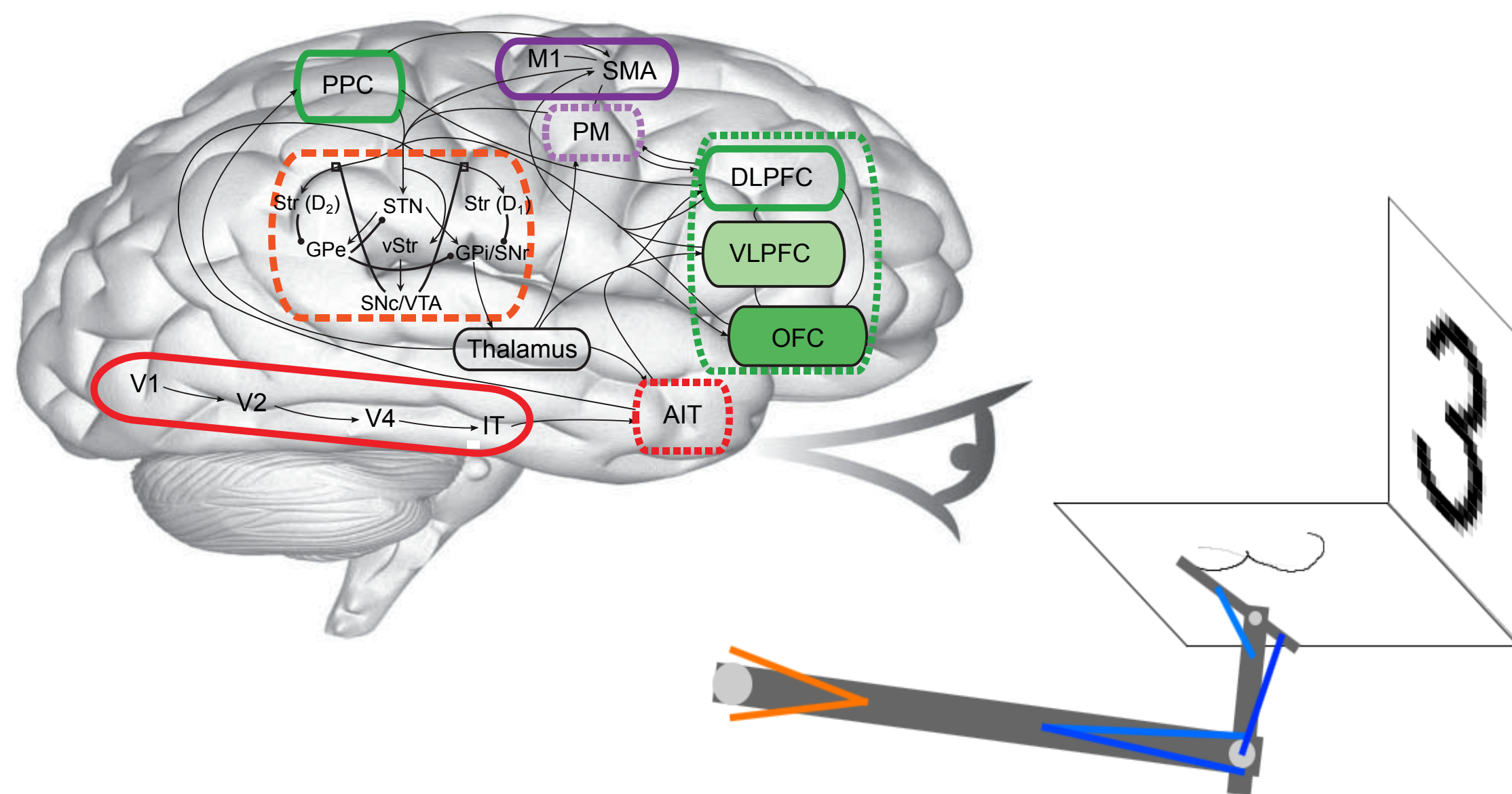
The Semantic Pointer Architecture Unified Network (Spaun) is a network of **2,500,000 interconnected artificial spiking neurons**. This is tiny compared to the human brain's 100 billion.



Spaun is composed of groups of neurons that perform functions necessary to complete cognitive tasks. It **flexibly coordinates** those groups depending on the cognitive task being performed.



These functionally related groups of neurons are mapped onto brain areas according to neuroscientific research. Spaun can be manipulated in order to **test hypotheses in neuroscience**.



Tasks that Spaun performs

Spaun's vocabulary includes the numbers 0 to 9, and the characters A, P, K, [,], and ?. We ask Spaun to perform a task by showing it a series of images containing those characters.

Copy drawing: "Copy this 2."

A 0 [2] ? ⇒ 2

Image recognition: "Write a 2."

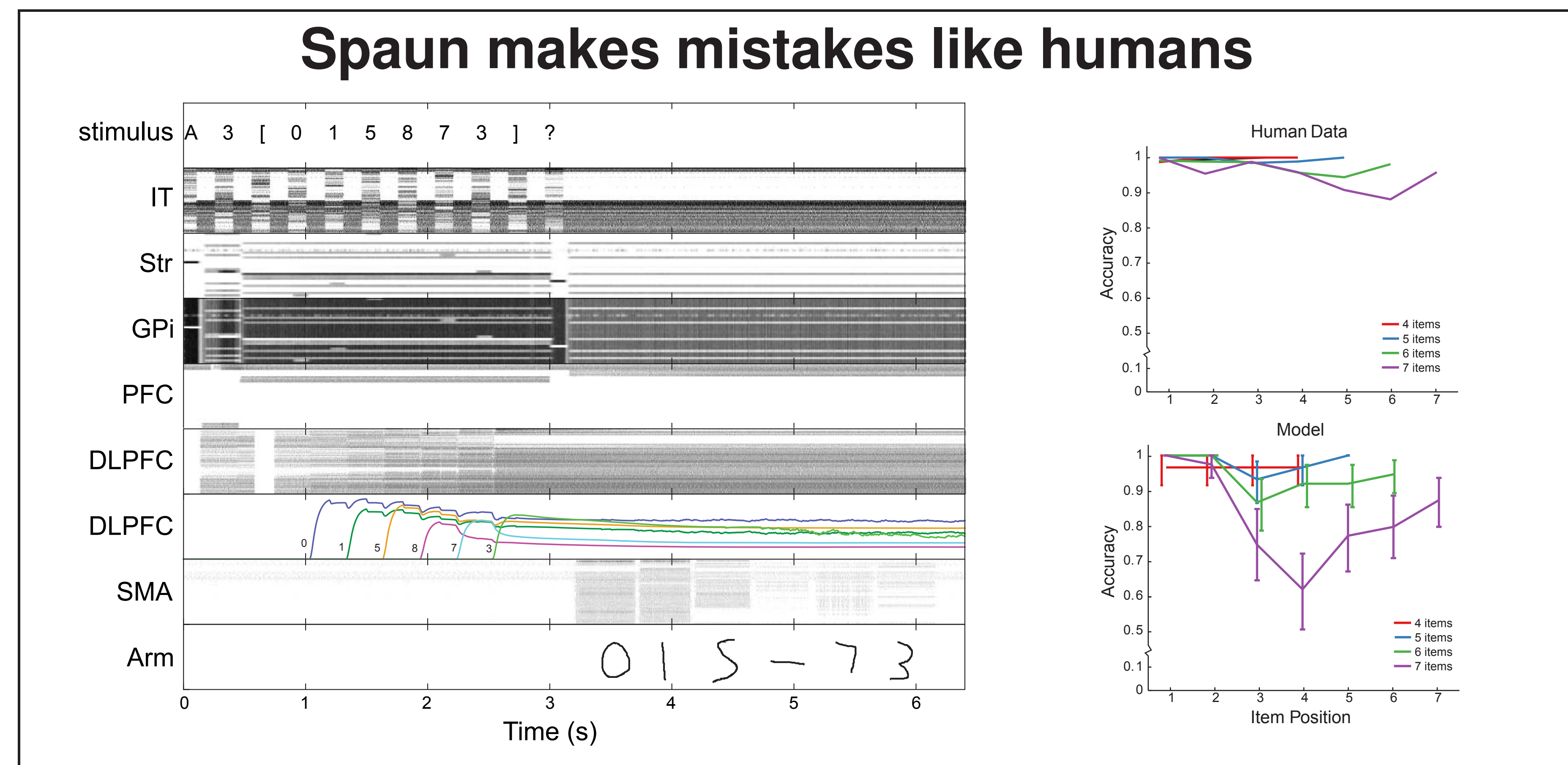
A 1 [2] ? ⇒ 2

Gambling: "Try slot machine 0, 1 or 2."

A 2 ? ⇒ 0 ⇒ 0

A 2 ? ⇒ 1 ⇒ 1

A 2 ? ⇒ 1 ⇒ 1



List memory: "Write the list 0 1 5 8 7 3."

A 3 [0 1 5 8 7 3] ?

⇒ 0 1 5 8 7 3

Counting: "Starting from 3, count 5."

A 4 [3] [5] ? ⇒ 8

Question answering: "Write the 2nd number in 0 1 5 8 7 3."

A 5 [0 1 5 8 7 3] [P] [2] ? ⇒ 1

Rapid variable creation:
"Complete the pattern: 0014→14, 0094→94, 0074..."

A 6 [0 0 1 4] [1 4]

[0 0 9 4] [9 4]

[0 0 7 4] ? ⇒ 7 4

Fluid reasoning "Fill in the last cell."

A 7 [1] [1 1] [1 1 1]

[4] [4 4] [4 4 4]

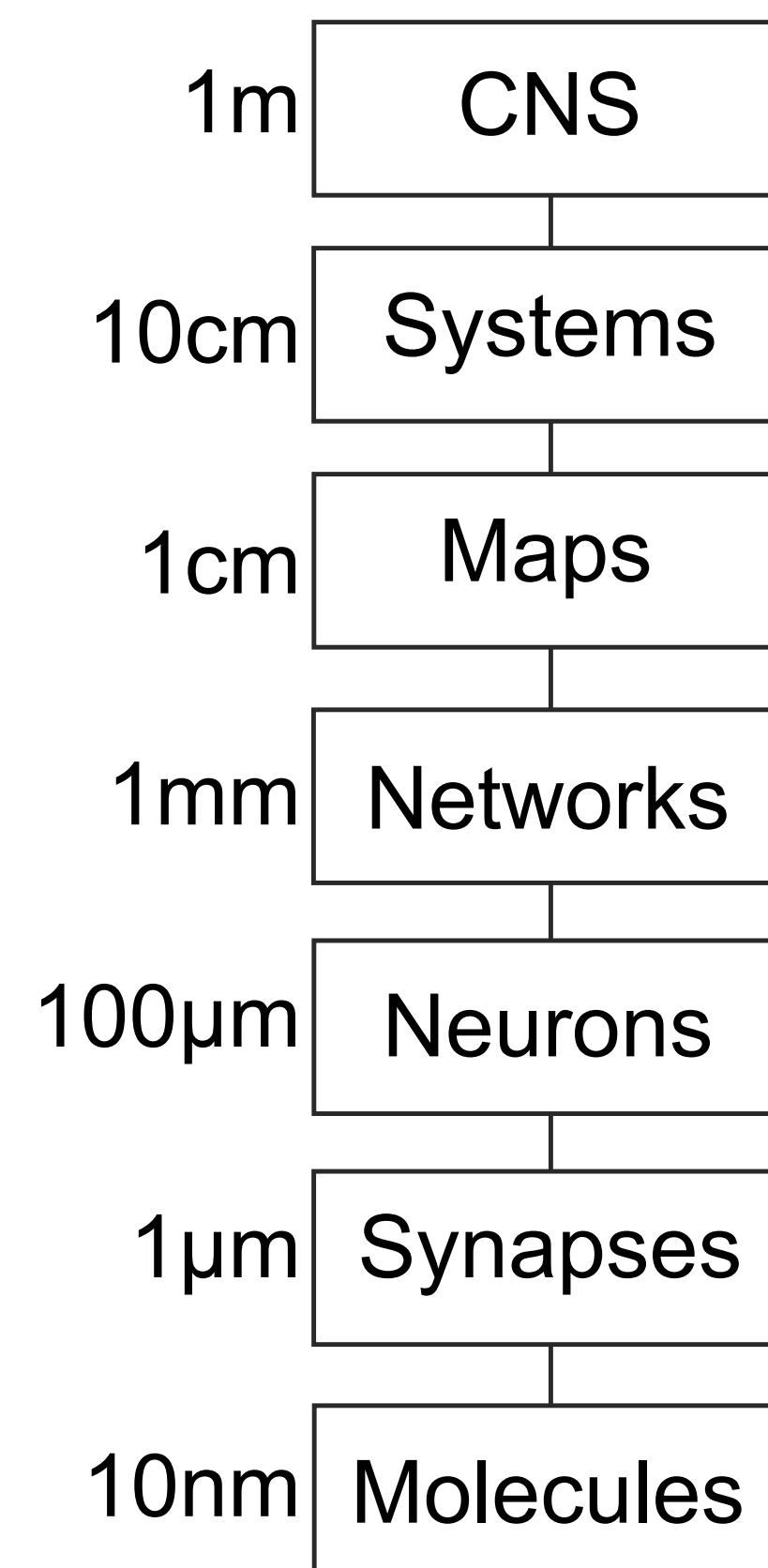
[5] [5 5] ? ⇒ 5 5 5

Chris Eliasmith, Terrence C. Stewart, Xuan Choo, Trevor Bekolay, Travis DeWolf, Yichuan Tang, and Daniel Rasmussen (2012). A large-scale model of the functioning brain. *Science*, 338:1202-1205.

Chris Eliasmith (2013). *How to build a brain: A neural architecture for biological cognition*. Oxford University Press.

View this poster online at <http://compneuro.uwaterloo.ca/files/spaun.pdf>

Theory



← Nengo modelling software

← Semantic pointer architecture

$List = Pos1 \otimes Item1 \oplus Pos2 \otimes Item2 \dots$

← Neural Engineering Framework

$$\omega_{ij} = \alpha_j \mathbf{d}_i \mathbf{e}_j$$

$$\hat{\mathbf{x}} = \sum_i \alpha_i(\mathbf{x}) \mathbf{d}_i$$

$$\alpha_i(\mathbf{x}) = G_i[\alpha_i \mathbf{e}_i \mathbf{x} + J_i^{bias}]$$

$$\frac{dV}{dt} = -\frac{1}{RC}(V(t) - J(t)R)$$

