Attention's place in the human cognitive architecture

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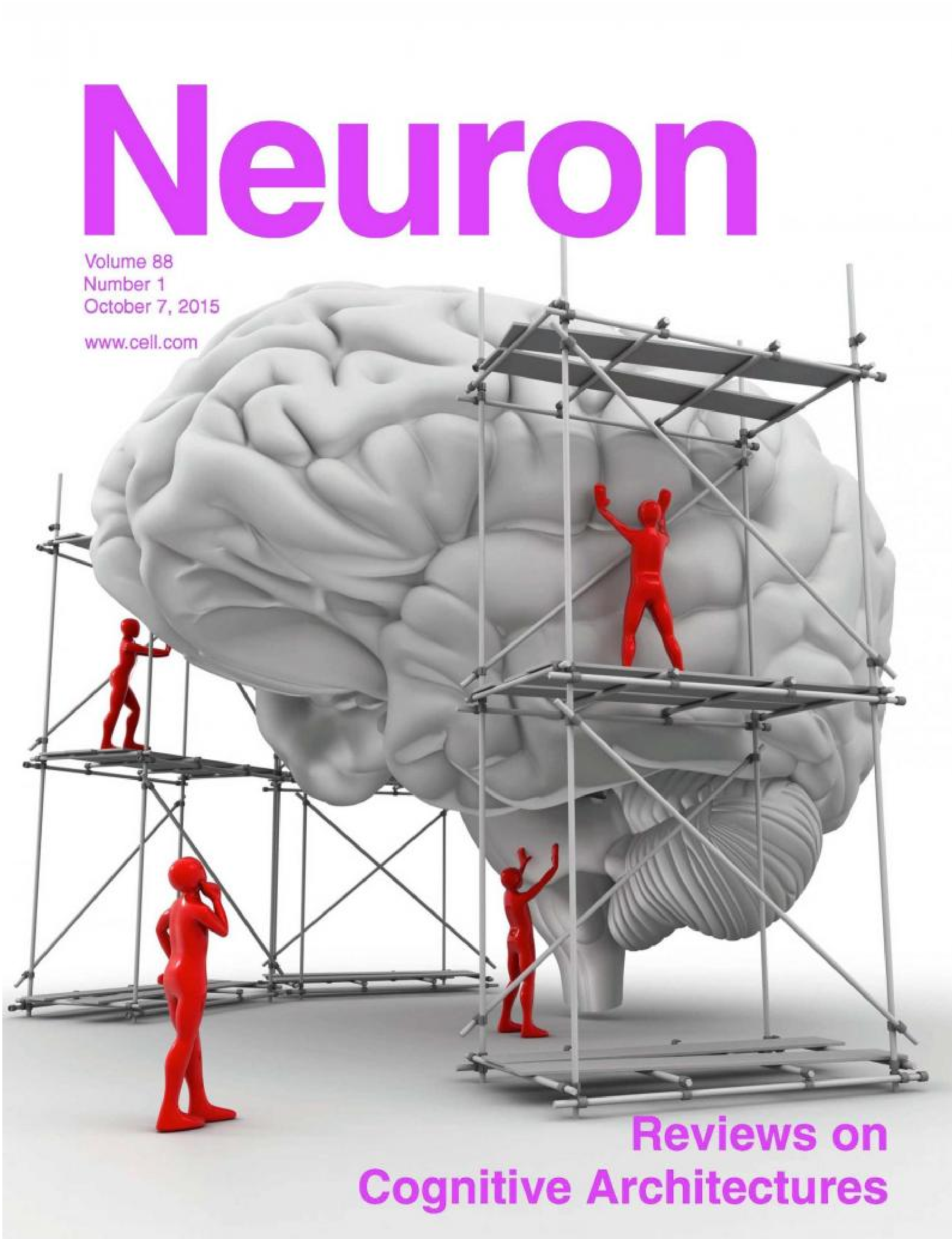

Neuron's special issue on Cognitive Architectures. Credit: Neuron 2015

Neuroscientists can't build a brain, so they have settled with reverse engineering—learning a lot about each part in hopes that they can understand how all of the pieces fit together. In a *Neuron* special issue on "Cognitive Architecture," published October 7, researchers present integrated theories on how processes—such as attention, body self-consciousness, and language—function within the hardware of the human brain.

Attention's place in this architecture is to help us structure our internal world so that the thoughts, emotions, or motivations that are most relevant to our goals will get preferential processing through the brain, explain Princeton University neuroscientists Timothy Buschman and Sabine Kastner in a review of attention research.

"Almost all high-order cognitive functions, such as memory, language, or decision making generally depend on "attentive state"; that is, attention is a core cognitive ability without which other cognitive functions are quite impaired," says Kastner. "Could the brain function without attention? Yes—it does in people with attention deficits, but this is a very difficult state to be in."

With over 1,000 papers on "attention" in neuroscience published for each of the past 3 years, the authors attempt to integrate this ocean of findings into a single theory. In basic terms, they propose that attention is a cascade of effects beginning when a relevant stimulus (e.g., a flash of light, a bolded word) grabs the attention of the front of the brain. From there, neurons suppress competing stimuli so that there is increased focus on what's relevant and decreased external "noise." Once the need to focus is over, the brain resets so attention doesn't get stuck on a single stimulus.

"By integrating these diverse findings into a single theory, our hope was to highlight commonalities between models and, possibly, discover some unified mechanisms," Buschman adds. "In general, I think unified theories have more power to make predictions. This not only reflects a deeper understanding of a subject but also allows for these predictions to be tested."

Their review focused mainly on visual attention but noted that there are close and somewhat unexplored relationships between attention and being able to remember information, learn from reinforcement, and exert cognitive control. Future directions for research also include understanding how attention is able to shift so rapidly and the role that specific neurons play.

Paper citation: *Neuron*, Buschman and Kastner: "From behavior to neural dynamics: An integrated theory of attention" http://dx.doi.org/10.1016/j.neuron.2015.09.017

Other noteworthy reviews in the special issue include:

Perception of Self Requires a Body

To look down at your body and know it belongs to you and that you are the person looking at your body is all a perception of the mind. Many studies have only examined the role of visual stimuli in promoting consciousness, but a review by neuroscientists Olaf Blanke and Andrea Serino of Ecole Polytechnique Federale de Lausanne, and Mel Slater of ICREA-University of Barcelona, proposes to study the self-consciousness of our body. It also supports that the integration of sensory inputs from different senses and from larger body sections, in particular from the trunk, are important contributors to make you feel that this body is actually you. This phenomenon is found in humans, monkeys, and potentially even flies.

The researchers suggest that, using these integration mechanisms, it could be possible to manipulate bodily self-consciousness and thus project the experience of our own body onto a virtual one. However, it would require at least four criteria to be met: 1. The real body and the virtual body positions must match. 2. The virtual body must be shaped like a body (e.g., not a piece of wood). 3. The virtual body must be in close proximity to the real body. 4. And the real body must have time to synchronize with the virtual body.

"Recent advances in digital technologies, such as communication, personal computing, and wearable technologies, now offer powerful tools to manipulate bodily and environmental information to study (bodily self-consciousness and the) first-person perspective," the authors write. "Detailed descriptions of the brain mechanisms of bodily self-consciousness might inform the exploitation of such technologies to produce or enhance the experience of being in other places and to control and perceive multiple artificial bodies, or body parts, and robots."

Neuron, Blanke et al.: "Behavioral, Neural, and Computational Principles of Bodily Self-Consciousness"
http://dx.doi.org/10.1016/j.neuron.2015.09.029

Five Ways the Brain May Recall Chains of Words, Sounds, or Patterns

The architecture of the brain is such that there are multiple mechanisms for how we can recall chains of syllables, song notes, or visual cues. Stanislas Dehaene of the Collège de France and INSERM, and colleagues, review evidence for five ways that the brain may store temporal sequence information:

1. The brain simply remembers the delay between specific events; so if a buzzer rings every 3 seconds or every 9 seconds; the silence observed is incorporated into the memory and allows the brain to make predictions for next time the pattern occurs.

2. The brain recalls a group of successive events as a single "chunk" of information - that's how words are formed.

3. The brain memorizes sequences as ordered lists (e.g., to remember the sequence A,B,C, it encodes which letter comes first, second, or third.).

4. The brain stores the abstract pattern of repetition - for instance it's easier to remember 7 7 5 than 7 6 5 because we encode that it starts with a repeated pair.

5. The brain follows symbolic rules that create tree structures—such structures underlie language, music, actions, and mathematics and may be a uniquely human feat.

"The coexistence, in different brain circuits, of multiple systems for sequence learning raises an interesting issue for further research: how does the brain determine what is the best model for a given sequence?" the authors write. "Specific experiments, putting multiple interpretations of the same sequence in competition with each other, will be needed to clarify this point."

Neuron, Dehaene et al.: "The Neural Representation of Sequences: From Transition Probabilities to Algebraic Patterns and Linguistic Trees" http://dx.doi.org/10.1016/j.neuron.2015.09.019

More information: *Neuron*, Buschman and Kastner: "From behavior to neural dynamics: An integrated theory of attention" http://dx.doi.org/10.1016/j.neuron.2015.09.017

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