A Road to the Principles: Taking the Brain's Perspective

IEEE CIMSVP Panel Session, 2009

April 1, 2009

Yoonsuck Choe

Department of Computer Science and Engineering

Texas A&M University

Approach

Instead of asking “what” the principles are, we will first consider “how” to get to the principles.

- Taking the brain’s perspective
- Taking an evolutionary perspective

Part I: Taking the Brain's Perspective

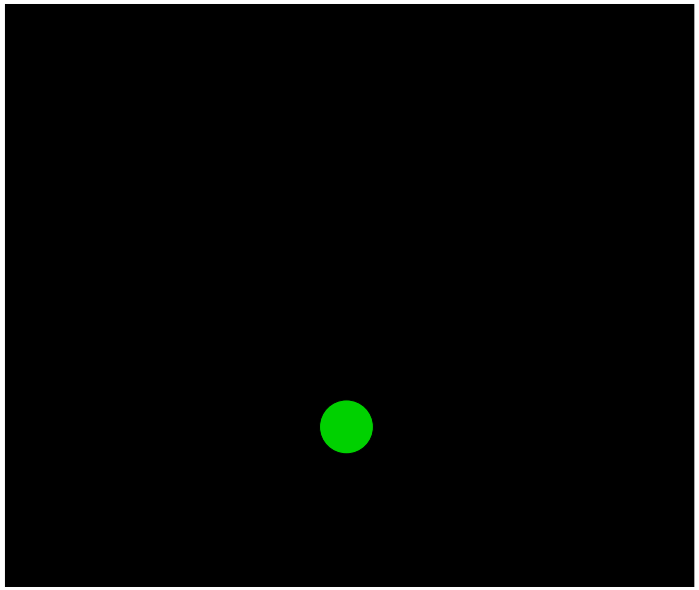
Taking the Brain's Perspective

- The brain may be faced with a completely different set of problems compared to those investigated by scientists.
- Identify those questions, and surprisingly easy (and unexpected) answers will follow.

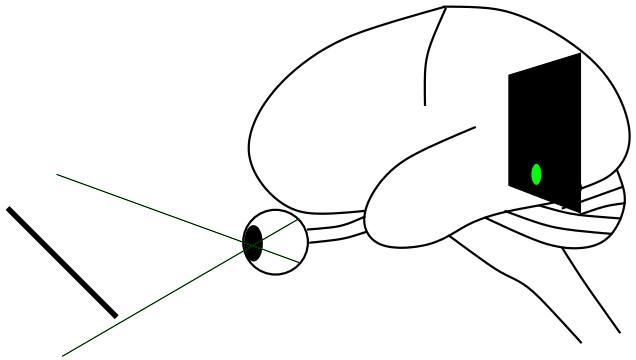
Problems Faced by the Inner Brain

- How to understand the spikes without direct reference to the external world?
- How to keep synchronized with the present?
- How to distinguish between input and output representations?

Understanding Spikes, from Within



(a) From the Inside



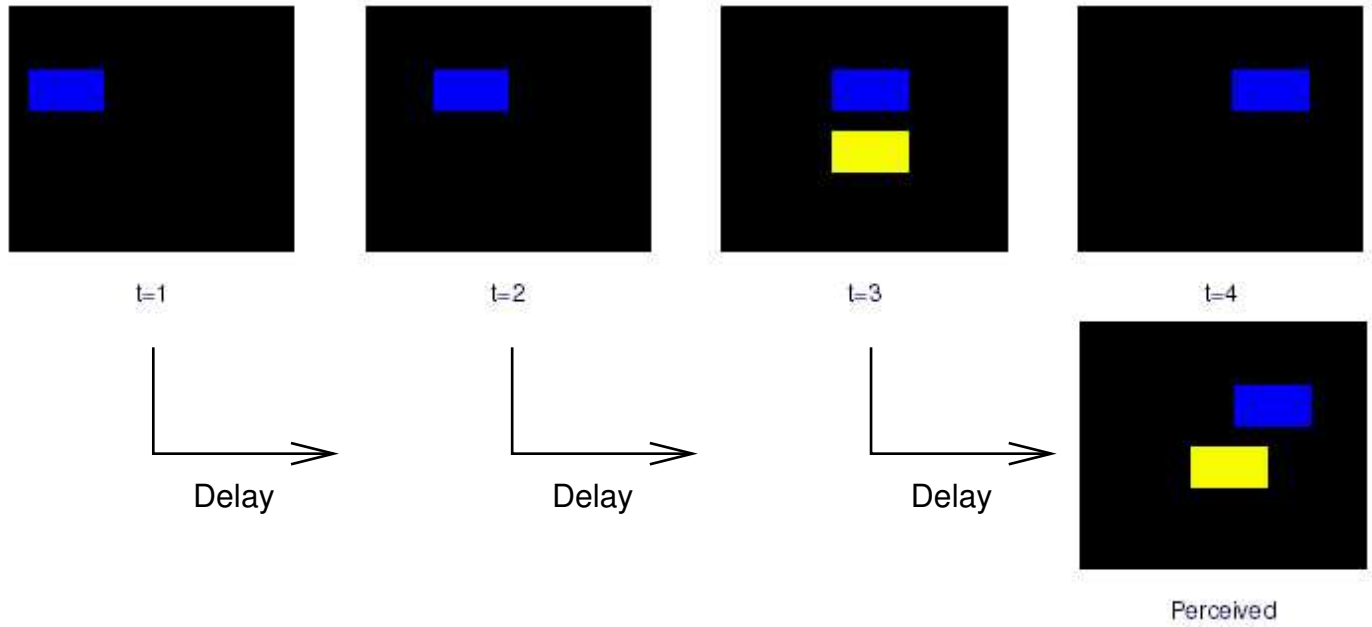
(b) From the outside

What do the green lights mean (represent)?

- From the inside: No clue!
- From the outside: No problem.

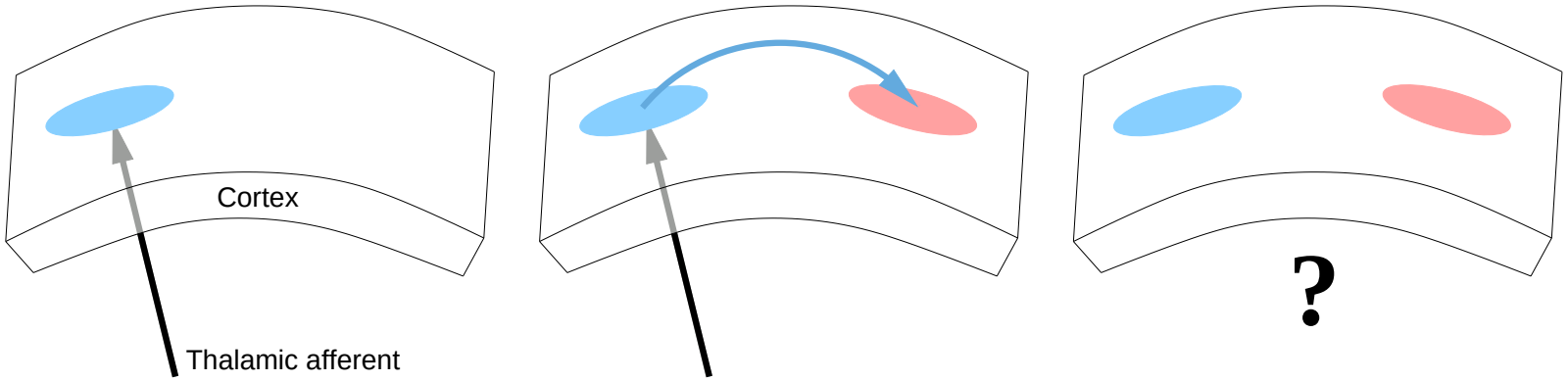
But this is absurd, because we operate like (a), not (b).

Keeping in Sync with the Outside



- Signals arrive in higher areas with a delay.
- What the higher areas perceive is in the past.
- Flash-Lag Effect demonstrates delay compensation.

Input or Output?



Input comes in | Output is generated | Confusion

- Binding problem: how can separate feature representations of the same object be “bound”?
- Binding problem is about input representations.
- What about the output representations?

Unexpected Answers

- Understanding spikes without external reference
  - Observe changes in spikes while performing action.
- Maintaining synchrony with reality
  - Short-term synaptic plasticity as delay compensation, not memory.
- Distinguishing input vs. output representations
  - Filtering within the thalamus-TRN-cortex loop, reactivating immediate output of cortical computation.

Part II: Taking an Evolutionary Perspective

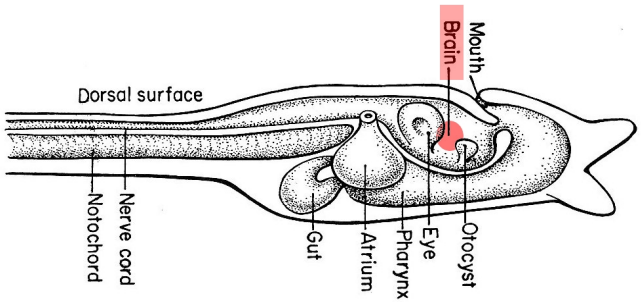
Taking an Evolutionary Perspective

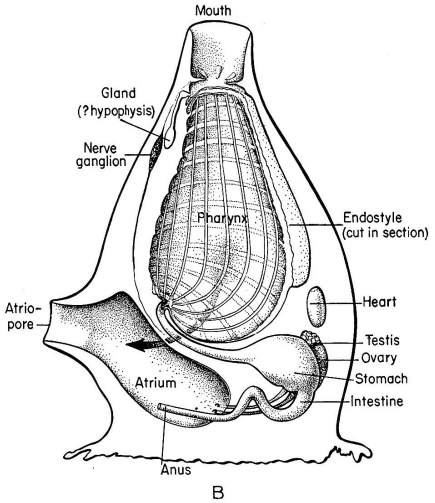
- Go beyond “what” and “how”, and ask “why”?
- Why did the brain evolve?
- What are the necessary conditions for X to evolve?

  (X = your favorite mental phenomena)

Why Did the Brain Evolve?

Brain! **No Brain!**



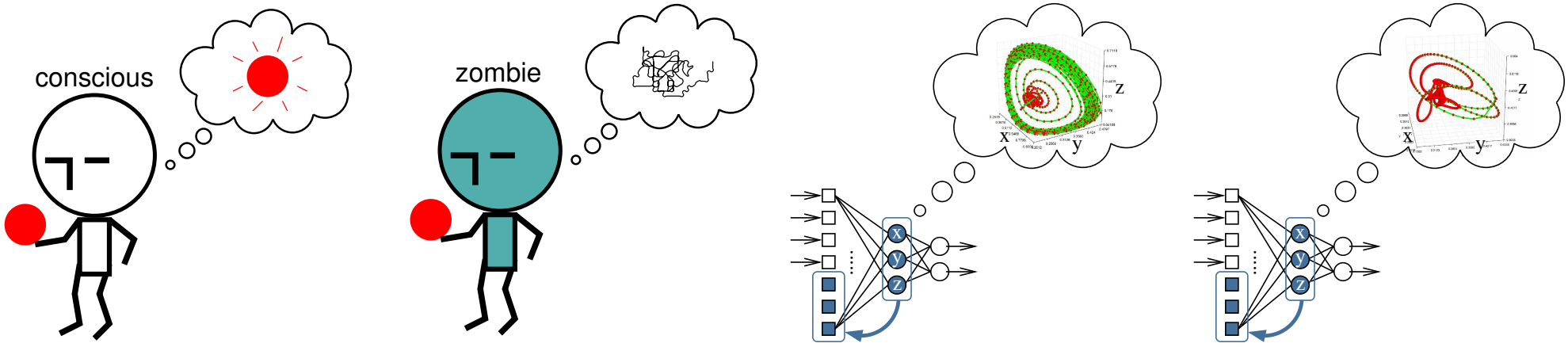


Larva (swimming) Adult (sedentary)

Llinás (2001)

- Marine tunicates: brain or no brain?
- Difference? One is mobile, the other is not.
- It is all about action and motor control!

Necessary Conditions for X?



Conscious Zombie Predictable dyn. Unpredictable dyn

- Subjective mental states are hard to investigate.
- Study the “necessary conditions” instead.
- E.g., prediction could be one necessary condition of authorship and the sense of self.

Part III: Principles Emerge

Principles Emerge

- The brain must maximize understanding: Action helps!
- The brain is about action.
- The brain must predict (to link past, present, and future).

References

Choe, Y. (2004). The role of temporal parameters in a thalamocortical model of analogy. *IEEE Transactions on Neural Networks*, 15:1071–1082.

Choe, Y., and Smith, N. H. (2006). Motion-based autonomous grounding: Inferring external world properties from internal sensory states alone. In Gil, Y., and Mooney, R., editors, *Proceedings of the 21st National Conference on Artificial Intelligence*. 936–941.

Kwon, J., and Choe, Y. (2008). Internal state predictability as an evolutionary precursor of self-awareness and agency. In *Proceedings of the Seventh International Conference on Development and Learning*, 109–114. IEEE.

Lim, H., and Choe, Y. (2008). Delay compensation through facilitating synapses and its relation to the flash-lag effect. *IEEE Transactions on Neural Networks*, 19:1678–1688.

Llinás, R. R. (2001). *I of the Vortex*. Cambridge, MA: MIT Press.