PHIL 255

**Week 9: Consciousness**

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Please turn off and put away all electronics.

Please avoid the last 2 rows.

Semantic theory competition

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# Theories of Consciousness

**Dualism:** Consciousness is a property of people's souls. Descartes, Chalmers.

**Neural:** Consciousness results from brain mechanisms. Damasio, Dehaene.

**Information integration:** Consciousness is a mathematical property of complex systems. Tononi, Koch.

**Quantum:** Consciousness results from quantum computation in microtubules. Hameroff, Penrose.

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# Three Mechanisms

| Parts | Interactions | Emergent result |
|---|---|---|
| Neurons | Excitation, inhibition, synaptic connections | Representation by firing patterns |
| Neural populations | Recursive binding | Semantic pointers |
| Semantic pointers | Interactive competition | Conscious experience |

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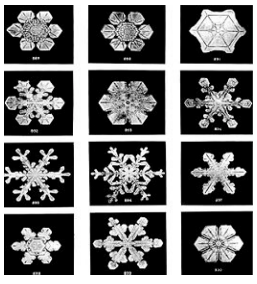
# Emergence

Emergent properties are possessed by the whole, not by the parts, and are not simple aggregates of the properties of the parts because they result from interactions of parts.



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# The New Synthesis

Thesis (1950s): Intelligence results from the processing of physical symbols. (Herbert Simon, traditional AI)

Antithesis (1980s): Intelligence results from sub-symbolic processes in neural networks, operating with distributed representations.

Synthesis: Neural networks are capable of symbolic processes, using semantic pointers.

Chris Eliasmith: *How to Build a Brain*, Oxford U. Press, 2013. Eliasmith et al. (2012), *Science*.

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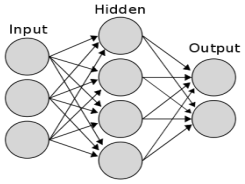
# Neural Representation

1. Local representation with individual neurons
2. Distributed representations
3. Pattern of spiking activity in neural population

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# Neural Representation in Theoretical Neuroscience

1. Neural populations have millions of neurons.
2. Firing patterns matter as well as rate of firing.
3. Populations are organized into brain areas whose interconnections matter more than modularity.
4. Neural populations encode sensory inputs and inputs from other neural populations. Multimodal.

See Eliasmith & Anderson, *Neural Engineering,* 2003.

Eliasmith et al., *Science*, Nov. 30, 2012.

Eliasmith, *How to Build a Brain,* 2013.

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# Neural Representation

(Chris Eliasmith, Terry Stewart)

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## Binding in the Brain

Synchrony: neurons fire in temporal coordination
- Syntax: e.g. Shastri, Hummel
- Consciousness: e.g. Crick, Engel, Scherer

Convolution: activity of neural populations becomes "twisted together": convolve.

Representations are braided together.

Eliasmith has shown how neural populations can perform convolution.

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## Convolution in Action

(Thagard & Stewart, AHA!, *Cognitive Science*, 2011)

## Recursive Binding

Binding is recursive: binding of bindings of bindings ....

Binding using vectors can produce syntactic complexity (Eliasmith and Thagard, *Cognitive Science*, 2001).

Binding (via convolution) can produce *semantic pointers* that function syntactically, semantically, and pragmatically, with properties akin to both symbols and distributed neural representations.

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## Semantic Pointers (Eliasmith 2013)

Semantic pointers are patterns of neural firing that:

1. provide *shallow meaning* through symbol-like relations to the world and other representations;
2. expand to provide *deeper meaning* with relations to perceptual, motor, and emotional information;
3. support complex syntactic operations;
4. help to control the flow of information through a cognitive system to accomplish its goals.

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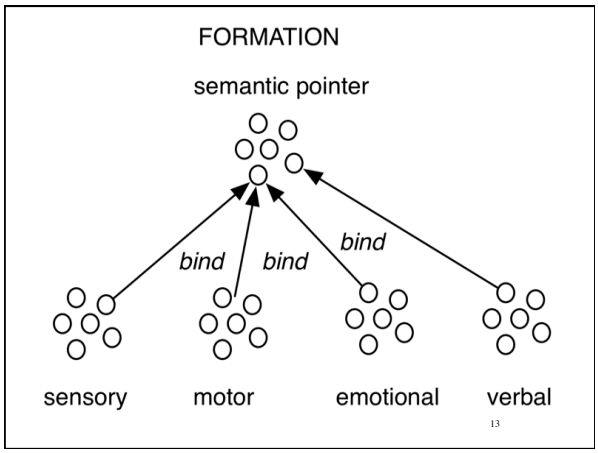


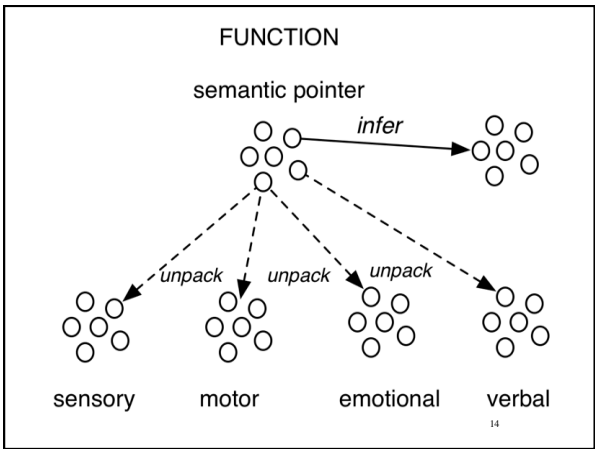


## Binding Procesess

Self-consciousness of creativity requires:

BIND (self, discovery, emotional reaction)

Discovery results from binding representations (Thagard & Stewart, *Cognitive Science, 2011;* Thagard, *The Cognitive Science of Science,* 2012).

Emotion results from binding cognitive appraisal and physiological perception (Thagard & Aubie, 2008; Thagard, *The Brain and the Meaning of Life*, 2010, Thagard & Schröder, in press).

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## Interactive Competition

Rumelhart & McLelland: Many processes, e.g. language result from interactive activation and competition in neural networks.

Smith & Kosslyn (2007): interactive competition model of attention.

Hypothesis: consciousness of all sorts results from interactive competition among semantic pointers!

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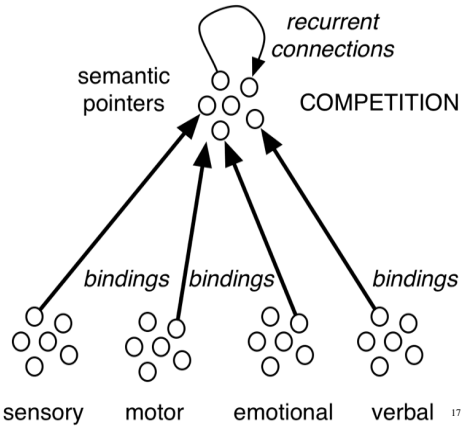


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## Discussion Question

How plausible do you find the semantic pointer theory of consciousness?

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## Consciousness Evidence

**Simulations (NENGO) of:**

1. Qualitative differences in experience, e.g. vision vs. smell
2. Onset and cessation, e.g. sleep
3. Shifts of consciousness, e.g. cocktail party
4. Kinds of consciousness, e.g. self
5. Unity and disunity, e.g. drugs

Thagard & Stewart, Two Theories of Consciousness, in progress.

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## Mental Imagery

Applies to all senses: see, hear, touch, smell, taste, pain, heat, hunger, balance, kinesthetic, fullness ...

Brain mechanisms: memory retrieval (i.e. recreate pattern of neural firing) and transformation of semantic pointers

Transformations are sense-specific, e. g. for vision we can do zoom, flip, rotate, scan, etc.

Transformations can be multisensory, e.g. imagine someone singing

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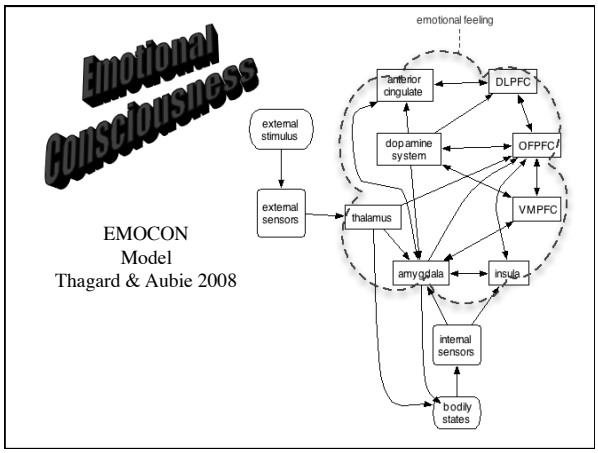
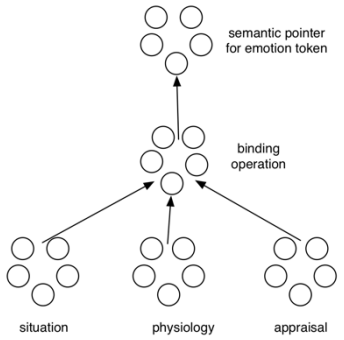



## Emotions as Semantic Pointers

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## Emotional Imagery

Examples:

Imagine how you would feel if you won the lottery.

Method acting: generate emotions for a character.

Empathy: Generate an emotion and project it onto someone else.

Brain mechanisms: Memory retrieval (recreate pattern of neural firing) + transformations.

Emotion transformations: intensity, combination, projection, etc.

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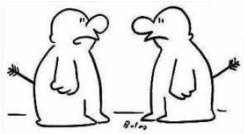
## Empathy

Empathy is the ability to identify with the emotional feelings of others. It often leads to sympathy, which is care and concern for others.

Empathy is emotional imagery: Retrieve an emotional experience as a semantic pointer, and transform it to project your emotional experience on to another.



"I know exactly how you feel."

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## Discussion Question

How plausible are the semantic pointer theories of emotion and empathy?

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