

Brain Mechanisms
Explain
Consciousness

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Outline

1. Why consciousness matters
2. What needs explaining
3. Theories
4. Semantic pointer competition
5. Alternatives
6. Conclusion



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Why Consciousness Matters

1. Consciousness is a fascinating aspect of mind.
2. Consciousness is the biggest obstacle to scientific (e.g. neural) explanations of consciousness.
3. Consciousness is an important part of knowledge and morality (conscience).

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What is Consciousness?
3-analysis

Exemplars: external perceptions such as colors, internal perceptions such as pain, emotions, thoughts, self-awareness

Typical features: experiences, awareness, attention, shifts, starts & stops, unity

Explains: reports, behaviors

Explained by: ?

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Theories of Consciousness

1. Consciousness is a property of non-material souls.
2. Consciousness is an illusion to be eliminated.
3. Consciousness is a computational process.
4. Consciousness is a neural process.
5. Consciousness is information integration.

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What Needs to be Explained

1. People have numerous conscious experiences of different kinds, e.g. perceptions, emotions.
2. Conscious experiences stop and start, e.g. sleep.
3. Consciousness shifts.
4. Consciousness is unified.
5. Consciousness has levels: basic, self.
6. Consciousness influences actions.

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Semantic Pointer Competition Theory

1. Semantic pointers are patterns of neural firing that result from binding of patterns derived from perception, motor control, emotions, and verbal representations
2. Semantic pointers compete to be active representations of the current situation.
3. Winning semantic pointers produce conscious experiences.

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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
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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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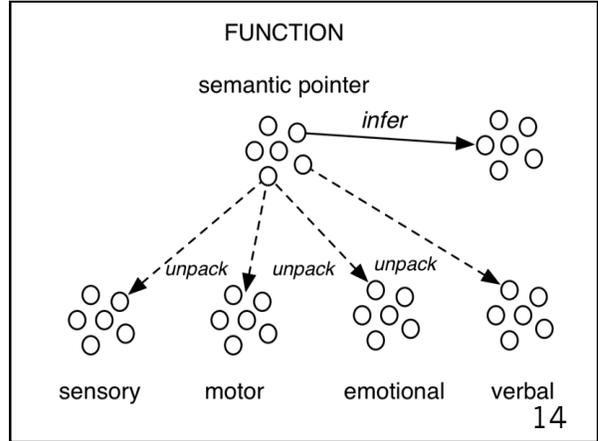
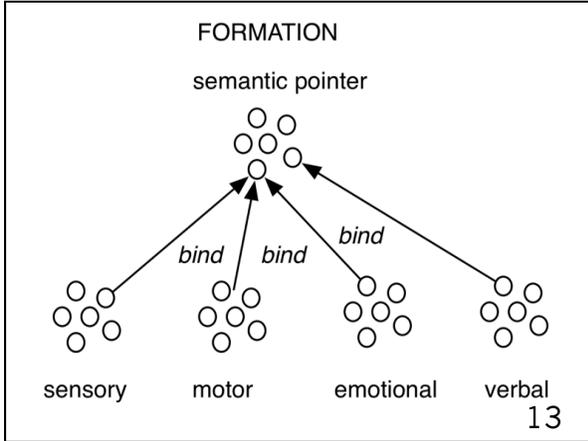
Semantic Pointers (Eliasmith 2013)



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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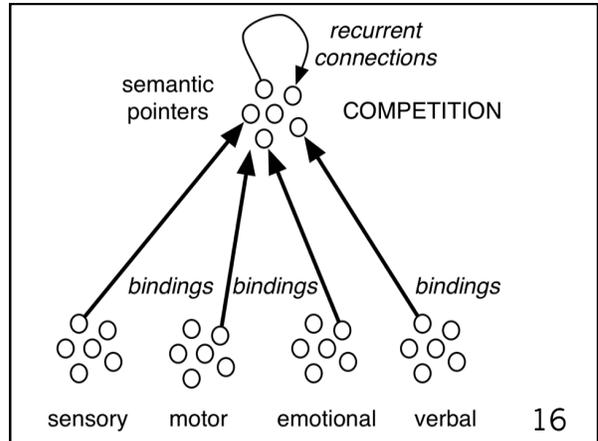
Interactive Competition

Rumelhart & McClelland: Many processes, e.g. language result from interactive activation and competition in neural networks. Example: categorization of something as a car or a truck.

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

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

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Explanations 1-3

1. Different experiences result from different bindings of perceptual, emotional, and verbal inputs.
2. Starting and stopping results from exceeding minimal levels neural firing.
3. Shifts result from different semantic pointers winning and losing the competition.

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Explanations 4-6

4. Consciousness is unified because of binding by convolution.
5. Consciousness has levels because of degrees of recursive binding. People can do more than other animals.
6. Consciousness influences actions because it encourages inclusion of different semantic pointers.

See simulations in Thagard & Stewart 2014 + Schröder, Stewart, and Thagard 2014.

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Why Accept This Theory?

1. It has been worked out in mathematical and computational detail.
2. The computational models based on it has been used to simulate 5 important phenomena, e.g. different modalities, stopping/starting, intensity, shifts.
3. It provides a better explanation of the evidence than alternative theories.

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Alternative Theory 1

Dualism: consciousness is a soul process.

Problems:

1. There is no evidence that souls and other non-material substances exist.
2. Dualism leaves consciousness a complete mystery because it cannot say how it results from unspecified operations of the indescribable soul.

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Alternative Theory 2

Global workspace theory (Dehaene):
consciousness results from a process that broadcasts information across the brain.

Problems:

- Does not explain what gets broadcast.
- Does not explain different experiences, starting/stopping, levels, action.
- But this could be combined with semantic pointer competition.

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Alternative Theory 3

Elimination: Consciousness is an illusion.

Problems:

1. Does not explain different experiences, starting/stopping, etc. Abandons explanation.
2. Consciousness exists, requiring explanation, unlike immortality, soul.

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Alternative Theory 4

Information integration: Consciousness occurs in anything that has more information as a whole than in its parts.

Problems:

1. Attributes consciousness to far too many entities, e.g. cell phones and countries.
2. Is mathematically obscure and not computable.
3. Fails to explain different experiences, starts and stops, shifts, intensity, action.

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Therefore

Semantic pointer competition provides the best available explanation of important aspects of consciousness.

So tentatively, subject to further evaluation, we should believe that consciousness results from semantic pointer competition.

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Conclusions

1. Consciousness results from neural representation, binding into semantic pointers, and semantic pointer competition.
2. Consciousness is a brain process.
3. We can reject dualism, elimination, and information integration.



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Problems

1. Why are there experiences at all? Answer: because they emerge from interactions of semantic pointers – millions of neurons.
2. Why did consciousness evolve? Answer: because it facilitates learning and teaching and was therefore selected for. Alternative: mere side effect.
3. Why aren't computers yet conscious? Answer: because they lack bindings of bindings.

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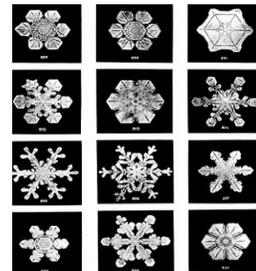
Three Mechanisms

Parts	Interactions	Emergent result
Neurons	Excitation, inhibition, synaptic connections	Representation by firing patterns
Neural groups	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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Philosophical Dead Ends

1. Qualia are things to be explained rather than processes.
2. There is something that it feels like to be conscious.
3. Thought experiments, e.g. zombies, are informative.
4. Science requires the elimination of consciousness.

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