


EUREKA!

Three Mechanisms of Creative Consciousness


Paul Thagard
University of Waterloo



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Outline

1. Self-consciousness of creativity
2. Neural representation
3. Recursive binding
4. Interactive competition
5. Objections




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Creative Intuition

Where does it come from?

1. Divine inspiration: Muses
2. Platonic apprehension
3. Computational generation
4. Neural mechanisms



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Mechanistic Explanation


How does a bicycle move?

Parts: frame, wheels, gears, chain, pedals, etc.

Structure: e.g. pedal connected to gear.

Interactions: e.g. pedal moves chain.

Changes: e.g. wheels turn.



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Self-consciousness of creativity

Eureka: I have found it.

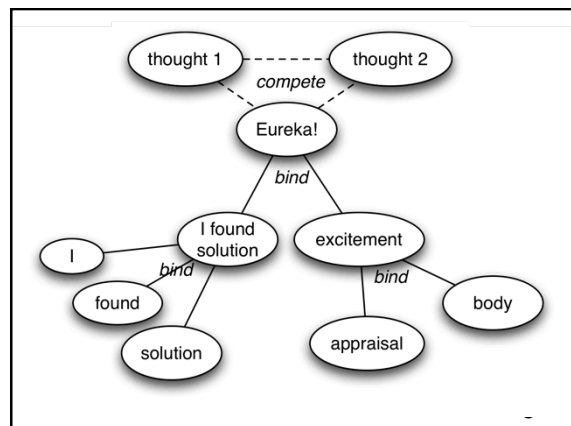
Requires understanding of:

- Self
- Consciousness, including emotions
- Creativity

All of these involve mechanisms for:

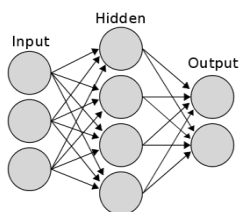
- Neural representation
- Binding
- Competition

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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, *How to Build a Brain*, forthcoming.

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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 2012)

Semantic pointers are patterns of neural firing that:

1. provide *shallow semantics* through symbol-like relations to the world and other representations,
2. expand to provide *deeper semantics* 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 Processes

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).

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Self as Semantic Pointer

Self-representation binds:

- Current experiences: sensory, bodily
- Memories
- Concepts of self and others

Result is a self-representation produced by recursive bindings. Unity and diversity.

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Interactive Competition

Rumelhart & McClelland: 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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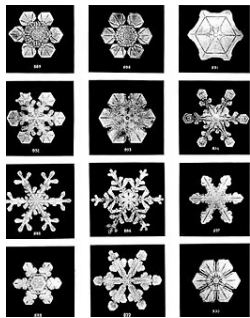
Three Mechanisms

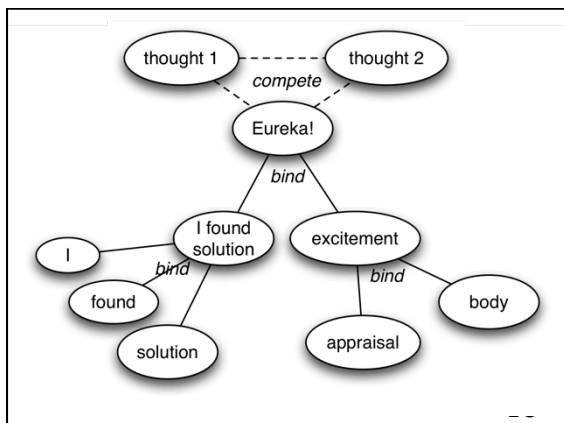
Parts	Interactions	Emergent result
Neurons	Excitation, inhibition, synaptic connections	Representation by firing patterns
Neural populations	Recursive binding	Semantic pointers
Semantic pointers	Interactive competition	Conscious experience

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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.





Objections

1. What about robots?

Response: Robots might have a different kind of Eureka some day.

Could Bayes nets generate Bayes nets? Represent themselves?



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Objections

2. Ascribing consciousness and creativity to the brain is a category mistake.

Response: categories change.

3. We can imagine beings with the three mechanisms that are not conscious.

Response: cognitive science is concerned with this world, not all possible worlds.

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Objections

4. What is it like to feel Eureka?

Response: feeling Eureka requires feeling self, discovery, and excitement.

Neural explanations explain self-representation, combination of representations, and emotional reactions.

Excitement: positive valence resulting from activation in dopamine circuits (e.g. nucleus accumbens), and intensity resulting from high firing rates.

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Planned Research

We already have neuro-computational models of:

Representation

Binding

Aha experience – *Cognitive Science*, 2011

We need to produce:

Self-representation = concepts + experiences

Binding of self with Aha

Interactive competition between semantic pointers

(Thagard & Aubie, 2008)

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Planned Research

Show how semantic pointer competition fits with:

Higher order representation theories.

Global workspace models of consciousness.

Integrative information theory.

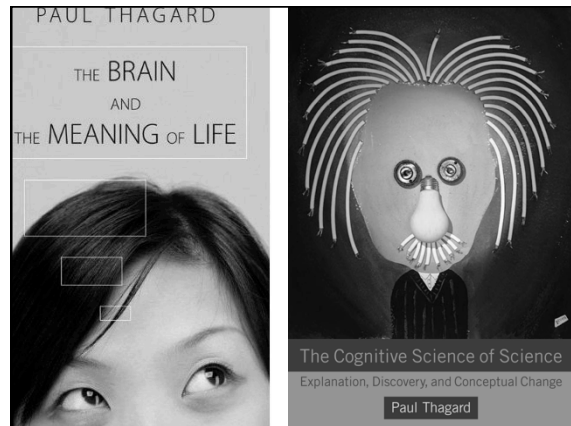
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Conclusions

1. Eureka experience is self-consciousness of creativity.
2. Key mechanisms are neural representation, recursive binding, and competition among semantic pointers.



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Query

Is the limited capacity of consciousness a bug or a feature?

Bug: side effect of limitations of neural representation.

Feature: adaptive for creating a cognitive bottleneck to favor action.

Both?

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