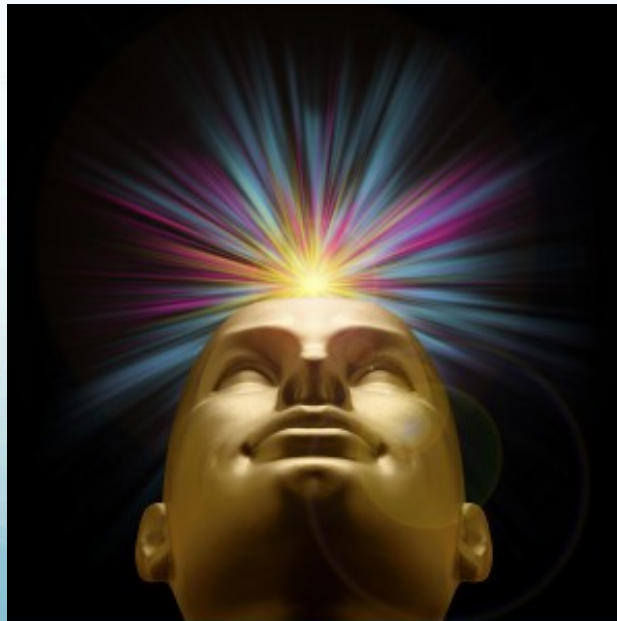


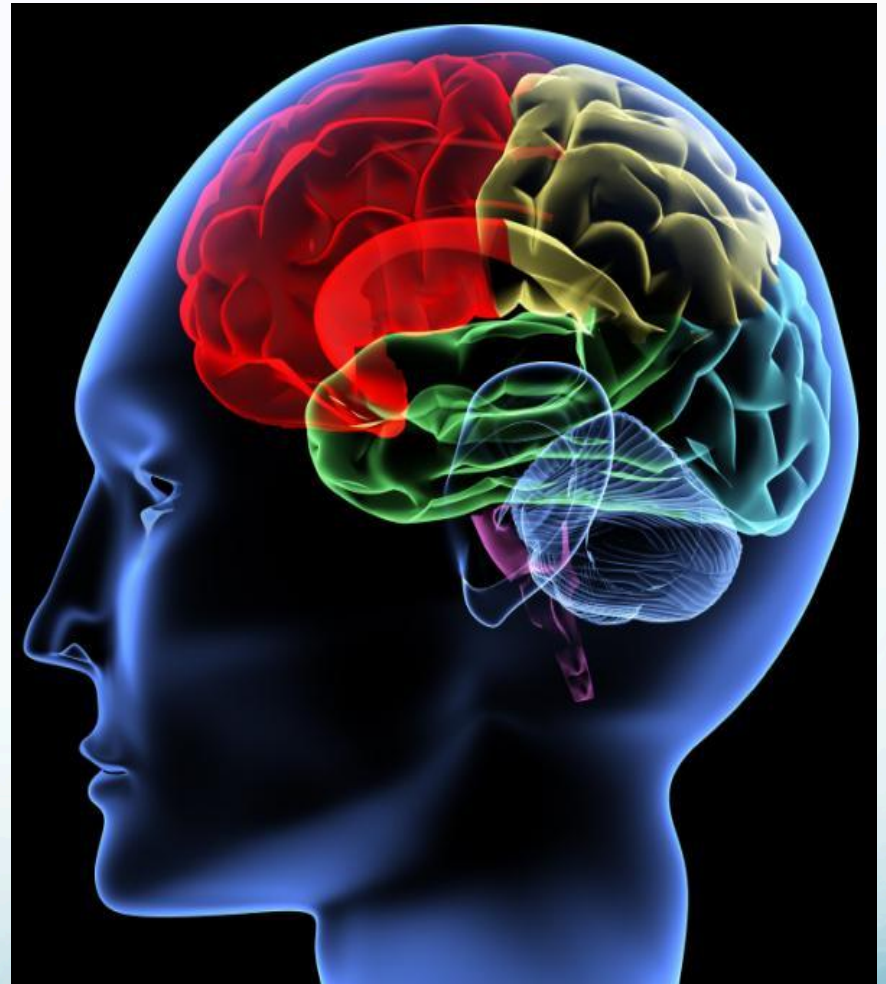
Brain Mechanisms Explain Emotion and Consciousness

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Outline

1. Why emotions matter
2. Theories
3. Semantic pointers
4. Emotions
5. Consciousness



What is Emotion?

3-analysis

Exemplars: happy, sad, fear, anger, disgust, surprise, guilt, pride, gratitude, envy ...

Typical features: positive/negative, intensity, conscious experiences, leads to action

Explains: experiences, reports, behaviors

Explained by: ?

“Concepts are Semantic Pointers”: Blouw, Solodkin, Thagard, and Eliasmith, in press, *Cognitive Science*.

Why Emotions Matter

1. Emotions are a major part of mental life: relationships, work, arts.
2. Emotions motivate actions, e.g.
Love => approach; hate => avoid.
3. Mental illnesses all have defective emotions.
4. Emotions are biologically valuable: evaluation, attention, motivation, social connection.

Theories of Emotion

1. Emotion is a property of non-material souls.
2. Emotion is cognitive appraisal (Nussbaum, Ortony, Scherer, etc.).
3. Emotion is physiological perception & embodiment (James, Damasio, Prinz, Niedenthal, etc.).
4. Emotion is social/linguistic construction (Harre, etc.).

5. Emotions are Semantic Pointers

Emotion = bind (concept or belief, cognitive appraisal, physiological perception)

Example: being happy to be in Paris = bind (Paris, appraisal, physiology)

Concepts, beliefs, appraisal, and physiology are all patterns of neural firing.

Binding is by convolution as performed in the Semantic Pointer Architecture.

Thagard and Schröder, “Emotions as Semantic Pointers”, 2014.

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*.

Representation and Binding

Representation: pattern of firing in population of neurons

Binding by synchrony: neurons fire in temporal coordination

Convolution: activity of neural populations becomes “twisted together”: convolve.

Representations are braided together.

Eliasmith shows how neural populations can perform convolution.



Semantic Pointers

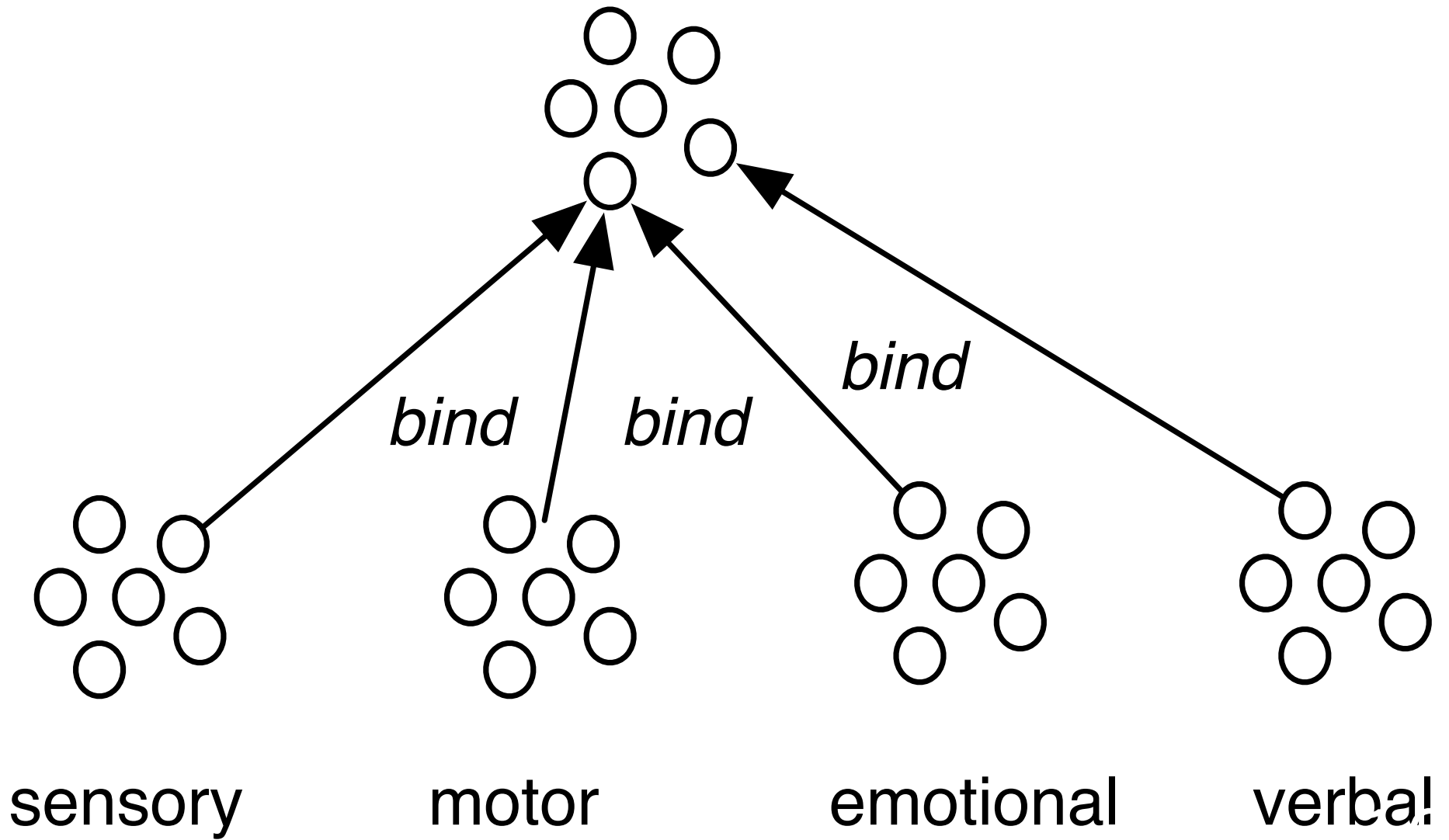
(Eliasmith 2013)

Semantic pointers are patterns of neural firing:

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. control the flow of information through a cognitive system to accomplish its goals.

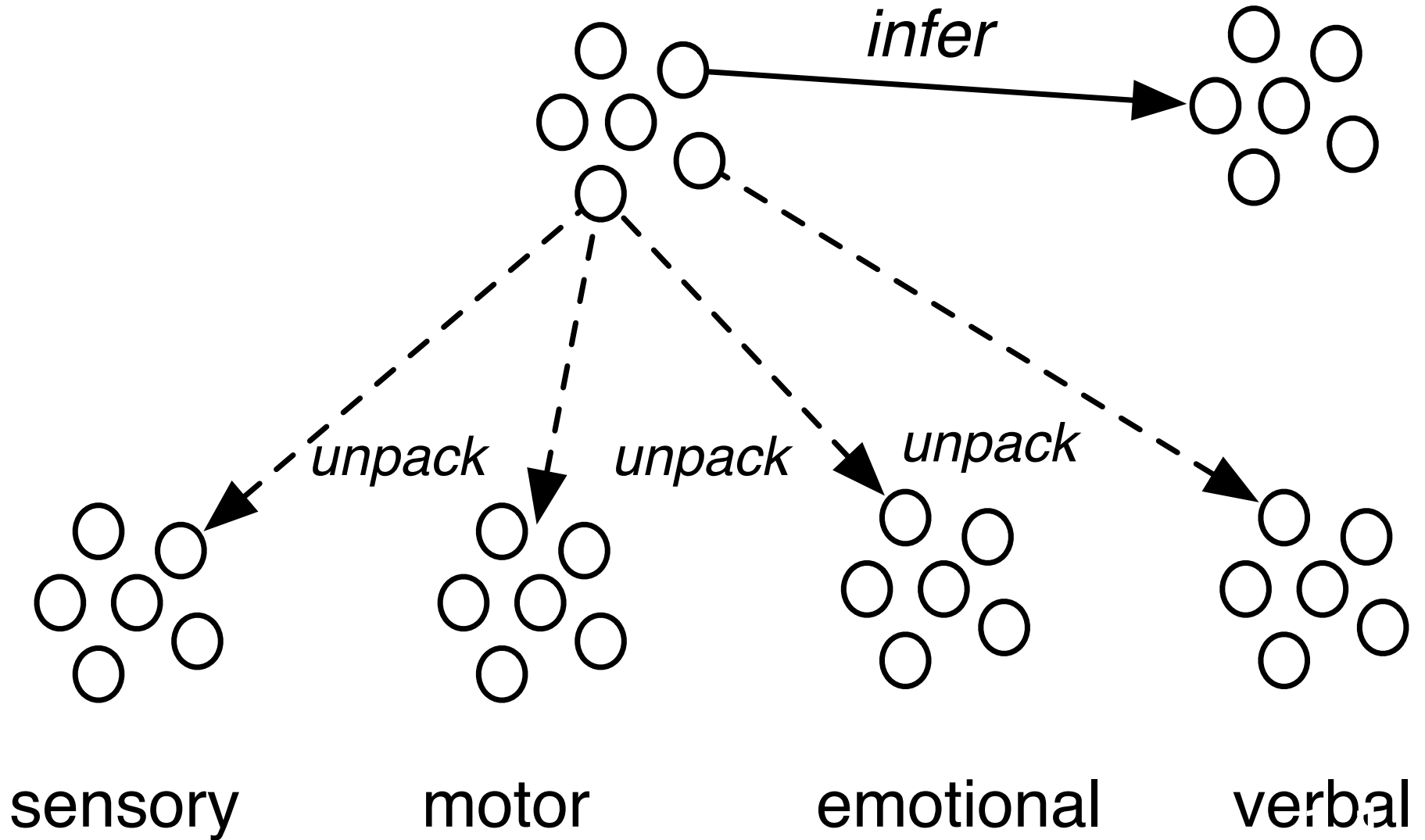
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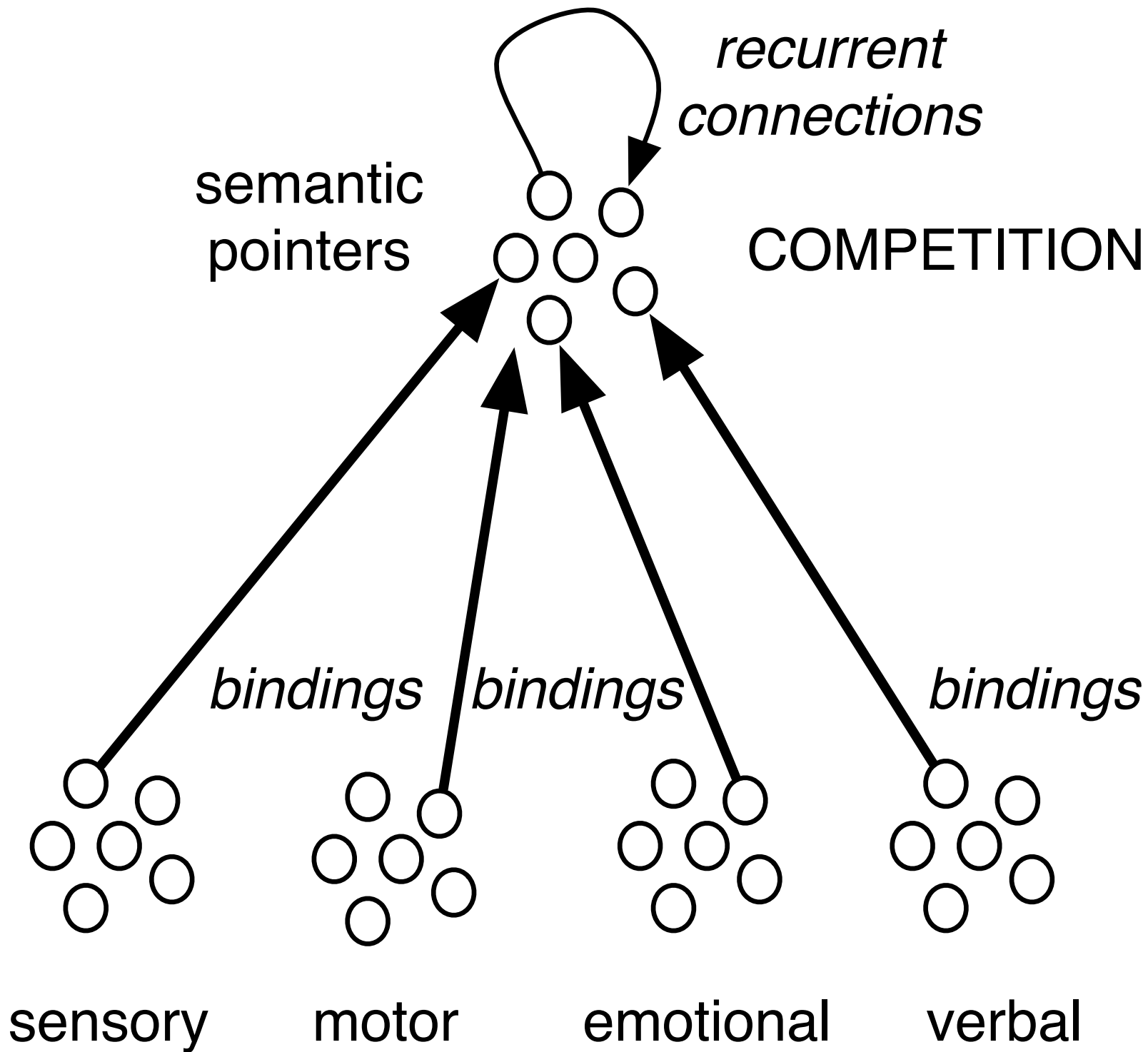
semantic pointer



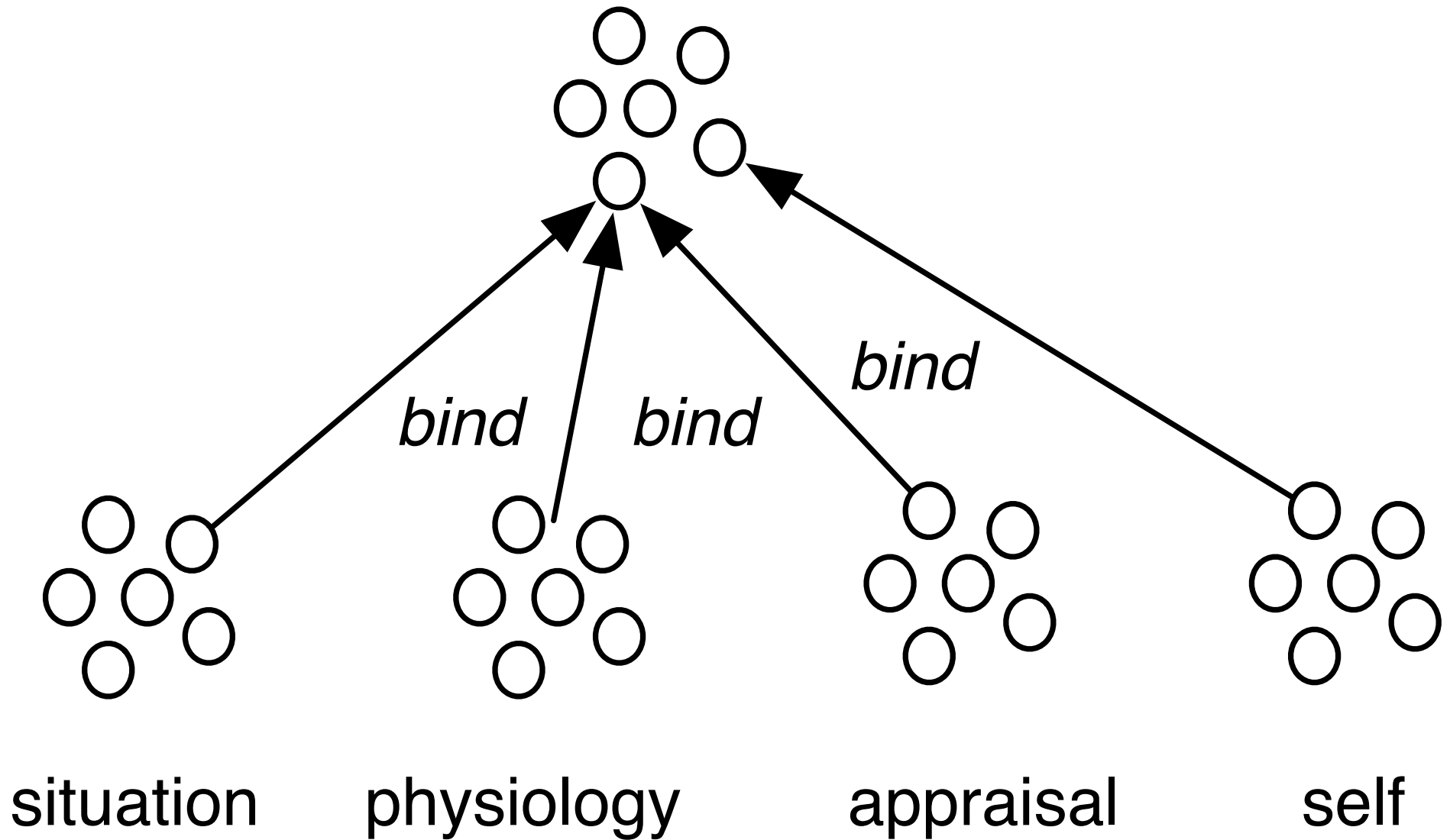
FUNCTION

semantic pointer

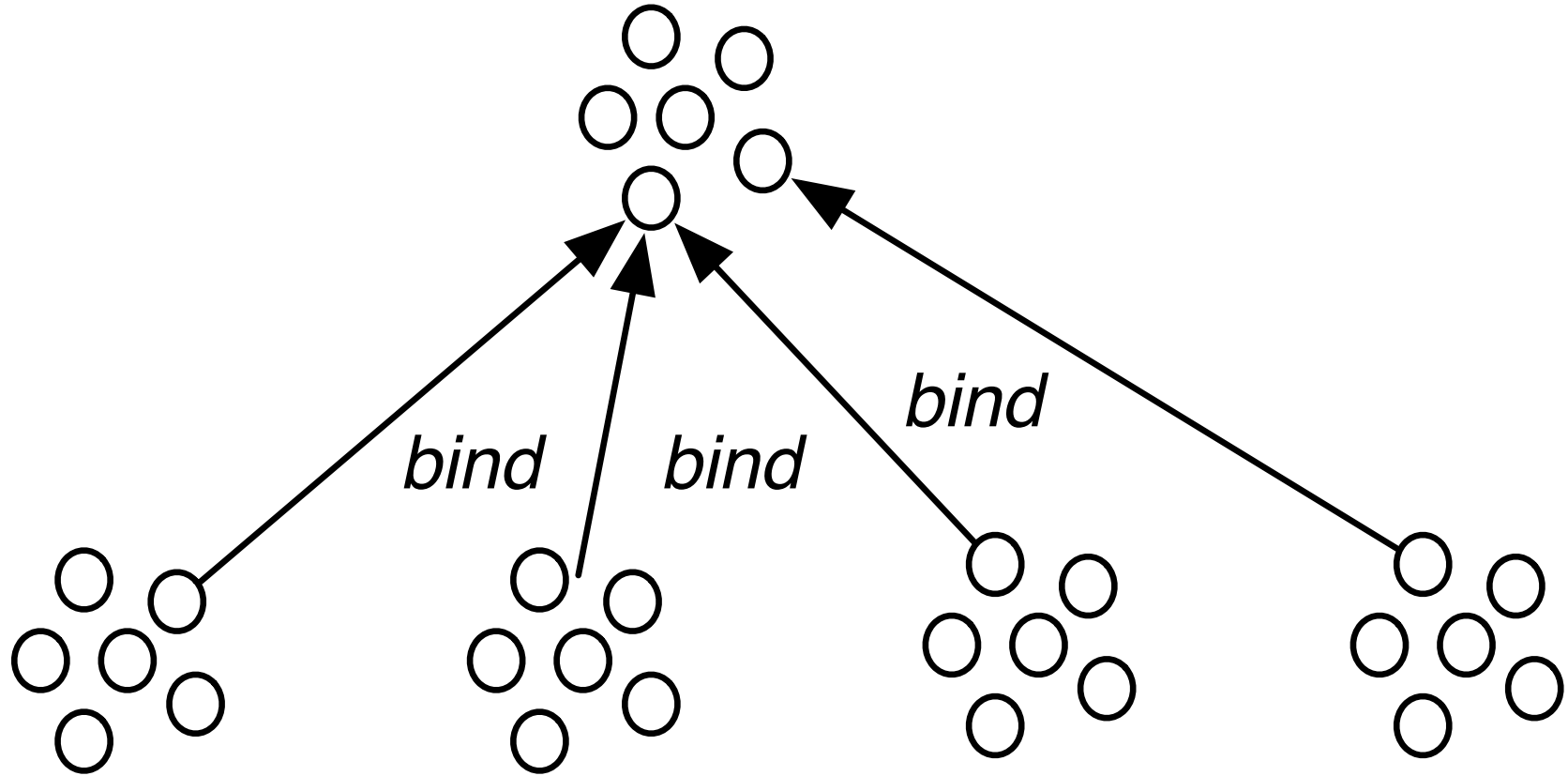




emotion semantic pointer



sadness
semantic pointer



situation:
rejection:
sensory, verbal

appraisal:
e.g. no
relationship

physiology:
low heart rate,
etc.

motor:
withdraw

Cognitive Appraisal

Appraisal is performed by parallel constraint satisfaction that integrates relevance of multiple goals. Thagard & Aubie, “Emotional Consciousness”, 2008.

Fast & frugal appraisal can employ emotional associations of words.

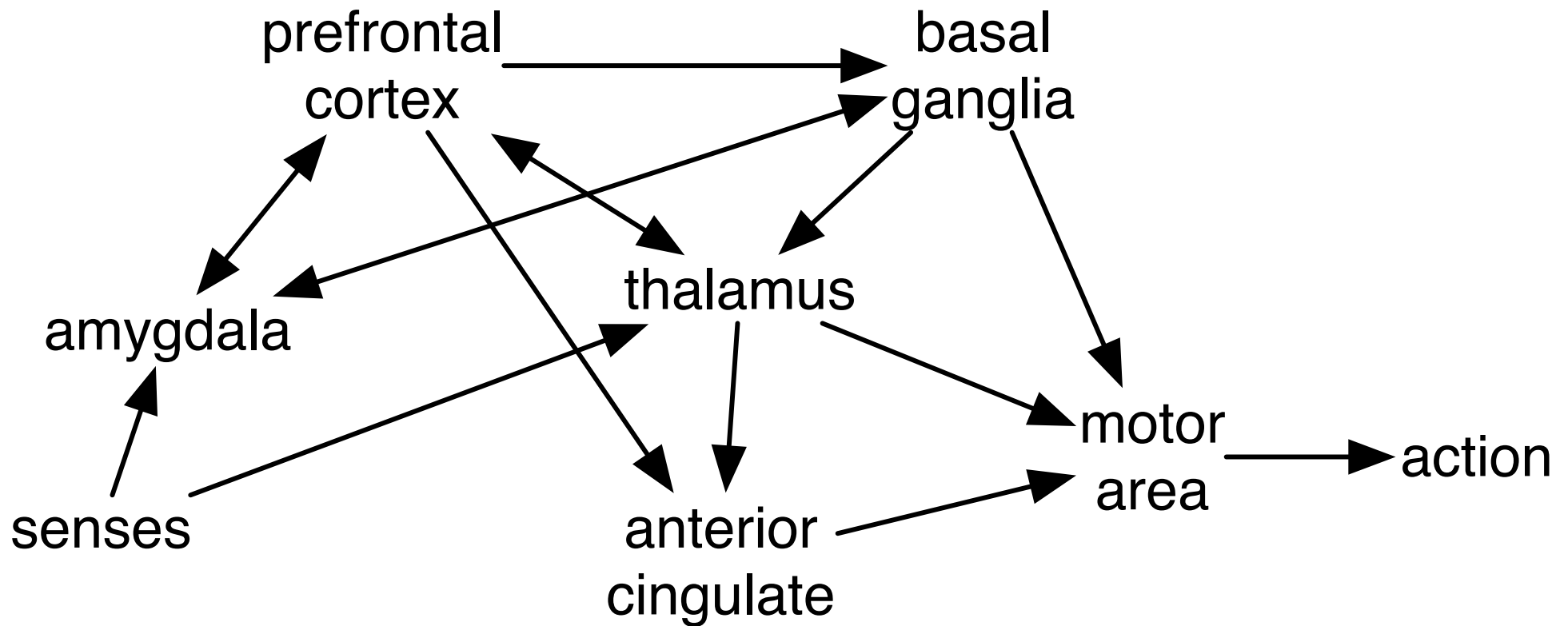
Appraisal in humans can take into account complex representations of self and social situation. Thagard, “The Self as a System of Multilevel Mechanisms”, 2014.

Emotional Phenomena to be Explained

1. How are emotions formed? ✓
2. How do emotions influence actions?
3. Why are emotions usually conscious?
4. How do emotions get distorted in mental illnesses?
5. How can emotions be both rational and irrational?

Emotion + Action

Expanded from Schröder, Stewart, and Thagard, “Intention, Emotion, and Action”, *Cognitive Science*, 2014.



Consciousness: 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.

Thagard & Stewart, “Two Theories of Consciousness”, 2014.

What Needs to be Explained - Consciousness

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.

Emotional Consciousness

Emotions are usually conscious because they outcompete other semantic pointers.

Emotional intensity contributes to the salience of semantic pointers: appraisal, physiology, language.

Conscious emotions can influence actions because they can outcompete automatic actions.

Hard Problem?

Problem: How and **why** do people have qualitative experiences?

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, teaching, social interactions, and delayed gratification, and was therefore selected for. Alternative: mere side effect.

Hard Problem?

Problem: **How** and why do people have qualitative experiences?

1. Emotions result from recursive bindings of representations of body, appraisal, situation, and self.
2. Different feelings result from different bindings, e.g. sad vs. happy.

Conclusions

1. Emotions and consciousness result from neural representation, binding into semantic pointers, and competition.
2. Semantic pointers integrate appraisal, physiology, and construction.
3. Emotions and consciousness are brain processes.



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.

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.

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 important phenomena, e.g. different modalities, stopping/starting, intensity, shifts.
3. It provides a better explanation of the evidence than alternative theories.

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.

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.

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.

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.

Therefore

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

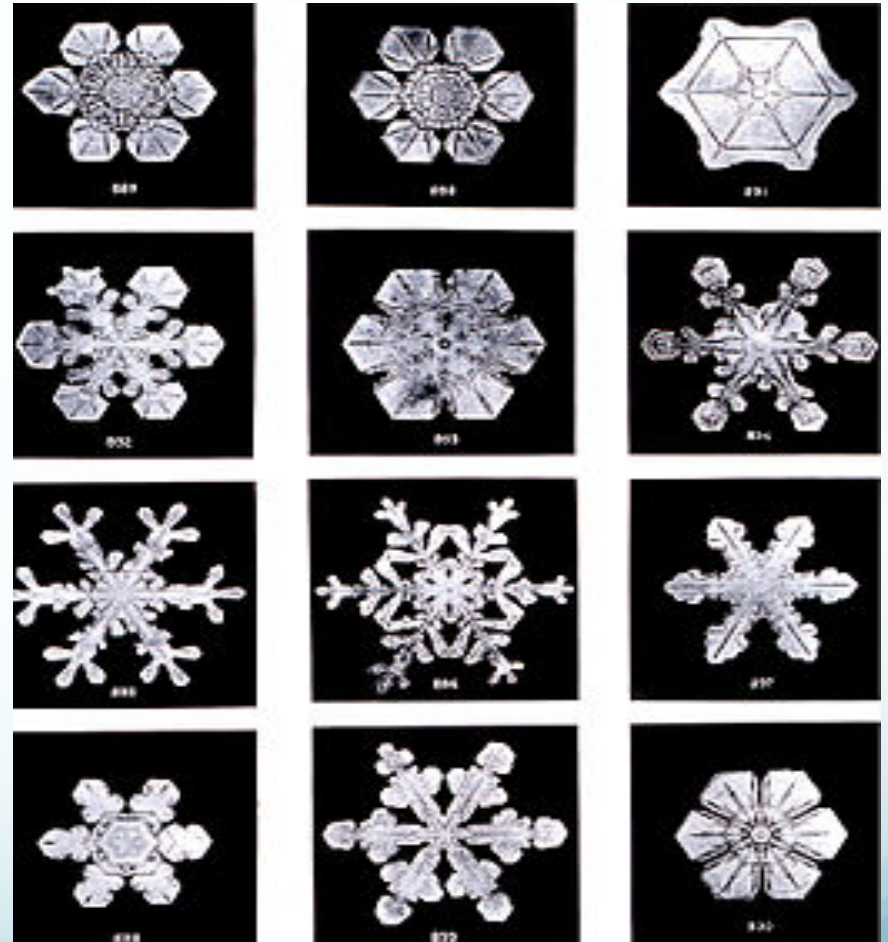
So tentatively, subject to further evaluation, we should believe that consciousness results from semantic pointer competition.

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

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.



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.