How Minds Work

Working & Episodic Memory

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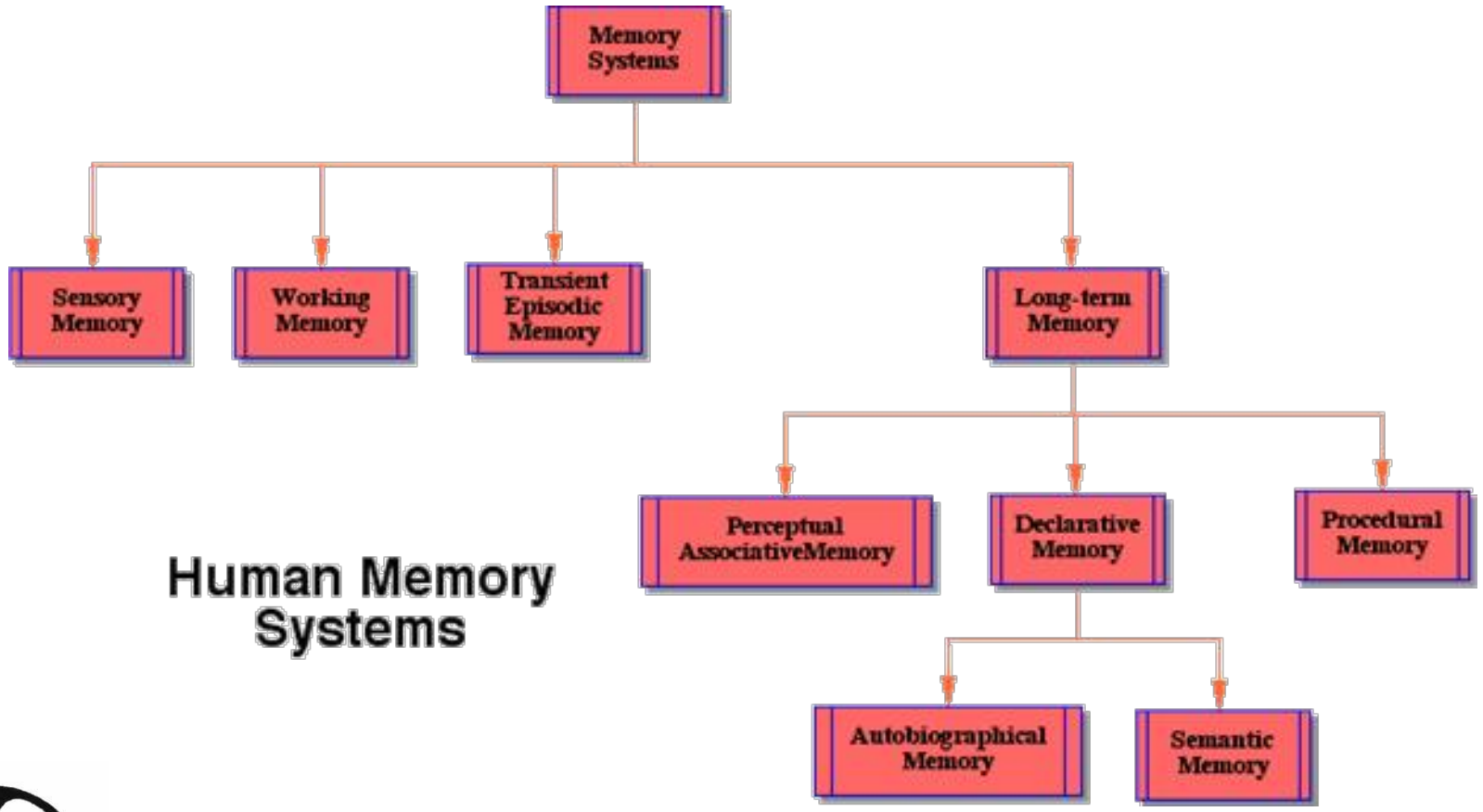
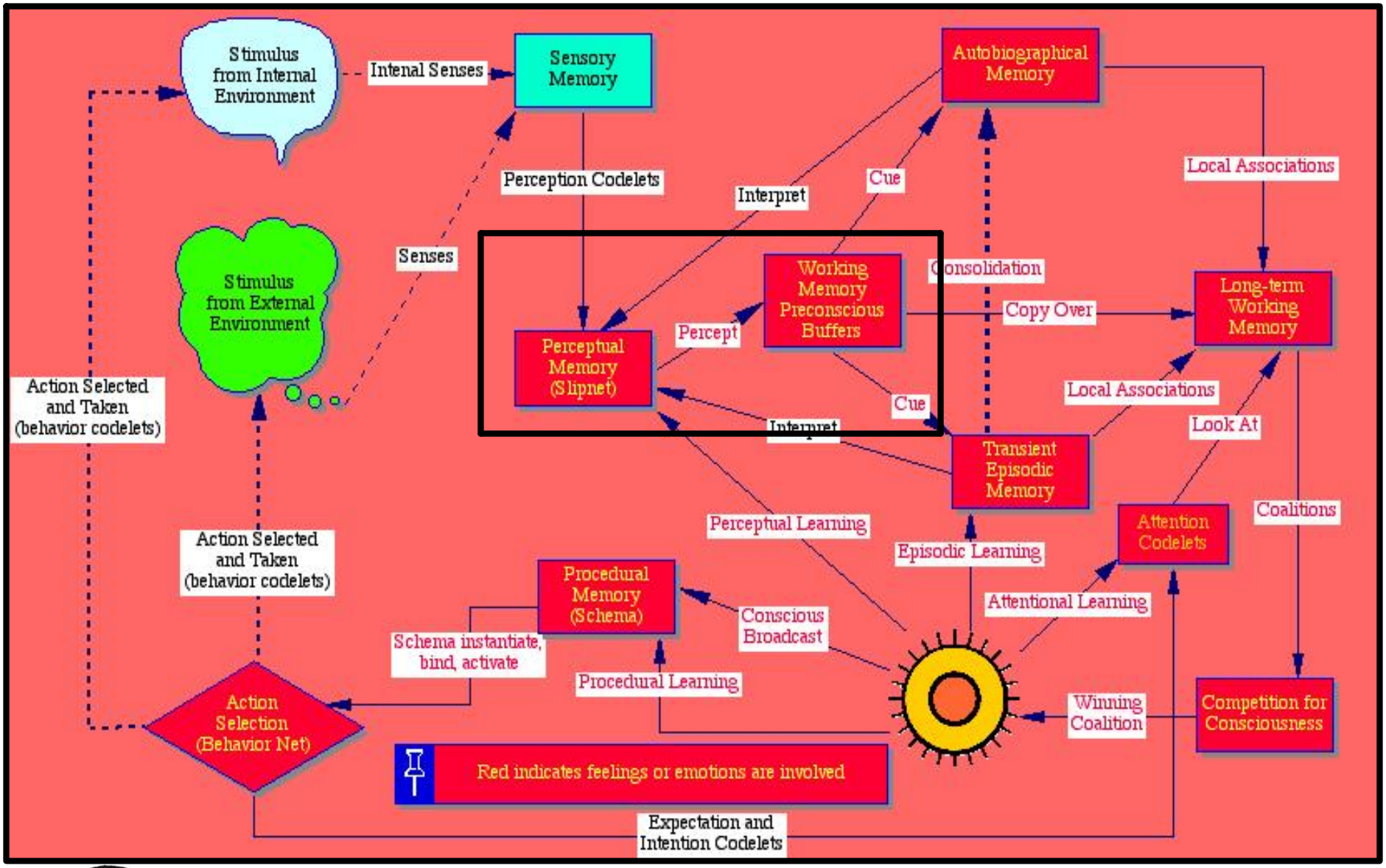
Memory Systems



Human Memory Systems


Stimulus from Internal Environment
Intenal Senses
Sensory Memory
Autobiographical Memory
Local Associations
Perception Codelets
Interpret
Cue
Stimulus from External Environment
Senses
Working Memory Preconscious Buffers
Consolidation
Copy Over
Long-term Working Memory
Percept
Perceptual Memory (Slipnet)
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Look At
Action Selected and Taken (behavior codelets)
Transient Episodic Memory
Perceptual Learning
Episodic Learning
Attention Codelets
Coalitions
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Procedural Memory (Schema)
Conscious Broadcast
Attentional Learning
Schema instantiate, bind, activate
Procedural Learning
Action Selection (Behavior Net)
Winning Coalition
Competition for Consciousness
Red indicates feelings or emotions are involved
Expectation and Intention Codelets

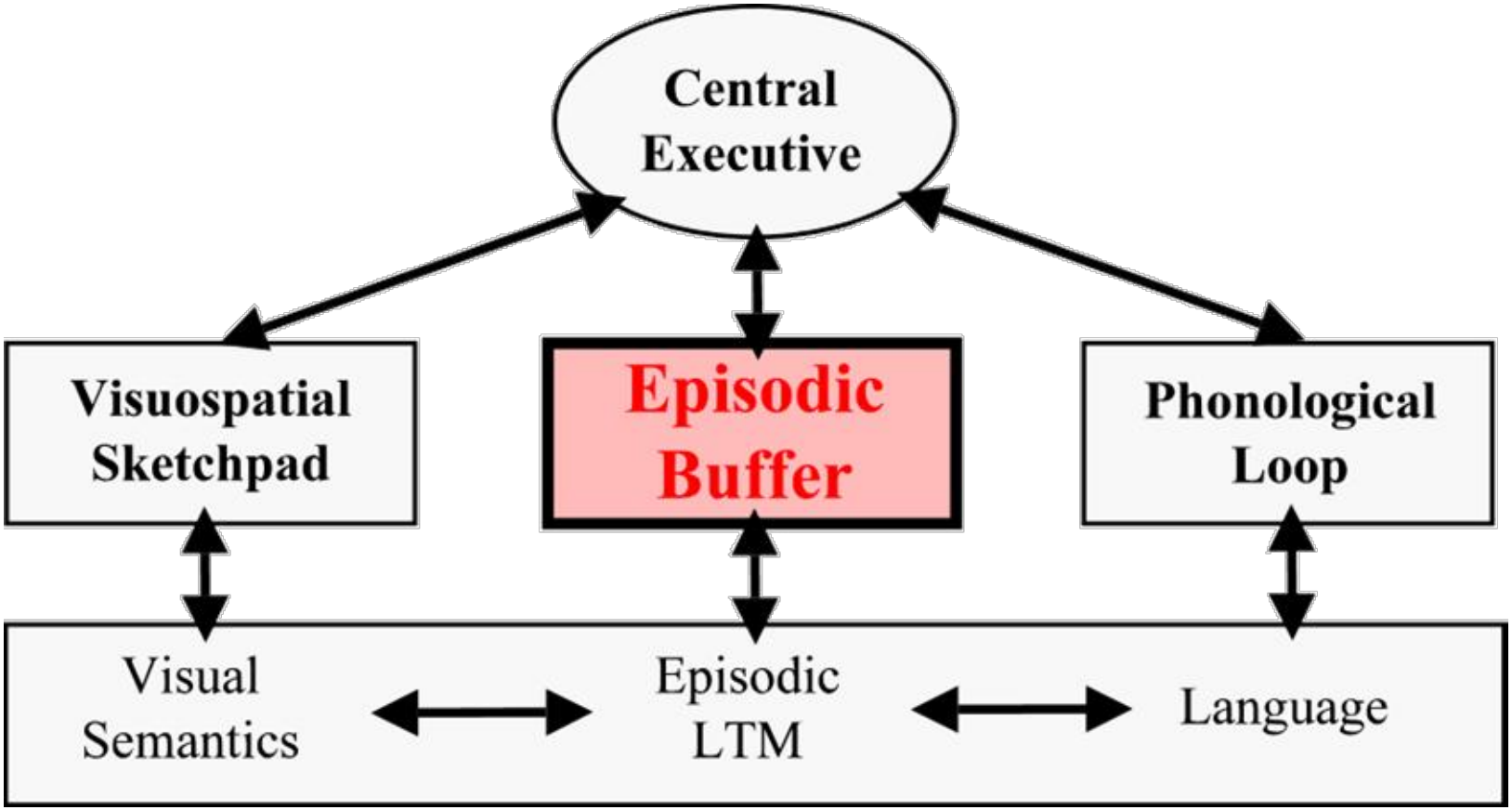
Percept

- Result of filtering in PAM
- Slipnet nodes are perceptual symbols
- Uniform representation throughout
- Includes sensory data, object recognition, categorization
- Preconscious
- May become conscious

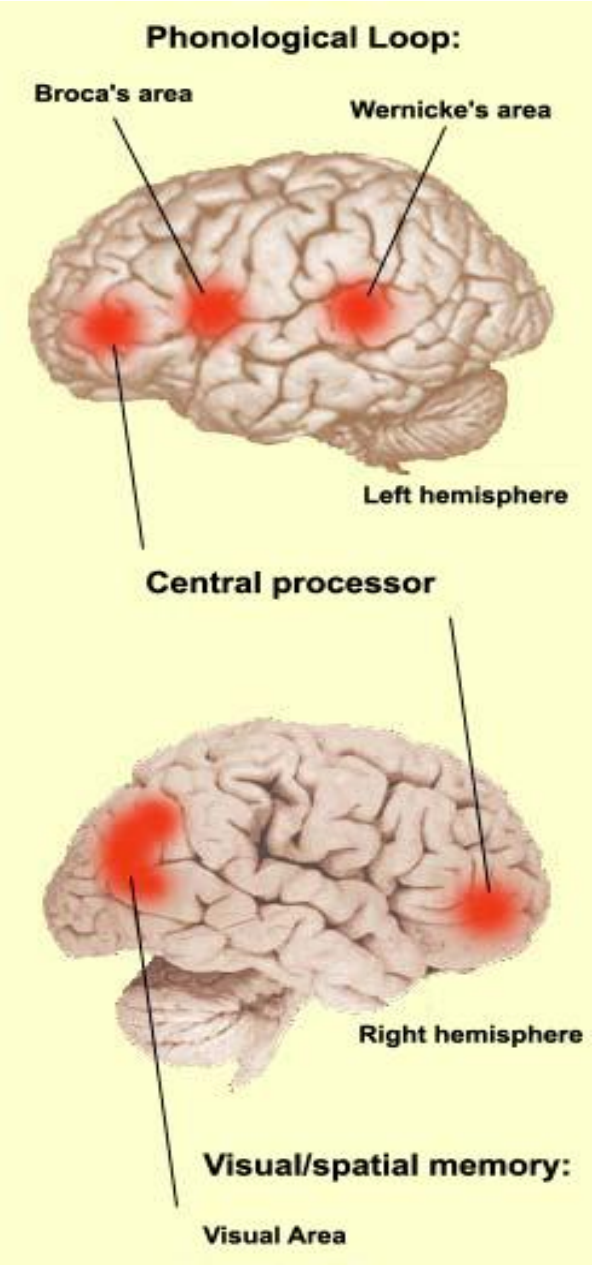
Working Memory

- A process to the psychologists
- Includes action selection & attention
- Attention a euphemism for consciousness
- Baddeley's model of cognition
- Decays within a few tens of seconds
- Limited capacity–seven plus or minus two

Working Memory Diagram



Working Memory in the Brain



Percept to Working Memory

- Preconscious working memory buffers
- One for each sensory modality (?)
- One for binding (? Controversial)
  - May occur during perception
  - Or in the episodic buffer
- Decays over a relatively few cycles

Episodic Memory

- Memory for events
- What, where, when
- Usually assumes conscious recall, internal virtual reality
- Episodic-like memory
- Experiment with scrub jays

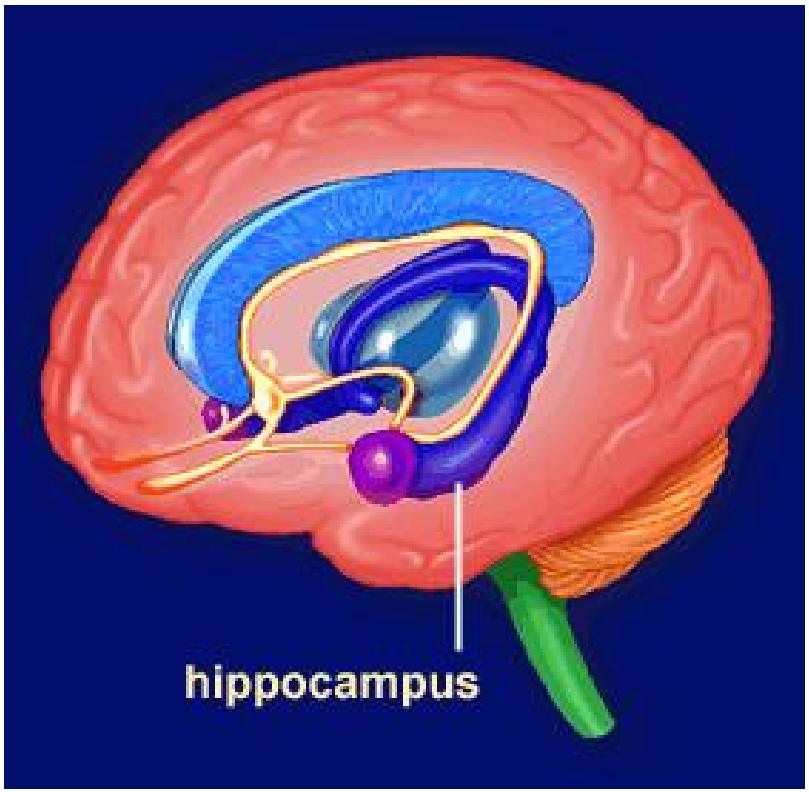
Transient Episodic Memory

- Memory for
  - Where I parked my car in the garage
  - What I had for lunch yesterday
- Interference affects
- Decays in humans in hours or a day

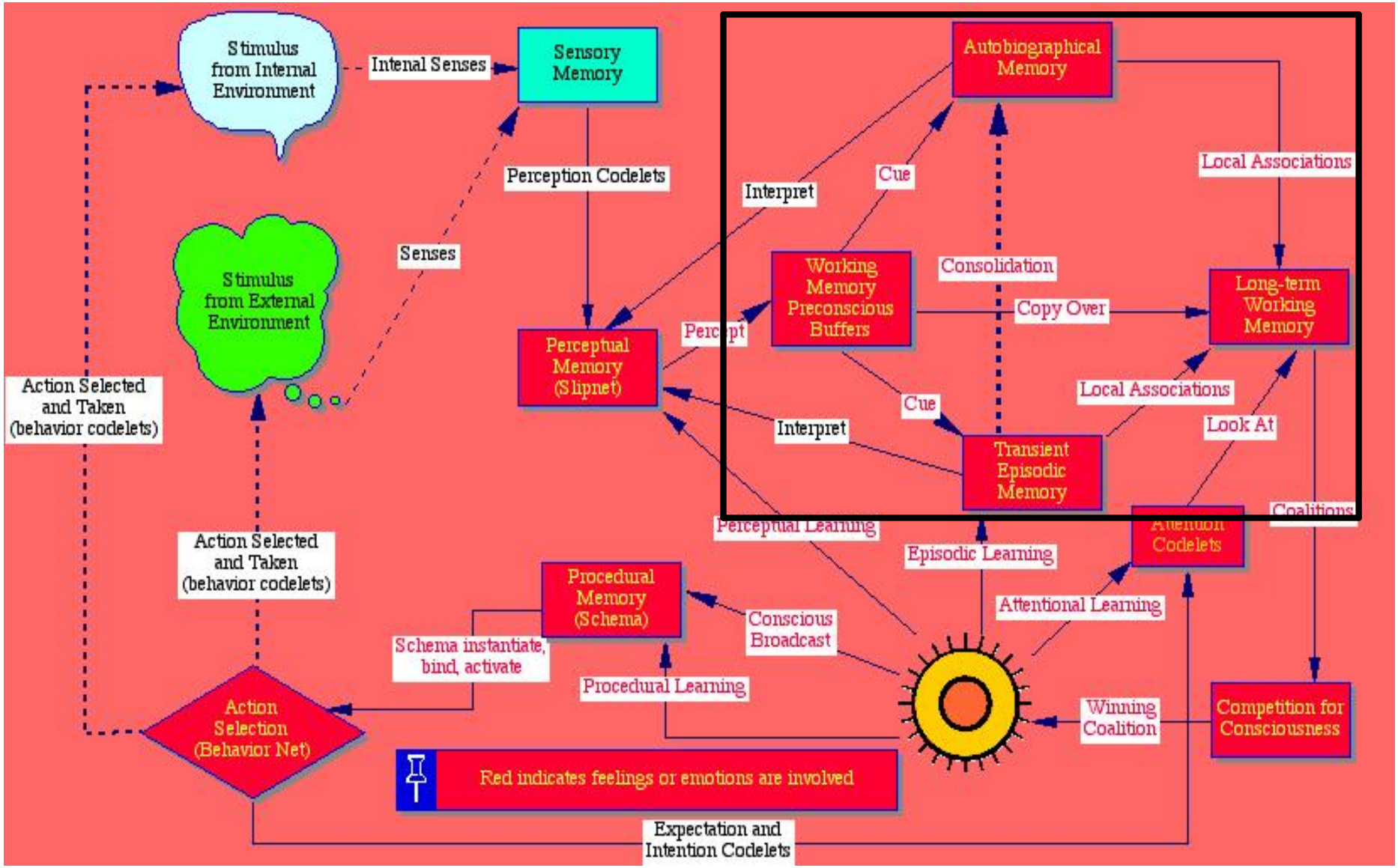
Declarative Memory

- Autobiographical Memory
- Semantic Memory
  - Memory for facts
  - Where and when have been lost
- Consolidation required
- Short and very long term

Hippocampus



- Part of limbic system
- No consolidation without it
- No encoding in transient episodic memory without it
- Clive Wearing movie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Local Associations

- Working memory contents cue
  - Transient episodic memory
  - Declarative memory
- Contents may include previous percepts
- Produces local associations in long-term working memory
- Including prior feelings and actions
- Long-term WM includes (=?) WM

SDM as Memory

- Random (vs sequential access)
  - Retrieve in equal time from any location
- Content addressable
  - Find complete contents from a part
- Associative
  - Find contents similar to a cue

Addresses in SDM

- Addresses — Boolean vectors of length 1000
- Address space = B_{1000}
- Too enormous to ever implement
- Each dimension a feature, either on (1) or off (0)
- 1000 not many features

Hard Locations in SDM

- Choose 2^{20} (~1,000,000) hard locations
- Uniformly distributed in address space
- 2^{20} hard locations out of 2^{1000} locations, ratio is $1/2^{980}$ — very sparse indeed
- median distance from random location to nearest hard location is 424
- Hard locations are certainly sparse

Counters

- Each hard location has 1000 counters
- Each counter has range -40 to 40
- Takes about a gigabyte of memory
- Writing a 1 to a counter increments it; writing a 0 decrements it
- Write to a hard location– write each coordinate to the corresponding counter

Access Sphere

- Access sphere at some location x — sphere of radius 451 centered at x
- Contains about 1000 hard locations
- To write to a location x — write to each hard location in its access sphere
- Distributed representation
- Hence Sparse Distributed Memory

Reading from a Hard Location

- If the *i*th counter of the hard location is
  - Positive, put a 1 in the *i*th dimension
  - Negitive, put a 0 in the *i*th dimension
- This is majority rule at each dimension
- A Boolean vector of the right dimension results
- It may differ from any previously written

Reading from any Location

- Find the access circle centered at the given location
- Read at each hard location in the circle
- Majority rule over these reading
- Iterate using the result as a new location
- Stop if the itteration stabilizes

Retrieval

- Items read in (with themselves as address) can be reconstructed
- Iterated reading allows reconstruction from a partial or noisy cue
- Reconstructions may not be exact
- Interference affects occur

Dimensions as Features

- Each dimension a (primitive?) feature (perceptual symbol)
- Event a collection of features
- Local associations interpreted by PAM

Modified SDM

- Implement TEM with
  - ternary memory space
    (0, 1 & “don’t care” [*])
  - binary address space for the *hard locations*
- Memory writes with partial feature-sets
- Flexible cuing with fewer features
- Missing features represented by “*”

Readings

- Read about Perceptual Symbols in
  - Barsalou, L. W. 1999. Perceptual symbol systems. *Behavioral and Brain Sciences* 22:577-609.
- Read about Working Memory in
  - Baddeley, A. D. 2000. The episodic buffer: a new component of working memory? *Trends in Cognitive Science* 4:417-423.
  - Baars, B. J., and S. Franklin. 2003. How conscious experience and working memory interact. *Trends in Cognitive Science* 7:166-172.
- Read about Transient Episodic Memory
  - Conway, M. A. 2002. Sensory-perceptual episodic memory and its context: autobiographical memory. In *Episodic Memory*, ed. A. Baddeley, M. Conway, and J. Aggleton. Oxford: Oxford University Press

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