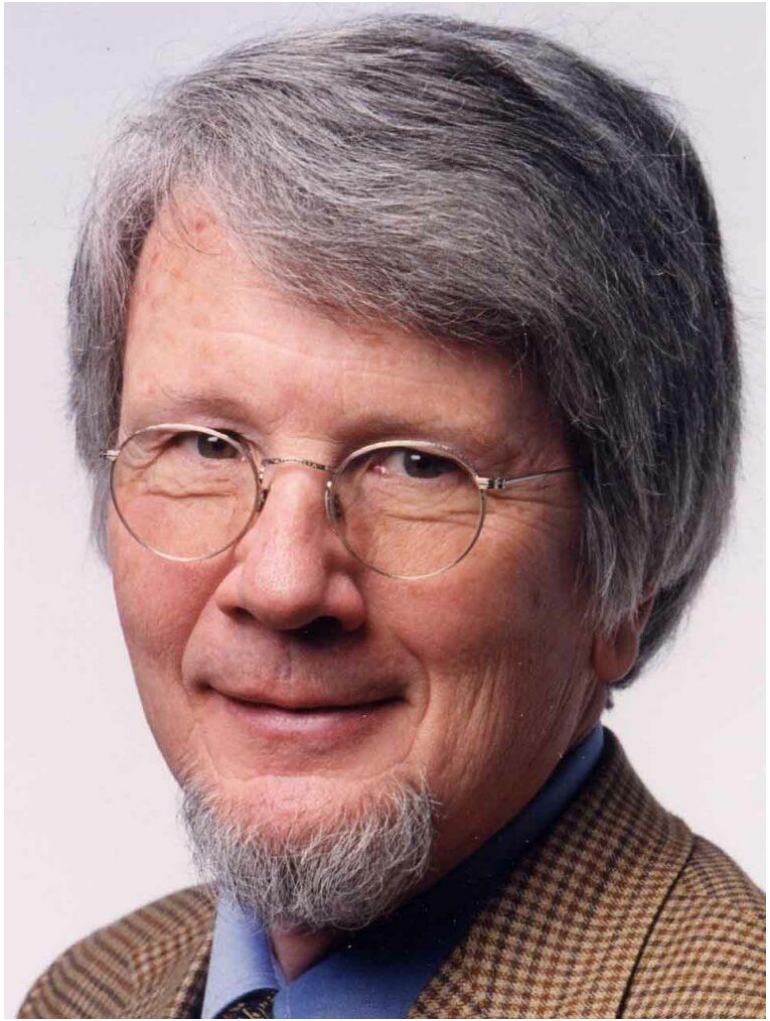
Randy Gallistel on Memory

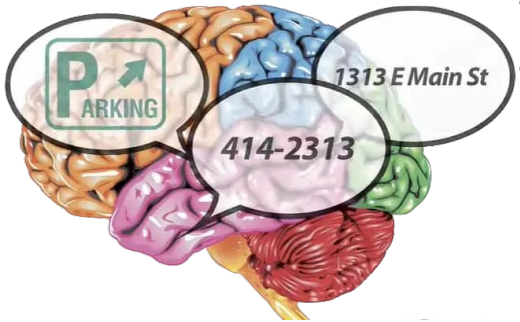
A presentation by Otto Mättas



Charles Ransom Gallistel

- b. 1941
- Professor Emeritus of Psychology at Rutgers.
- Known for challenging established neuroscience perspectives on memory.

The Nature of Memory



- memory is a fact-based system, full of facts.
- mainstream neuroscience does not address memory as being filled with explicit, retrievable facts.

Desert Ant Navigation Case Study

The Problem

- Desert ants return home in straight lines after complex foraging paths
- Navigate accurately in featureless terrain
- Store and compute exact distances and angles

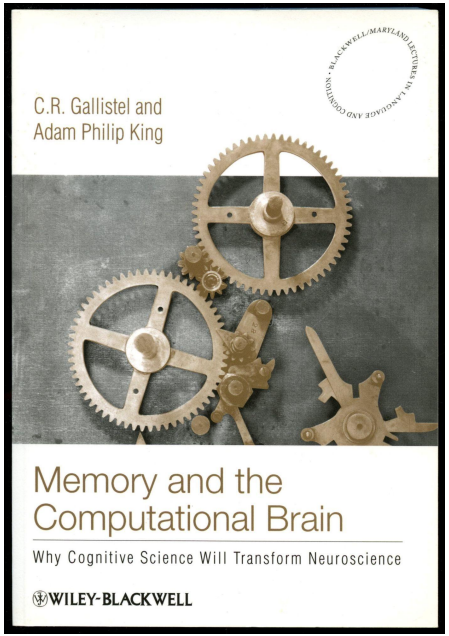
Why it matters?

- Requires precise numerical storage
- Path integration involves ongoing calculations
- Can't be explained by simple associative learning

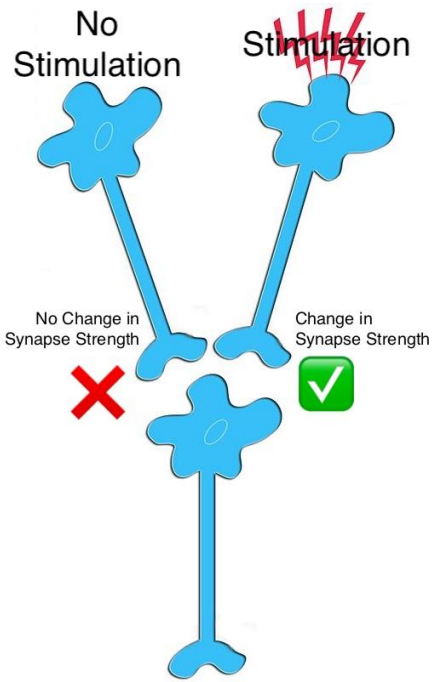
Implications

- Demonstrates need for exact number storage
- Shows active computational processes
- Supports Gallistel's symbolic memory theory

Computational Theory of Mind

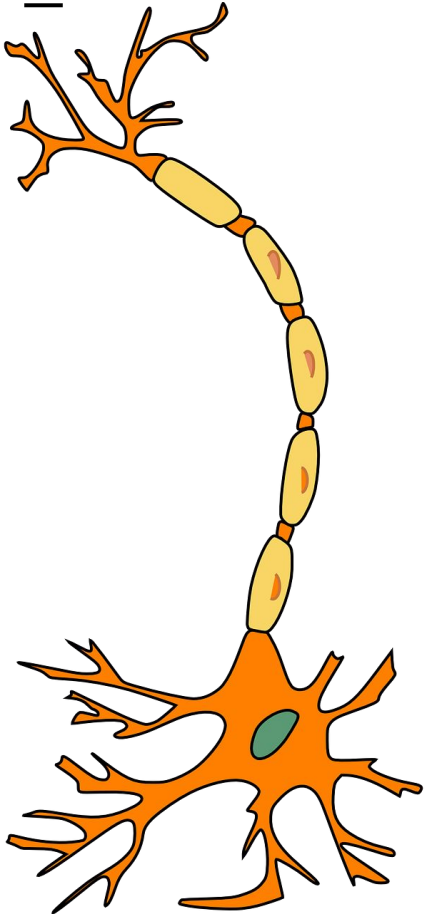


- the brain must have an addressable, read-write memory mechanism that encodes, stores, and retrieves facts similar to a computer.
- memory involves symbolic processing, contrasting with the dominant connectionist model focusing on associative synaptic connections (associationism).



Synaptic Plasticity

- can not be the basis / register of memory.
- does not explain how specific information, like numerical data, is stored:
  - distances,
  - directions,
  - temporal durations.
- How do you store a number in a synapse?

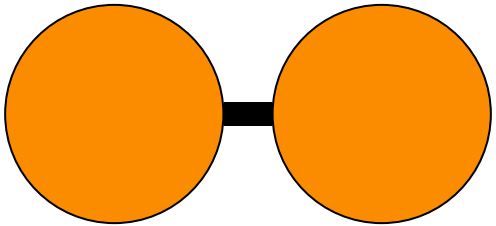


Memory Storage Theory

- memory might be stored within individual neurons rather than across synapses.
- memories could be encoded in **polynucleotides**, such as DNA or RNA, which allows for stable, symbol-based storage.

Two Views of Memory Storage

Traditional

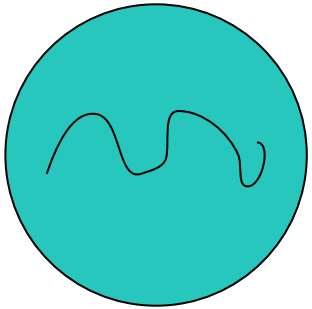


Synaptic Storage

Stores patterns through connection strengths

VS

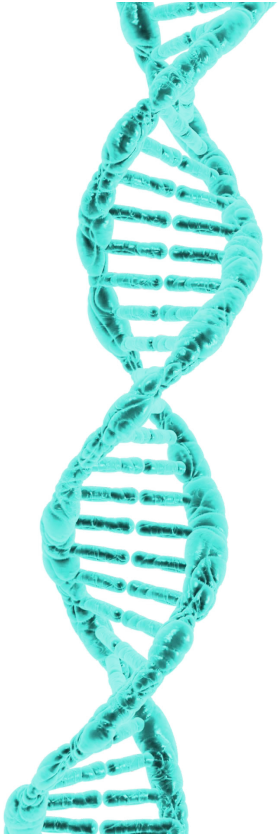
Gallistel



Intracellular Storage

Stores precise values like computer memory

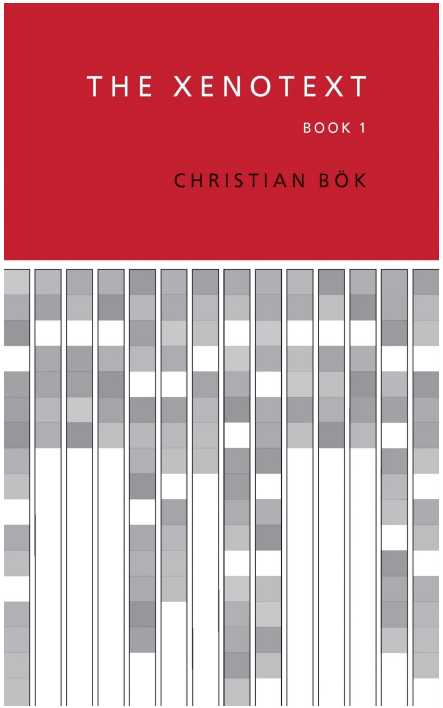
Engrams are hypothetical units of memory stored in the brain or other tissue.

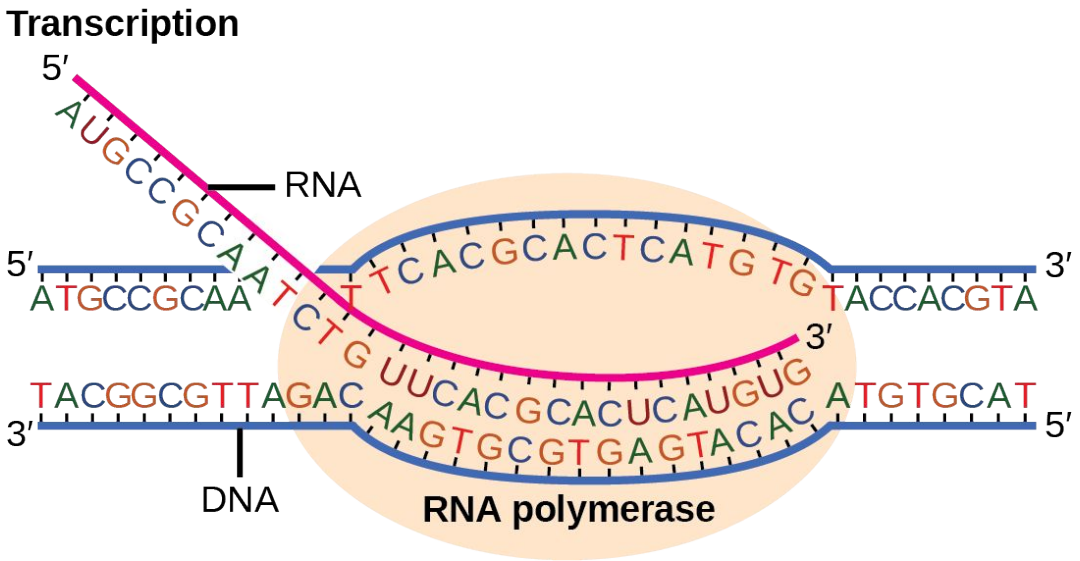


Memory's Physical Trace

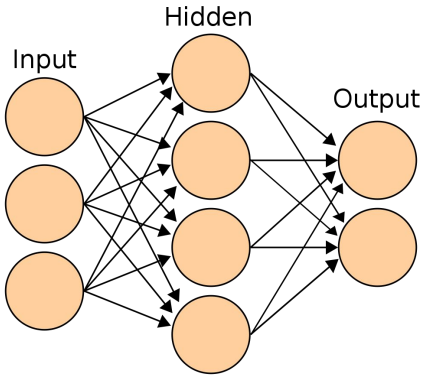
- **engram** is the hypothesised physical trace of memory.
- memories are stored intracellularly and not as distributed synaptic patterns.
- understanding intracellular mechanisms, like RNA-based storage, might reveal how memories are encoded.

The Xenotext





Universal Approximation Theorem



- neural networks can approximate functions.
- this does not equate to genuine symbol manipulation or memory encoding.

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Memory, Facts, and Symbolism

- the necessity of symbols in cognitive processing, contrasting with current models of artificial neural networks.
- he believes computational theories must address the symbolic nature of memory.
- symbols are fundamental for memory and cognition, beyond associative links.

Practical Implications

For Medicine

- New approach to memory disorders
- Target molecular mechanisms inside neurons
- Potential for more precise interventions

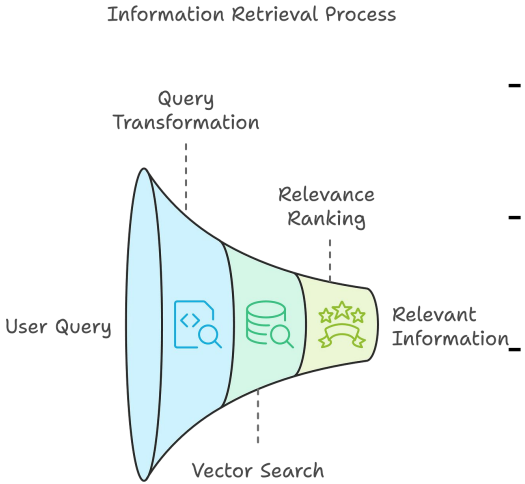
For AI Development

- Rethinking neural network design
- Combining symbolic and neural processing
- More accurate memory storage systems

For Future Research

- Focus on intracellular mechanisms
- Develop new tools for memory investigation
- Bridge gap between AI and biological memory

Implications for the Future



- potential impacts of Gallistel's ideas on neuroscience and cognitive science.
- reshape memory studies and influence computational models of the brain.
- impacts on AI or machine learning if we incorporate symbolic models of memory.

Gallistel's Legacy

- questioning the fundamentals.
- explore new possibilities for cognitive processes.
- ongoing interdisciplinary dialogue.

How do you store a number in a synapse?