Associativity Mechanisms in a Neural Network Model of Conscious and Unconsious Processes

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Motivation

- Develop schematic, self-organizing, neural-network models to describe mechanisms associated with mental processes.

Neurocomputational Models

- Understand the importance of the capacity for operating on symbols in the psychic aparatus and in therapy.
- Understand cognitive functions involved in consciousness ⟶ artificial consciousness
- Study the topological properties of these models. Concepts and methods from statistical mechanics and complex networks.

Neuroses by Freud

- Traumatic or repressed memories are knowledge which is present in the subject, but which is momentarily or permanently inaccessible to his consciousness: unconscious knowledge.

- Neurotic patients systematically repeat symptoms in the form of ideas and impulses: compulsion to repeat, related to the repressed memories.

- Neurotics have obtained relief and cure from strong neurotic symptoms through a mechanism called working-through: constructing conscious knowledge of the repressed and understanding and changing the compulsion to repeat through transference → creativity.

  Freely talking, analyzing dreams, etc...

- Freud's observations regarding the unconscious may give us important insight regarding basic neuronal mechanisms underlying consciousness.

Functional Model for Neuroses

Neuroses manifest themselves as an associative memory process: network returns a stored pattern, when it is shown another input pattern sufficiently similar to the stored one.

Compulsion to repeat: neurotic symptom is acted when the subject is presented with a stimulus which resembles, at least partially, a repressed or traumatic memory trace, $\hat{S}$.

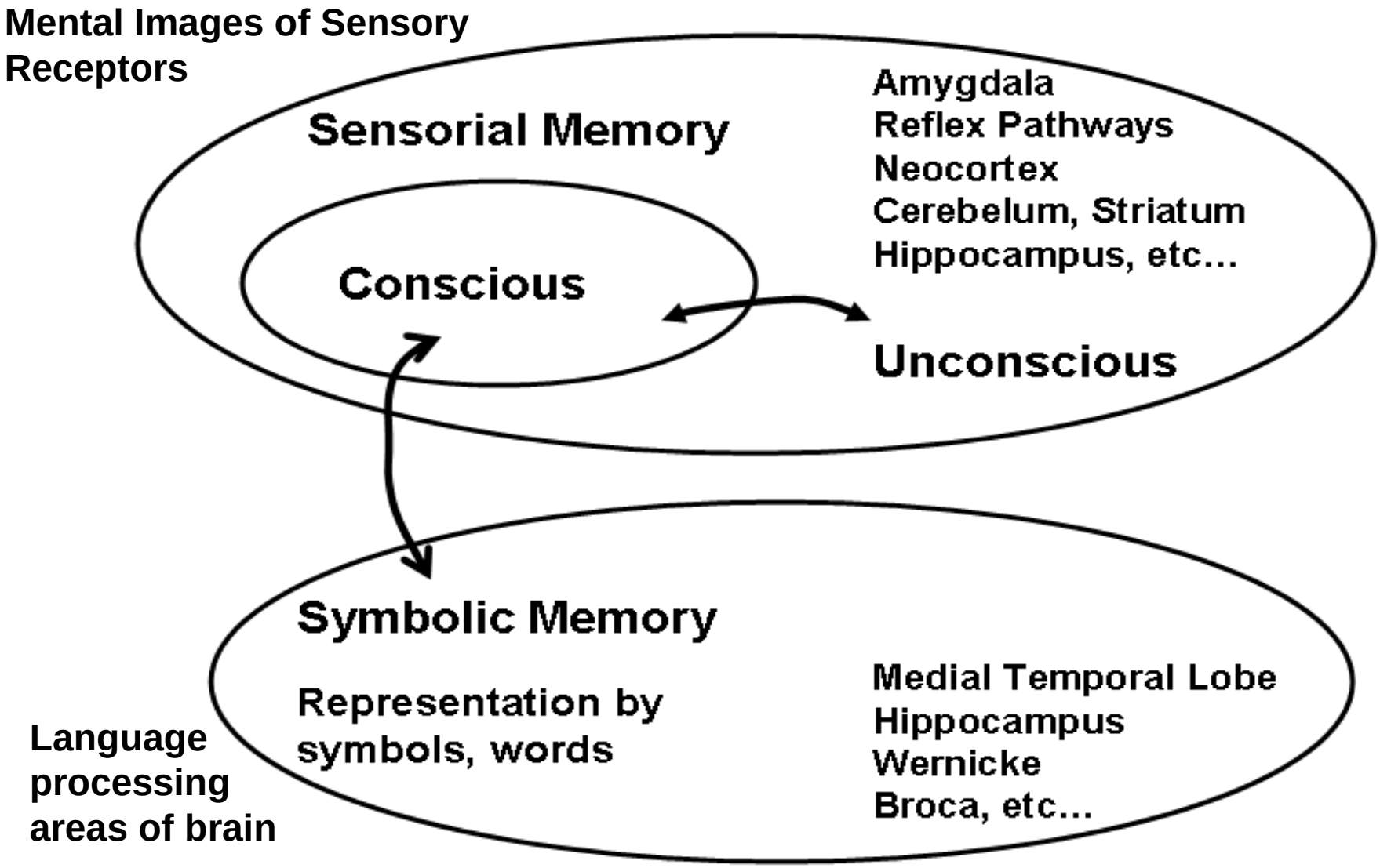
stimulus → net stabilizes on $\hat{S}$ → neurotic act

Neurotic behavior: the act isn´t a result of the stimulus as a new situation, but a response to $\hat{S}$.

Psychoanalytic working-through:

linguistic, symbolic associative process, language → **reinforcing synapses among memory traces in brain (also declarative memory, consciousness)**

Architecture for Conscious / Unconscious Processes



Computational Model

We developed **Algorithm Neuroses**[1,2] to ilustrate these ideas.

- **Hierarquical Clustering Algorithm**: generates clustered hierarchical topology in memory networks, based on competitive and cooperative biological mechanisms: neural growth factors and Hebbian learning. Networks store neurotic traces.
- **Memory Access Mechanism**: Simulated annealing mechanisms on the network to reach stable states of the neural net ⟶ stored memory traces.
- **Working-through Algorithm**: based on Hebbian learning mechanism that regulates synaptic plasticity and reconfigures connectivity of network topology. ⟶ New stable memories.

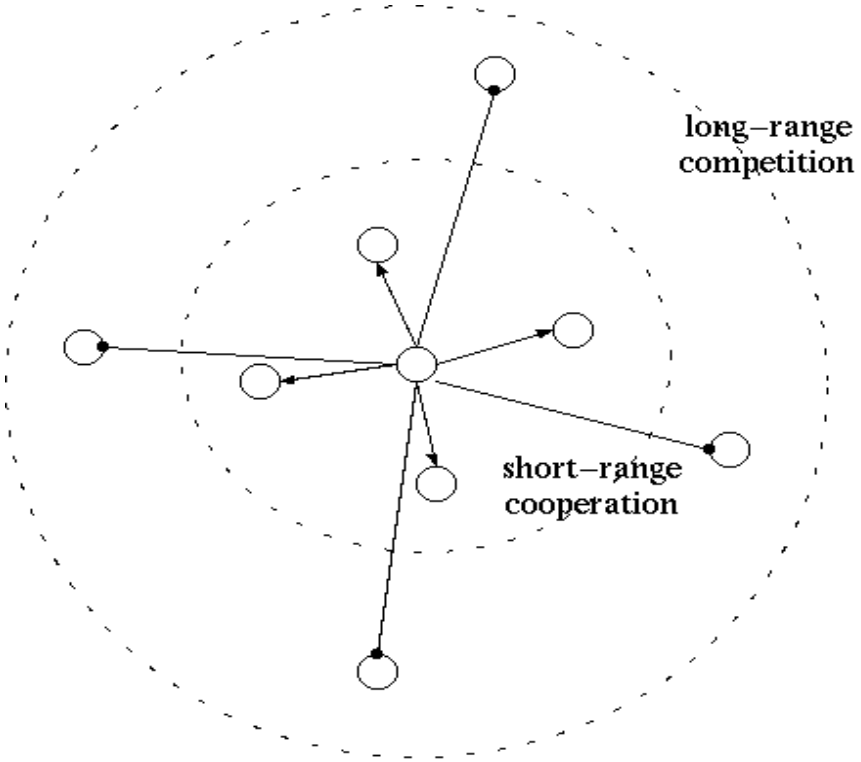
[1] **R. S. Wedemann, R. Donangelo, and L. A. V. Carvalho, Chaos 19, 015116, 2009.**

[2] **R. S. Wedemann, L. A. V. Carvalho, and R. Donangelo, Neurocomputing, 71, 3367–3371, 2008.**

Hierarquical Clustering Algorithm: generates structure of the topology of each memory

In many animals,
brain cells have
a structure called[1]
on-center / off-surround.

Cooperation / Competition



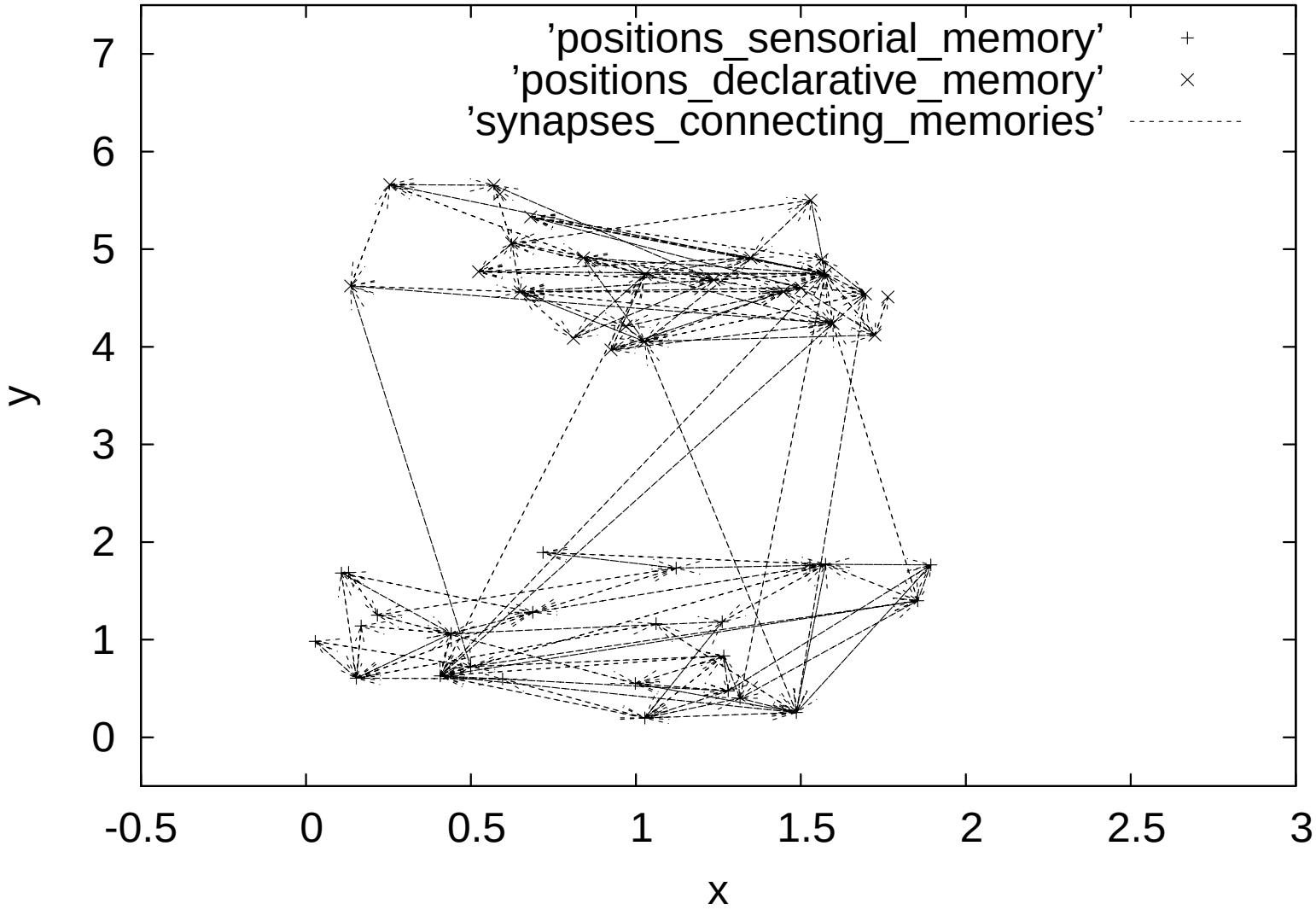
[1]**H. Hartline, F. Ratcliff, "Inhibitory Interactions of Receptor Units in the Eye of Limulus", Journal of General Physiology, 40, 351-376, 1957.**

excitation

inhibition

Network Topology with Long Range Synapses:

N = 50, σ = 0.58



```
ERROR: invalidrestore
OFFENDING COMMAND: restore

STACK:

-savelevel-
-savelevel-
-dictionary-
```