

Hierarchical Temporal Memory

A Theoretical Framework for the Neocortex

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LessWrong Community Weekend 2019

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Tests for Intelligence

Tests for Intelligence

- Turing test

Tests for Intelligence

- Turing test
- 'IQ' tests

Tests for Intelligence

- Turing test
- 'IQ' tests
- Problem solving tests

Tests for Intelligence

- Turing test
- 'IQ' tests
- Problem solving tests
- Tests for behaviour

Tests for Intelligence

- Turing test
- 'IQ' tests
- Problem solving tests
- Tests for behaviour
- ...

Defining Intelligence

What does the brain **do**
all the time?

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The Human Brain in Numbers

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Neurons in cerebellum	69 billion (80%)
Rel. size of cerebellum	10% of brain
Neurons in cerebral cortex	16 billion (19%)
Rel. size of cerebral cortex	82% of brain
Neurons in brain stem	1 billion (1%)

Data from [1].

The Human Brain

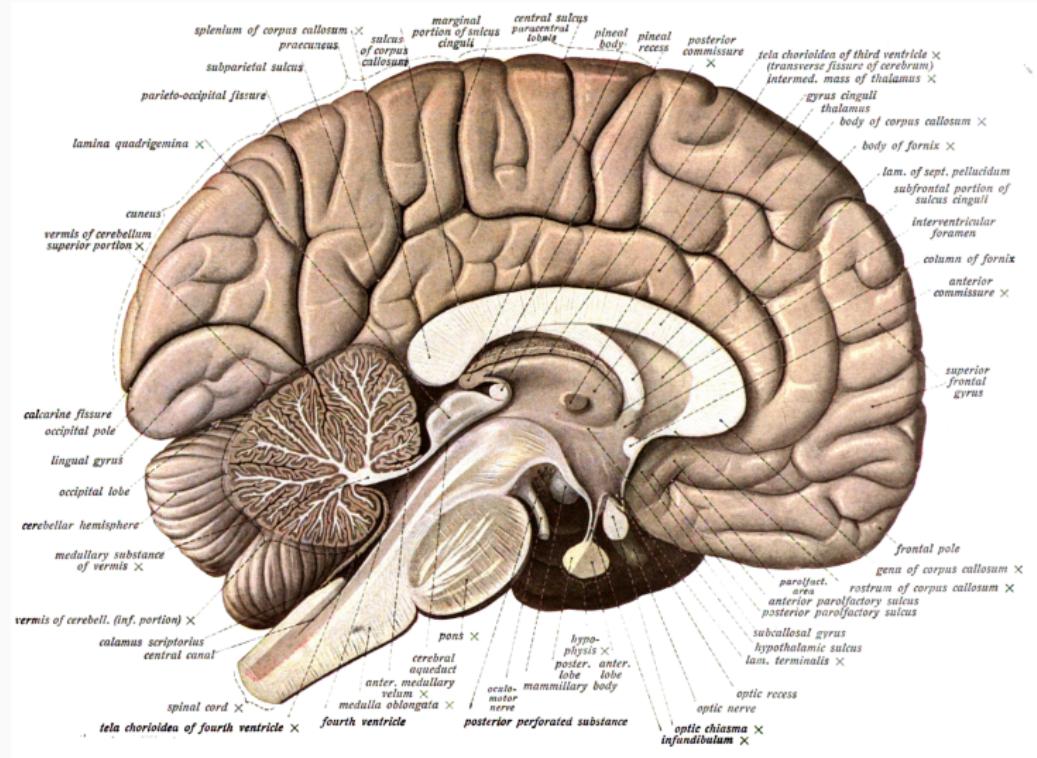
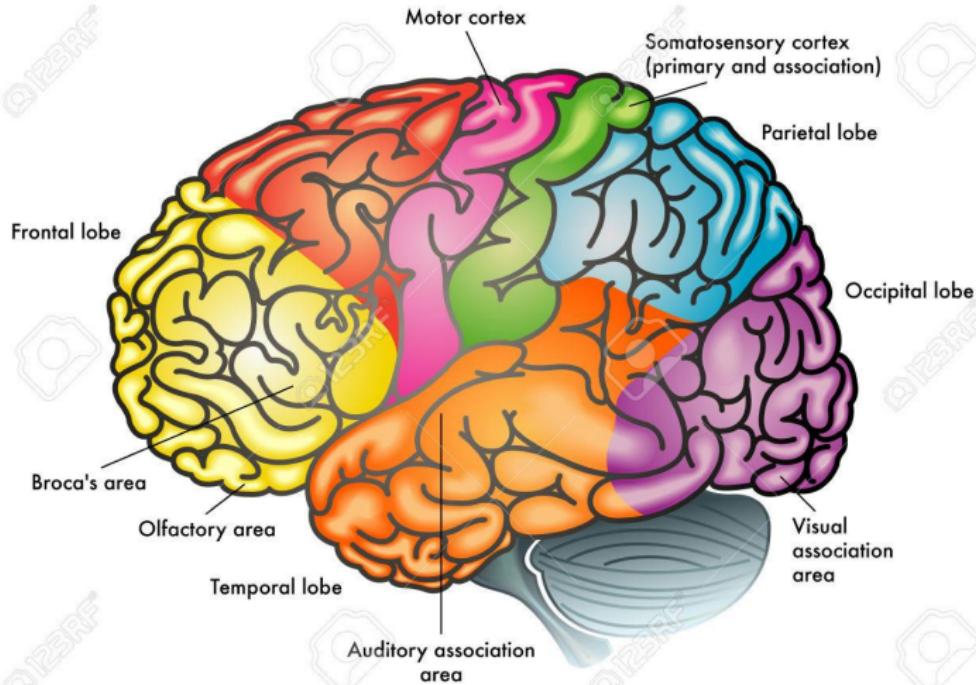


Image from [2].

The Human Brain - Different Areas



Cortical Column

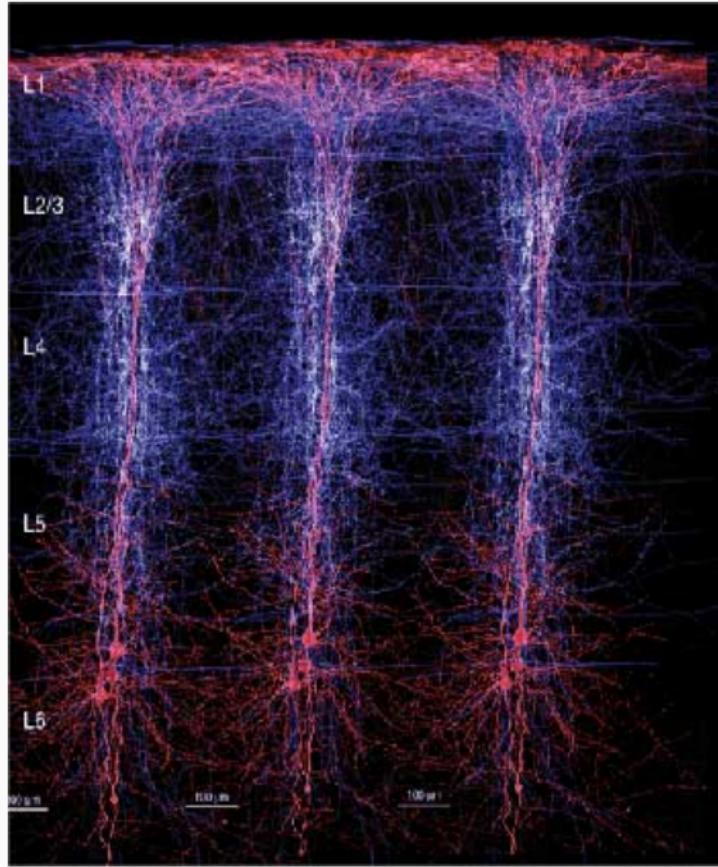


Image from [3].

Cortical Column

- Everywhere in the Brain

Cortical Column

- Everywhere in the Brain
- 200-400 Neurons

Cortical Column

- Everywhere in the Brain
- 200-400 Neurons
- smallest symbol unit

Neuron - Number of Connections

Neuron - Number of Connections

Min. n. of connections	1'000
Avg. n. of connections	7'000
Max. n. of connections	10'000

Neuron - Number of Connections

Min. n. of connections	1'000
Avg. n. of connections	7'000
Max. n. of connections	10'000
Firing Rate	20-250 Hz (453 Hz [4])

Connection data from [1] and firing rate from [5].

Neuron - Spike Frequencies

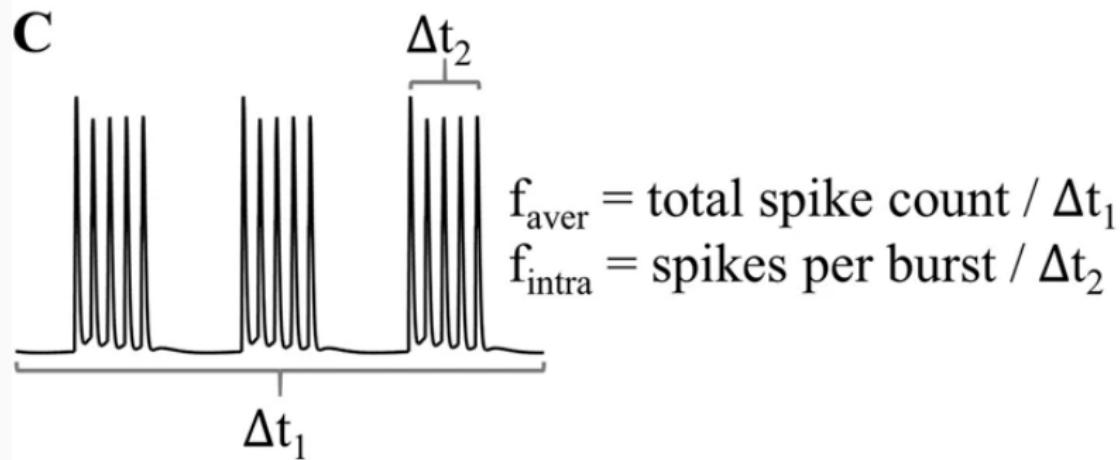


Image adapted from [6].

Neuron - Overview

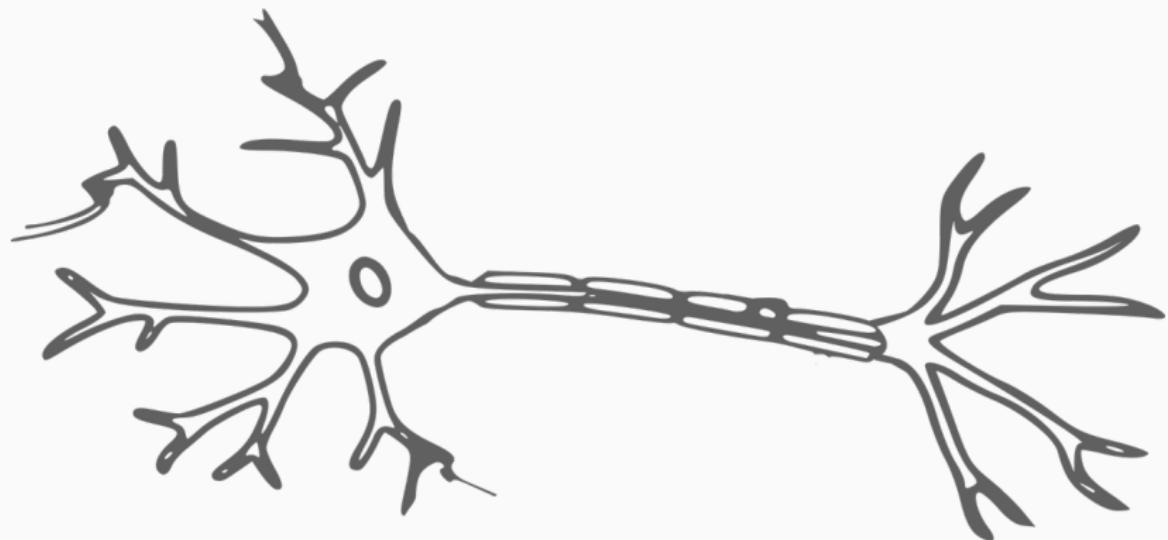


Image from [7].

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What is HTM?

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- biologically constrained **theory of intelligence**

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- **based on neuroscience** of the brain

What is HTM?

- biologically constrained **theory of intelligence**
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- **based on neuroscience** of the brain

→ Learning Algorithms

What is HTM?

- biologically constrained **theory of intelligence**
 - originally described in "On Intelligence"
 - **based on neuroscience** of the brain
- Learning Algorithms (of the brain)

Attributes of HTM Algorithms

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- can store, learn, infer and recall higher-order sequences

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- suited for prediction, anomaly detection, classification

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- can store, learn, infer and recall higher-order sequences
- learns unsupervised time-based patterns in unlabeled data on continuous streams
- robust against noise
- can learn multiple patterns at once
- suited for prediction, anomaly detection, classification
- tested and implemented in software
- commercially used

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Why Hierarchy?

Why Hierarchy?

If there is a connection cost, hierarchies are more efficient [8].

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If there is a connection cost, hierarchies are more efficient [8].

Especially when tasks change regularly.

Why Hierarchy? II

Why Hierarchy? II

- Reduced Training Time

Why Hierarchy? II

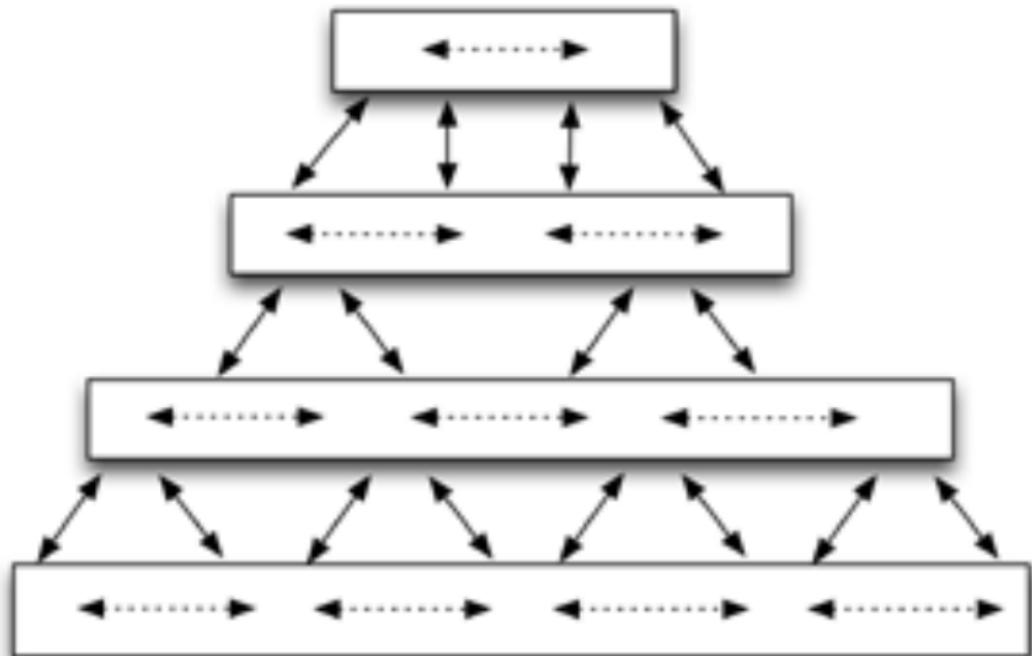
- Reduced Training Time
- Reduced Memory Usage

Why Hierarchy? II

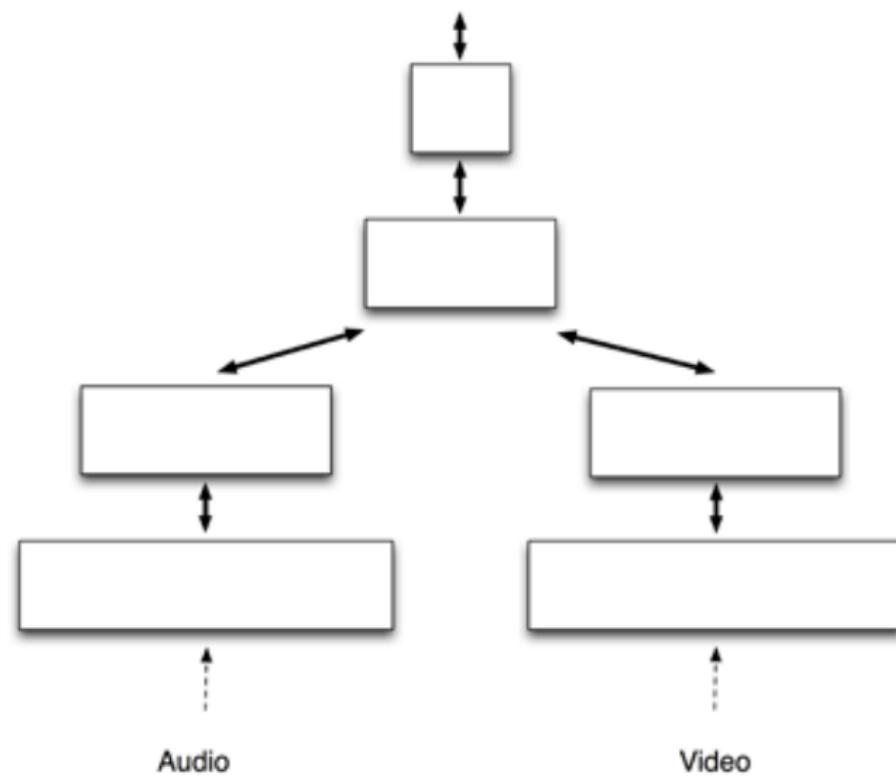
- Reduced Training Time
- Reduced Memory Usage
- Learned patterns are recombined at higher levels

What Hierarchy

What Hierarchy



For What



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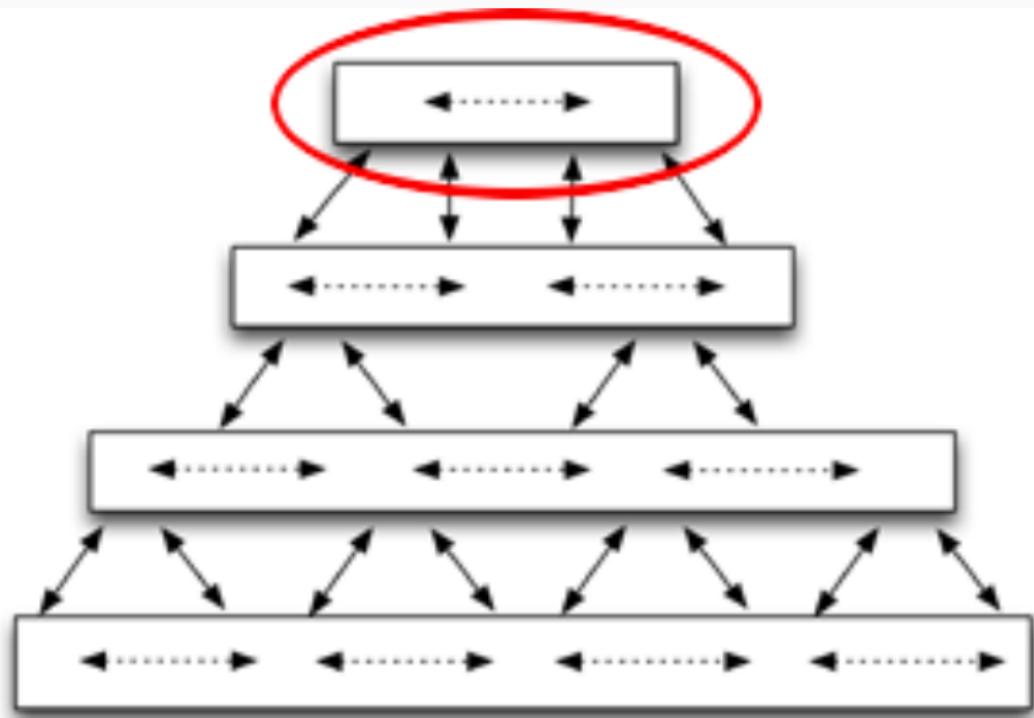
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Introduction - Region

Introduction - Region



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Attributes of the Brain

Attributes of the Brain

- Invariant

Attributes of the Brain

- Invariant
- Auto-associative

Attributes of the Brain

- Invariant
- Auto-associative
- Massively Parallel

Bit Arrays

Bit Arrays

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Main Brain Task

What does the brain **do**
all the time?

Main Brain Task

What does the brain **do**
all the time?

Predict.

What does the brain **do**
all the time?

Predict. Learn.

Definition - Intelligence

Intelligence

Definition - Intelligence

Intelligence is the ability to create models.

Definition - Intelligence

Intelligence is the ability to create models.

Not behaviour. Or anything else.

Definition - Understanding

Understanding

Definition - Understanding

Understanding means to have a precise model about <Thing>.

Definition - Meaning

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Open Questions

- Neuron fire frequency

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Sources i

The slides are online: <https://github.com/fkarg/things-to-talk-about/blob/master/htm/main.pdf>

Drop me a mail: fkarg10@gmail.com

Sources ii

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End

Additional slide

without numbering, does not show up in normal numbers