



A THOUSAND BRAINS

A new theory of intelligence

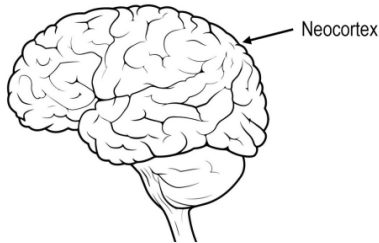
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New Brain

Human brain itself had evolved over time by adding new parts on top of the older parts. The newest part of our brain is the **neocortex**, which means “new outer layer.” All mammals, and only mammals, have a neocortex.

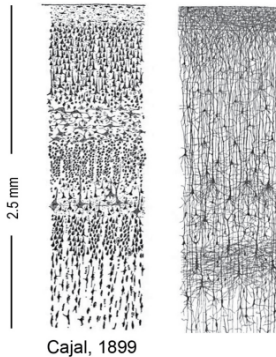
The human neocortex is particularly large, occupying about 70 percent of the volume of our brain. It wraps around the older parts of the brain such that when you look at a human brain, most of what you see is the neocortex (with its characteristic folds and creases).



A human brain

Neocortex

The neocortex is the organ of intelligence. Almost all the capabilities we think of as intelligence —such as vision, language, music, math, science, and engineering— are created by the neocortex. So to understand how the brain creates intelligence, first we must understand the neocortex.



Neurons in a slice of neocortex

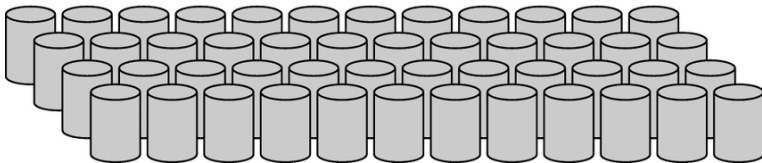
Observations about the Neocortex

There are three general observations about the neocortex:

- 1 **The Local Circuits in the Neocortex Are Complex:**
The precise and extremely complex neural circuits seen everywhere in the neocortex tell us that every region is doing something far more complex than feature detection.
- 2 **The Neocortex Looks Similar Everywhere:** The complex circuitry of the neocortex looks remarkably alike in visual regions, language regions, and touch regions. All regions, no matter what function they perform, look similar in detail to all other regions.
- 3 **Every Part of the Neocortex Generates Movement:**
The complex circuitry seen everywhere in the neocortex performs a sensory-motor task. There are no pure motor regions and no pure sensory regions.

Vernon Mountcastle's Big Idea

The neocortex got big by making many copies of the same thing: a basic circuit. In fact, it starts small, but then grows larger, not by creating anything new, but by copying a basic circuit over and over. Every part of the neocortex works on the same principle. Mountcastle proposed that the reason the regions look similar is that they are all doing the same thing. What makes them different is not their intrinsic function but what they are connected to.



Cortical Column: The Building Block of Neocortex

- The fundamental unit of the neocortex, the unit of intelligence, is a “cortical column.” Looking at the surface of the neocortex, a cortical column occupies about one square millimeter. It extends through the entire 2.5 mm thickness, giving it a volume of 2.5 cubic millimeters. By this definition, there are roughly 150,000 cortical columns stacked side by side in a human neocortex.

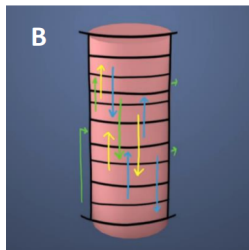
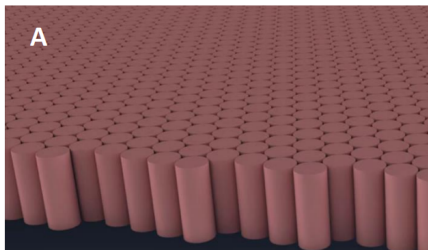


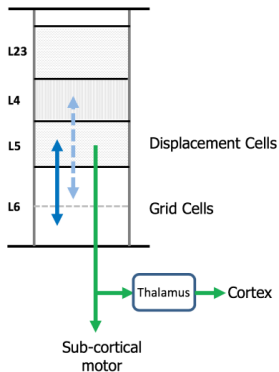
Figure 2A. Cartoon rendering of the neocortex spread flat, comprising cortical columns.

2B. Cartoon rendering of the complex circuitry within a single cortical column.

Cortical Column

Ahmed Subutai , Hawkins Jeff - 2019

The first thing Cajal and others observed was that the neurons in the neocortex appear to be arranged in layers. Cajal saw six layers in a slice of neocortex; So we consider six layers in a cortical column as it's a small volume of neocortex. A simple interpretation is that each layer of neurons is doing something different.



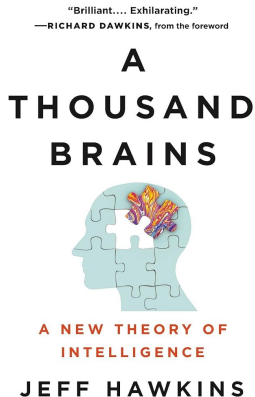
Layers of Cortical Column

- **L1:** This layer consists primarily of the dendrites of neurons in lower layers and contains few actual neurons (so we can simply ignore this layer in modellings).
- **L2&3:** Layers 2 and 3 are considered often together because they have similar patterns of connectivity. Also the final intra-cortical decision making happens in this layer and it sends output to other adjacent cortical columns laterally (with horizontal connections).
- **L4:** This layer is the main sensory input layer.
- **L5:** This layer sends output to other cortical areas. We propose cortical place cells are in layer 5.
- **L6:** This layer receives location input. We propose cortical grid cells are located in layer 6.

Thousand Brains Theory of Intelligence

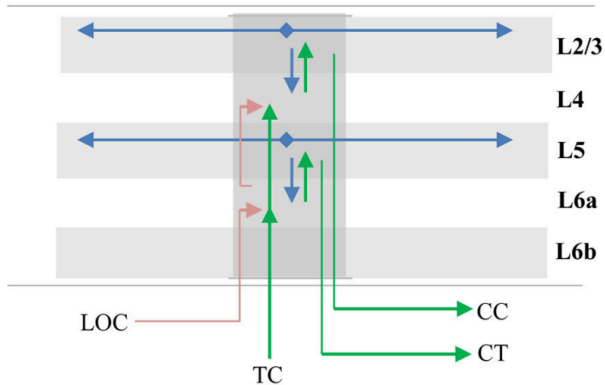
Hawkins Jeff - 2021

Thousand Brains Theory of Intelligence says that all cortical columns have a signal representing location. Every column combines its sensory input with the location signal. In other words, a column knows not only what feature is being sensed, but where that feature is on the object. This theory propose that every cortical column learns models of complete objects through movement. They call this idea the Thousand Brains Theory of Intelligence because if every individual column is learning complete models, then our brain is not building one mega-model of an object, but rather thousands of models of an object in parallel.



Our Research!

If we want to create intelligence, first we must build the unit of intelligence! So we are willing to simulate a cortical column using spiking neural networks.



Thanks for listening!



Please feel free to reach me out in case of any questions;
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