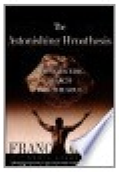
Though we should be cautious about comparing brains to computers, they are similar in at least one important respect. They are both "smarter" than the elements from which they're constructed. According to the weighted voting model, neurons perform a simple operation, one that does not require intelligence and can be performed by a basic machine.

How could brains be so sophisticated when neurons are so simple? Well, maybe a neuron is not so simple; real neurons are known to deviate somewhat from the voting model. Nevertheless, a single neuron falls far short of being intelligent or conscious, and somehow a network of neurons is.

This idea might have been difficult to accept centuries ago, but now we've become accustomed to the idea that an assembly of dumb components can be smart. None of the parts in a computer is by itself capable of playing chess—but a huge number of these parts, when organized in the right way, can collectively defeat the world champion. Similarly, it's the organized operation of your billions of dumb neurons that makes you smart. This is the deepest question of neuroscience: How could the neurons of your brain be organized to perceive, think, and carry out other mental feats? The answer lies in the connectome.

This thought balloon makes reference to Francis Crick's book The Astonishing Hypothesis. Appropriate extracts are given here.



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The astonishing hypothesis: the scientific search for the soul

By Francis Crick

The Astonishing Hypothesis is that "You," your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules. As Lewis Carroll's Alice might have phrased it: "You're nothing but a pack of neurons."† This hypothesis is so alien to the ideas of most people alive today that it can truly be called astonishing.

Chapter 1 starts with a bold statement about the Astonishing Hypothesis that encapsulates my approach to the brain—that to understand ourselves we must understand how nerve cells behave and how they interact. Earlier, prescientific ideas about consciousness and the soul are contrasted with our modern scientific knowledge of the universe. I then discuss briefly a few somewhat philosophical issues, such as reductionism, qualia, emergent behavior, and the reality of the world.

Chapter 2 outlines the general nature of consciousness (as described by William James a century ago and by three modern psychologists) and links it to attention and very short term memory. I then state the assumptions I make (and the attitudes I take) to come to grips with the problem and why I concentrate on one particular sort of consciousness—visual awareness—rather than on other kinds, such as consciousness of pain, self-consciousness, and so on.

Chapter 3 describes how the rather naïve ideas most people have about seeing are largely incorrect. Although we do not yet know exactly what happens in our brains when we see something, we can at least outline a possible way to approach the problem scientifically. Chapters 4 and 5, while fairly long, deal with only a few of the complexities of visual psychology. They should give the reader some idea of what has to be explained.

a power outage erases the RAM of a computer. Connections are left intact, so long-term memories survive. But recent information is lost, having not yet been transferred from activity to connections.

Can the stability–plasticity tradeoff also help us understand why the brain might use reconnection in addition to reweighting as a means for storing memories? Through Hebbian plasticity, neural spiking is continually altering synaptic strengths. Therefore the strength of a synapse is not so stable, and the memories stored by reweighting might not be either. This could explain why the memory of what you had for dinner yesterday will most probably fade. On the other hand, the existence of a synapse may be more stable than its strength. A memory stored by reweighting might be further stabilized by reconnection. This is likely the case for memories that endure for a lifetime, such as your name. Indelible memories may depend less on maintaining synaptic strengths at constant values and more on maintaining the existence of synapses. As a more stable but less plastic means of storing memories, reconnection may serve a complementary role to reweighting.

This chapter has been a mixture of empirical fact and theoretical speculation, biased uncomfortably toward the latter. We know for sure that reweighting and reconnection happen in the brain. Whether these phenomena create cell assemblies and synaptic chains is unclear, however. More generally, it has been difficult to prove that these phenomena are involved in any way in the storage of memories.

One promising method is to disable Hebbian synaptic plasticity in animals using drugs or genetic manipulations that interfere with the appropriate molecules at synapses, and then do behavioral experiments on the animals to see whether and how memory is impaired. Such experiments have already yielded fascinating and tantalizing evidence in support of connectionism. Unfortunately, the evidence is only indirect and suggestive. And its interpretation is complicated, because there is no perfect way of getting rid of Hebbian synaptic plasticity without creating other side effects.

The following parable is my attempt to illustrate the difficulties that