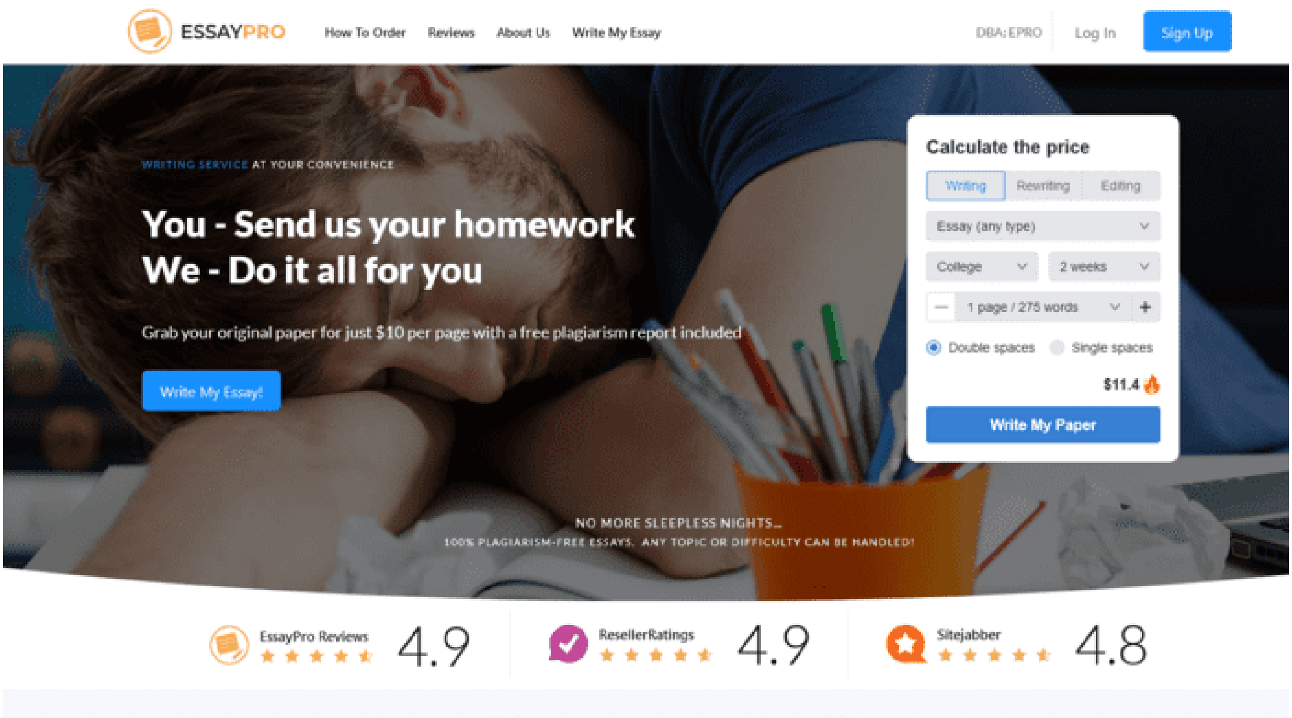
Neural Cells as Harmony Detectors



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Neural Cells as Harmony Detectors

The issues of harmony have notably low profile in the current AI research. Meanwhile, when it comes to brain architecture, harmony plays the central role. As we hope to demonstrate in this essay, neural cells act primarily as local harmony detectors. On a less local scale, the consensus is that perceptions correspond to certain stable periodic patterns of neuron firing. A harmony-based architecture would probably be more successful than current AI paradigms.

It would help here to recall the basics of neuron firing theory. In the rest state neuron membrane typically has electrochemical polarization potential of 70 millivolts. When the firing impulse comes to the neuron from another neuron via the corresponding synapse (the site of their connection), this polarization potential changes, typically by 1-2 millivolts or less. If the polarization potential decreases beyond the threshold of approximately 60 or 55 millivolts, the neuron fires, otherwise the polarization potential tends to rapidly relax to the original rest level of 70 millivolts.

Hence, when the reception of an impulse via a synapse decreases the membrane polarization potential of the receiving neuron, we call this synaptic connection excitatory, because the decrease of the polarization potential makes it easier to fire for our neuron. Otherwise, the synaptic connection is called inhibitory. Because the reception of an impulse changes the polarization potential by at most 2 millivolts and because the polarization potential tends to rapidly relax back to 70 millivolts, the neuron can fire only if it receives several (from 4 to more than a dozen) impulses via excitatory connections simultaneously or in a very quick succession.

Hence the neuron works as a detector of several excitatory impulses coming almost simultaneously. So we can say that the neuron detects the harmony between its incoming impulses.

Now we shall turn to learning mechanisms in the brain, and observe that the local learning (on the level of one neuron) is directed towards detecting this harmony even better. As we have noted, the reception of an impulse changes the polarization potential usually by 2 millivolts or less. The actual value of this change is usually called synaptic strength. This value is not constant, but changes with time. This ability of synaptic strength to change is the key mechanism of neural learning and is called synaptic plasticity.

The most typical rule of synaptic plasticity for excitatory connection works approximately as follows. If a neuron fires shortly after receiving an excitatory impulse (i.