

Mother Nature's most secret plot?

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Like any plot in a drama, Mother Nature may have designed an amazing plot where she hides one of her secrets about our nervous system functions. The secret is about sparking inner sensations (for example, a cue stimulus sparking sensory features of a memorized item in the latter's absence). If confirmed true, then it is very surprising!

On average, each neuron has a large number of input terminals (dendritic spines or postsynaptic terminals) and output terminals (axonal or presynaptic terminals). The junction between one input terminal of one neuron and one output terminal of a second neuron is called a synapse. Inside the output terminal, chemical neurotransmitter molecules are packed within the synaptic vesicles. From single synaptic vesicle neurotransmitter molecules are released continuously (called quantal release) all the time (including when the synapse is at rest during sleep). The released neurotransmitter molecules bind to a small proportion of receptors at the postsynaptic terminal and depolarize its membrane. Occasionally, when an action potential arrives at the presynaptic terminal, it will lead to the release of a volley of neurotransmitter molecules that lead to a large depolarization of the postsynaptic terminal that propagates towards its neuronal cell body. Is there any functional role for the CONTINUOUS quantal release of the neurotransmitter molecules into the synaptic cleft?

Here is where a surprising mechanism may reside. Imagine that "you" are the postsynaptic membrane. You get used to receiving the quantally released neurotransmitter molecules (and get depolarized) from your presynaptic terminal. In addition to the quantal release, you (the postsynaptic membrane) will occasionally receive a volley of neurotransmitter molecules when activity arrives at your presynaptic terminal. When the released neurotransmitter molecules bind to the receptors on you, either from quantal release or from the volley of neurotransmitter release, you (the postsynaptic membrane) get depolarized. For you, some signal is arriving from your presynaptic terminal AT ALL TIMES. This is your default state even while sleeping. You will eventually get used to this!

I can now trick you (I mean, I can trick the postsynaptic membrane). In your world, you are constantly receiving neurotransmitter molecules from your presynaptic terminal that constantly generate potentials on you. In this context, when I suddenly inject some current (this will change the potential) on to you, you will feel a "cellular hallucination" that the potential is arriving from your presynaptic terminal. The sensory content of this hallucination depends on the sensory stimuli from the environment capable of reaching at your presynaptic terminal. The sensory content of your (postsynaptic membrane's) cellular hallucination forms a unit of inner sensation. In short, you (the postsynaptic terminal) won't sense that I am injecting current to you. The semblance hypothesis (1) has hypothesized that potentials arriving at a postsynaptic terminal from its lateral aspect through a LINK formed with a neighboring postsynaptic terminal can evoke such cellular hallucinations. What would have produced the LINK there? The LINK is expected to form when two abutted postsynaptic terminals are co-activated by two sensory stimuli when they are associatively learned. A similar operation is likely taking place while artificially inducing sensory hallucinations (2).

The cellular hallucination explained here can be viewed as the fundamental operational mechanism for the formation of all the first-person inner sensations of higher brain functions such as perception, retrieved memories, thought process, and consciousness. Potentials arriving through the LINK (one vector component) along with synaptic transmission (second vector component) can contribute to the oscillating extracellular potentials. It has been found that the frequency of these oscillations should remain at certain level for the system to remain operational. Therefore, the net cellular hallucination (from large number of locations) induced at the background state is essential to provide the systems property of various inner sensations. The inter-postsynaptic LINK fulfills the expected properties of the K-lines proposed by Marvin Minsky (3).

References

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