A Possible Way to Couple Artificial Electrical Signals into a Live Neural System

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Abstract—**We propose that electromagnetic waveguide structures are naturally formed in a biosystem; the transient transmembrane ion currents passing through sodium channels can generate pulses of electromagnetic waves, and it is possible to couple artificial pulses of electromagnetic wave into a live neural system, thus to cure neural dysfunctions.**

I. Introduction

A thick unmyelinated axon in a giant octopus may have a diameter of 800 microns, but it only has a thin membrane consisting of one phospholipid bilayer and allows a maximum propagation speed < 10 m/s for action potentials. By sharp contrast, action potentials can propagate along a twenty micron-diameter myelinated axon as fast as 100-150 m/s. Myelinated axons have thick myelin sheaths consisting of a few to dozens of phospholipid bilayers. The sheath is developed from Schwann cells that wrapping themselves again and again over the axon core. In clinical practice, when the sheath of a myelinated axon is not firmly bonded to the core, it causes a number of neural dysfunctions. It is therefore reasonable to challenge the current textbooks whether the thick myelin sheath serve only as an effective insulation layer.

II. Results

We have proposed that, electromagnetic (EM) waves seem playing an important role in the propagation of action potentials. Several kinds of naturally formed EM waveguide structures are recognized in a biosystem [1]. Typically such structures are formed with a phospholipid bilayer membrane (or the myelin sheath) that is sandwiched between ionic fluids at its both sides, as shown in **Figure 1a**. Pulses of EM wave can be generated by the transient transmembrane ion currents passing through sodium channels, in the way similar to a dipolar antenna.

We have shown that macro-scale softmaterial EM waveguides can be formed by plastic tubes immersed in solutions [2], as schematically shown in **Figure 1b**. The EM waves passing through such a softmaterial waveguide can maintain a higher electrical intensity over the same distance as compared to that in free space. The enhancement factor is measured up to 4-5 times at a distance of 20-40 cm [2]. The transmission efficiency depends on the ionic concentrations in and out of the tubes, as well as on the thickness of the tubes. Furthermore, if a pulsed EM is transmitted through such a waveguide structure, the transmission efficiency is also affected by the duration of the pulse [3].

Usually the neural signals are coded with frequency spectrum and total number of identical action potentials, so we believe it is possible to create artificial EM pulses similar to the natural ones, and couple them into damaged (by disease or surgery) ends of a live neural system in the way of waveguide coupling, as shown in **Figure 1c** & **1d**. If this is true, it may open up a novel approach for curing a variety of neural disease and functional disability of a biosystem.

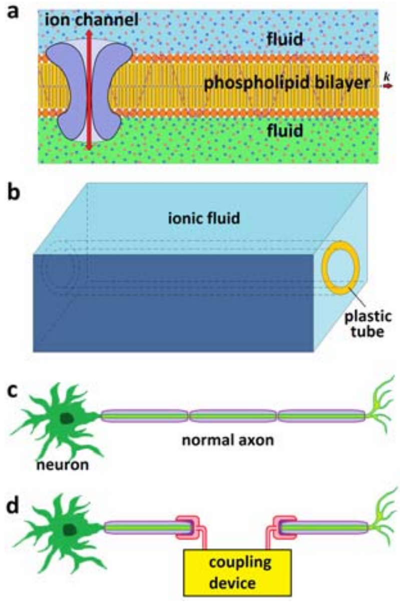

Figure 1. Schematic images of: **a)** A natural EM waveguide structure; **b)** A softmaterial EM waveguide constructed with a plastic tube immersed in fluid; **c)** A normal myelinated axon; **d)** A artificial device that couples EM pulses into the two ends of a damaged (by disease or surgery) myelinated axon.

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References

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