On Brownian Motion During Neurodevelopment

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Abstract

In this note, the authors propose an alternate approach to the capacity of the field of information within a growing nervous system.

Consider an action potential propagating along a myelinated axon via saltatory conduction. The axon model is three dimensional with each node and internode being cylindrical shapes. Thus the action potential voltage envelope is actually a three-dimensional hopping "bulge." During neurodevelopment, when axons are growing, they seek their path through the unformed nervous system. In this setting, the very conduction of action potentials along axons acts as "stimulation" for further growth along the axon in that very direction. Within this setting, the electrodynamic environment of an action potential can influence its conduction. This environment includes other sources of electrodynamic effects, such as other growing axons with action potentials. In other words, within this entire "sea" of criss-crossing action potential bulges or waves, the electric fields lead to interaction and coupling which guides the overall neural growth.

Since influences are small, yet possibly additive, they can be modeled as small perturbations along the path of the bulge. Hence, the analytical task reduces to accurately modeling the propagation of a single bulge as a type of brownian particle's motion [1, 2]. Further extensions include modeling the propagation of several bulges which couple together due to long range current and field based effects. Overall, this study would capture the communication capacity of the electrodynamic field in a brain. See also [3, 4].

References

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