A three state model can explain the dynamics of class IV Drosophila dendritic tips

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A three state model can explain the dynamics of Drosophila class IV dendritic tips
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Abstract

Individual neurons form highly intricate dendritic structures that receive synaptic input from other neurons or sensory input from the outside world. The precise dendritic morphology is crucial for the proper connectivity and information processing of neural circuits. However, little is known about how the dendrites form and grow. We observed that the dendrites of our model system, Drosophila class IV neuron, are highly dynamic. Using an automated tip tracking Matlab software, we characterized the dynamics of the dendritic tips and observed that the tip traces can be segmented into regions of growth (G), shrinkage (S) and paused (P) states. We were able to identify these regions by fitting a piecewise linear function to the traces. There are fast algorithms by which we can fit piece-wise linear function to the individual traces to get the distributions of these three states (G, S and P). Finally, we were able to calculate the velocity distribution of all the traces of these three states (G, S and P). We measured the growth rate of the neuron by imaging them at different stages of their lifecycle and measured the equivalent diameter. The slope turned out to be 5.38 μm/hour (0.088 μm/min). We measured 70 individual neuron diameters from 10 different embryos and compared with the expected growth rate. We found out that there is no significant difference between the expected growth rate and measured growth rate.

Automatic filament tracking software can track the dynamics dendritic tips with reasonable accuracy

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We observed that the dendrites of our model system, Drosophila class IV neuron, are highly dynamic. Using the above mentioned dynamic parameters (growth and shrink velocities and transition rates) we will be able to simulate an in silico model to quantitatively compare whether the morphologies predicted by the model capture the complexities of the morphologies observed during development.

Dendritic tips of Drosophila class IV sensory neurons are highly dynamic

We discovered the imaging condition at which the larvae and neurons grow.

Neurons grow at expected rate in our imaging condition

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Fitting a three state piecewise linear model to the traces: L-curve method

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Conclusions

The three state model successfully captures the mesoscopic process of the dendritic growth, shrinkage and paused states and the transition rates between the states. Using these measured parameters we can build an in silico model to predict the final morphology of the dendritic arbor. Finally, we can investigate how these individual parameters change under different mutations and how that lead to different morphologies2.

References:

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