3D Volumetric Reconstructions Reveal Distinct Difference in Spinule Sizes

Within Primary Visual Cortex

Cheri Kim & Marc Nahmani

Abstract

The brain has communicative neurons that send signals through synapses from a presynaptic neuron to a postsynaptic neuron. In a presynaptic neuron’s information-sending end (known as a ‘bouton’), there are often microscale prominent projections called ‘spinules,’ which may assist in neuronal communication or serve to stabilize synapses. Since the precise functionality of spinules are still unclear, and as a first step toward uncovering this function, we sought to determine whether spinules originating from different parts of neurons (e.g. axons, dendrites, spines) have different sizes that might lend themselves to distinct functions.

In this study, we sought to three-dimensionally reconstruct spinules from distinct neuronal sources within a focused ion-beam scanning electron microscopy image volume from adult ferret primary visual cortex. We performed 3D reconstructions of 10 excitatory spinule-bearing boutons (SBBs), their invaginating spinules, and postsynaptic densities (i.e. synapses) to observe the relationship between excitatory boutons and the sizes of their embedded spinules. We discovered that SBBs had an average volume of 0.28 µm$^3$ and their embedded spinules averaged volume 0.009 µm$^3$, such that spinules take up ~3% of their bouton’s volume. Additionally, we observed that spinules projecting from postsynaptic spines had 0.013 µm$^3$ larger volumes (0.024 µm$^3$) when compared to spinules from adjacent dendrites (0.011 µm$^3$) or adjacent axons (0.0027 µm$^3$), while PSDs from these spinules were 0.0096 µm$^3$, 0.011 µm$^3$, and 0.012 µm$^3$, respectively. In conclusion, our data suggest that the spinules from postsynaptic spines may play an important role in stabilizing the synaptic connections of their SBBs, based on their size investment within their excitatory presynaptic bouton.