Title: Bridging scales in astroglial calcium dynamics: from nanoprocesses to whole-cell modeling in the cerebellum

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Abstract
Astroglial cells form hundreds of nanoprocesses that enwrap neuronal synapses, extend specialized endfeet to the vasculature, and create a rich landscape of calcium signaling. Despite being as essential as neurons to brain function, astroglia remain less studied - particularly in computational modeling. A key challenge is to understand the relationship between astroglial function and morphology. We set out to build a detailed yet computationally feasible full-cell model of a single cerebellar astrocyte, incorporating the major mechanisms underlying astroglial calcium dynamics. Because of the lack of astroglia-specific computational tools, we developed the CellRemorph toolkit (Keto & Manninen, 2023), available on GitHub (https://github.com/lauraketo/CellRemorph). Using CellRemorph together with the NEURON simulator (Carnevale & Hines, 2006) and ASTRO framework (Savtchenko et al., 2018), we built a whole-cell Bergmann glial model to investigate how its unique morphology (Grosche et al., 1999; Lippman et al., 2008) gives rise to diverse calcium signaling patterns. At the nanoscale level, we further explored how morphology influences stochastic calcium dynamics within Bergmann glial microdomains using both particle- and voxel-based simulators. This work advances our understanding of astroglial contributions to cerebellar function, bridging scales from microdomains to the whole cell.

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