Matveev *BMC Neuroscience* 2015, **16**(Suppl 1):P162
http://www.biomedcentral.com/1471-2202/16/S1/P162

BMC Neuroscience

POSTER PRESENTATION Open Access

A novel method for approximating equilibrium single-channel Ca^{2+} domains

Victor Matveev

From 24th Annual Computational Neuroscience Meeting: CNS*2015
Prague, Czech Republic. 18-23 July 2015

Localized calcium (Ca^{2+}) signals control some of the most fundamental physiological processes, including synaptic transmission as well as its activity-dependent plasticity. Computational and mathematical modeling played a crucial role in the understanding of spatio-temporal Ca^{2+} dynamics that drives these processes, and showed that Ca^{2+} concentration around a single Ca^{2+} channel reaches a quasi-stationary distribution (known as the Ca^{2+} "nanodomain") within tens of microseconds after the opening of the channel, and collapses as rapidly after the closing of the channel. Such localization of Ca^{2+} in time and space is achieved by its rapid diffusion as well as its binding to its multiple interaction partners collectively called Ca^{2+} buffers and Ca^{2+} sensors. One of the successes of mathematical modeling was the development of several analytic approximations describing the equilibrium concentration of Ca^{2+} as a function of distance from the open Ca^{2+} channel, such as the Rapid Buffering Approximation (RBA), the Linear Approximation (LA) and the Excess Buffering Approximation (EBA) [1-4]. Each of these approximations has a particular applicability parameter regime created by the interplay between the properties of Ca^{2+} buffers, in particular their mobility and Ca^{2+} binding rates, and the strength of the Ca^{2+} current. Here we present a novel approximation method which does not rely on a specific range of the relevant Ca^{2+} and buffer parameters, and is based on matching the low-distance and large-distance asymptotic behavior of the concentration function. Even at low orders, the resulting approximation is as accurate as the second-order RBA and EBA approximations [4], but its validity extends far beyond the parameter range of applicability of RBA and EBA. The usefulness of the resulting approximation is two-fold: first, together with the previously developed approximations, the novel method could provide a deeper intuition into the dependence of Ca^{2+} nanodomain properties on the relevant buffering parameters, and second, it constitutes an efficient numerical approximation tool in the modeling of the Ca^{2+} signals underlying presynaptic and postsynaptic phenomena.

Correspondence: matveev@njit.edu
New Jersey Institute of Technology, NJ 07030, USA

Published: 18 December 2015

References

1. Neher E: **Usefulness and limitations of linear approximations to the understanding of Ca^{2+} signals.** *Cell Calcium* 1998, **24(5-6)**:345-357.
2. Smith GD, Wagner J, Keizer J: **Validity of the rapid buffering approximation near a point source of calcium ions.** *Biophys J* 1996, **70(6)**:2527-2539.
3. Bertram R, Smith GD, Sherman A: **Modeling study of the effects of overlapping Ca^{2+} microdomains on neurotransmitter release.** *Biophys J* 1999, **76(2)**:735-750.
4. Smith GD, Dai LX, Miura RM, Sherman A: **Asymptotic analysis of buffered calcium diffusion near a point source.** *Siam J Appl Math* 2001, **61(5)**:1816-1838.

doi:10.1186/1471-2202-16-S1-P162
Cite this article as: Matveev: A novel method for approximating equilibrium single-channel Ca^{2+} domains. *BMC Neuroscience* 2015 **16** (Suppl 1):P162.