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Periodic and chaotic dynamics in a map-based neuron model

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Map-based neuron models are an important tool in modelling neural dynamics and sometimes can be considered as an alternative to usually computationally costlier models based on continuous or hybrid dynamical systems. However, due to their discrete nature, rigorous mathematical analysis might be challenging. We study a discrete model of neuronal dynamics introduced by Chialvo [Chaos, Solitons & Fractals 5, 1995, 461–479]. In particular, we show that its reduced one-dimensional version can be treated as an independent simple model of neural activity where the input and the fixed value of the recovery variable are parameters. This one-dimensional model still displays very rich and varied dynamics. Using the fact that the map whose iterates define voltage dynamics is S-unimodal, we describe in detail both the periodic behaviour and the occurrence of different notions of chaos, indicating corresponding regions in parameter space. Our study is also complemented by a bifurcation analysis of the mentioned dynamical model.