

Criticality Control of Glucose-Insulin Release

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ABSTRACT

This paper elaborates on the need and further development of a model of coupled oscillators that exhibits the behaviour of the glucose-insulin release system. This research is tied to a PhD project under the supervision of co-authors Dr. Tjeerd olde Scheper and Dr. Arantza Aldea at Oxford Brookes University. The paper highlights the methodology used, the preliminary results, and the further work that needs to be conducted.

KEYWORDS

dynamical systems, oscillations, insulin release, rate control

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1 INTRODUCTION

The discovery of oscillations in the glucose-insulin release system in the pancreas [5] supports the approach of non-linear local dynamic states contributing to a globally stable glucose function. This control of the local non-linear behaviour that is cardinal to control the global system is modelled using oscillators that exhibit criticality. This is a property of rate controlled chaotic systems allowing near scale-free dynamics.

The main consideration for any given nonlinear critical model is to represent the system as a network of weakly coupled oscillators arranged in clusters, where the connectivity strength will be varied in order to observe the response of the system in terms of global and local feedback.

2 METHODOLOGY

Prior to defining the modelling methodology for this project, a systematic review on the state of the art in physiological modelling was conducted. The results of this review revealed a few limitations, most of these associated with the reduction in mathematical complexity of the system. Upon this realization, it was decided to use three different base models for comparison in terms of their dynamic capabilities and biological relevance. The Berry model [1] describes a bienzymatic cyclic model with two autocatalytic loops, the Lengyel-Epstein system of an activator-inactivator system, and the Brusselator autocatalytic model [2]. These have been chosen for their capacity to operate in a state of continuous oscillation, given the right conditions. With this, we aim to develop a model capable of maintaining the dynamic

complexity of the system. In the current stage of development, these systems are being simulated with the incorporation of the rate control of chaos method (RCC) [4] and the appropriate conditions to generate criticality within the system. Given that the insulin-release system is categorized as a dynamical system with highly non-linear components, it qualifies as a system that is attracted to a critical state associated to stable glucose levels, which is why generating criticality in our model becomes a crucial factor to simulate the conditions of operation.

3 PRELIMINARY RESULTS

The methods capable of representing the environment to generate criticality in a dynamic system are detailed in [3]. The results obtained so far have been promising, showing that the physiological state can be represented while maintaining the dynamic properties and generating criticality in the system.

4 FURTHER WORK

Further tests, such as the definition of the appropriate ranges of operation of the connectivity strength, and the evaluation of the system under conditions that represent a pathological state, will be conducted to select the best system of equations for the desired model.

In further stages of development the model will be validated and tested using data from real subjects, this will be facilitated given the collaboration with Pepper project EU (<http://www.pepper.eu.com/>)

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