Chaos Analysis of Compound Action Potentials Evoked in Sural Nerves from Rats Reared without Littermates

V. Martínez-Alvarez[1] E. E. Rodríguez-Torres[3]* U. Paredes Hernández[4] V. García Muñoz [2] M. Tetlalmatzi-Montiel[3] J. Viveros-Rogel[3] F. Menéndez-Conde-Lara[3] I. Jiménez Estrada[1]

[1]Centro de Investigación y Estudios Avanzados del IPN, México
[2]Centro de Investigaciones en Matemáticas, Maestría en Matemáticas, México
[3]Centro de Investigación en Matemáticas, Instituto de Ciencias Básicas e Ingeniería, Universidad Autónoma del Estado de Hidalgo, Mineral de la Reforma, Hidalgo, México. [4]Licenciatura en Física y Tecnología Avanza

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Introduction

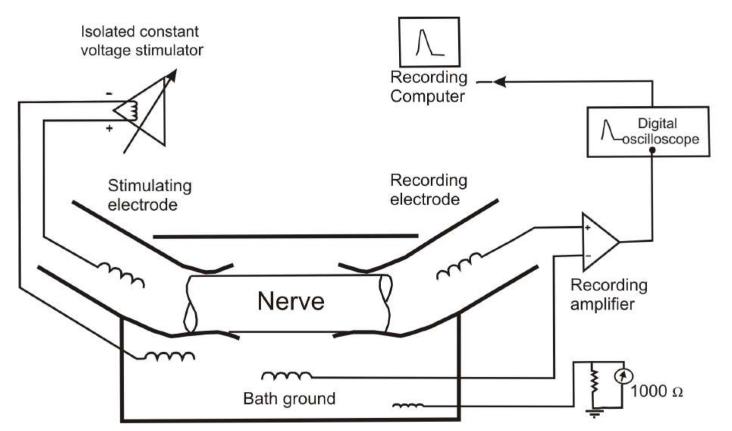
Recently it has been an increased interest on individual differences among siblings. Thereby a variety of pre- and postnatal factors are considered as a source of individual variability in mammals, which is often considered as unwanted noise. In biomedical research, it has been considered prenatal factors such as intrauterine environment, neighbor fetus interaction and nutrition status of the mother as contributors of long-term alterations (fetal programming) [3]. Nowadays, sibling interaction has been considered as a potential contributor of behavioral and physiological phenotypes. For example, pups reared without littermates have a delay in the development of motor skills compared with normal reared litter [4]. Early sibling deprivation is also associated with the development of anxiolytic and addictive behaviors in adult rats. Thus the aim of this study was to evaluate by means of a chaos methodology implemented in this study, the effect of rearing with and without littermates on the CAP evoked in the sural nerve of the rat.

Methods

Animals: Male rats reared in litters composed of one (n=6) or nine pups (n=7) provided by the Animal House Facility of our institution were used. The second group of rats were weighted and grouped in light, intermediate and heavy. At the postnatal age of 60 days, the animals were anesthetized and their sural nerves were dissected. All of the experiments were performed in accordance with the guidelines of the institutional Committee for the Use of Experimental Animals (UPEAL-Protocol 013-02, CINVESTAV).

Stimulation and recording

Both ends of each SU nerve dissected were drawn into suction electrodes to record and evoke the CAP response.



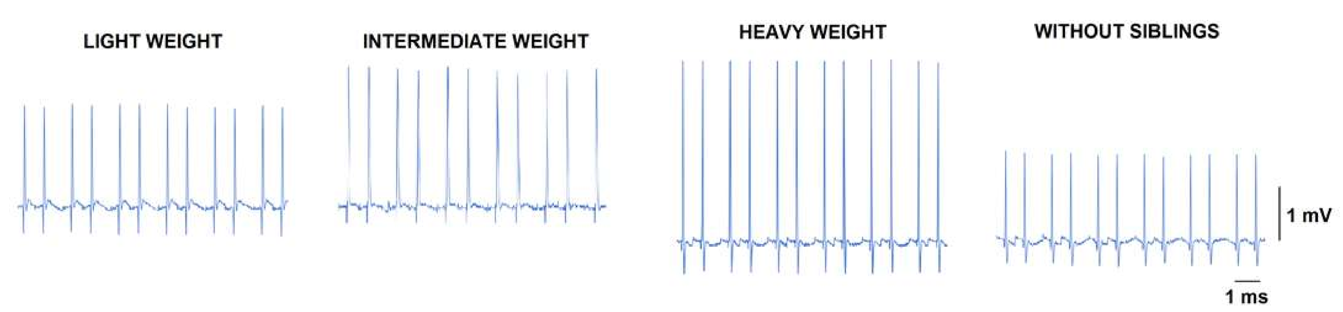


Figure 1: Figure 1. A) Diagram of the experimental arrangement. B) CAP response evoked by low current pulses (2xT) which are associated to the activation of low-threshold, fast conducting, myelinated type A-afferent fibers in the nerve.

Phase-Space Reconstruction

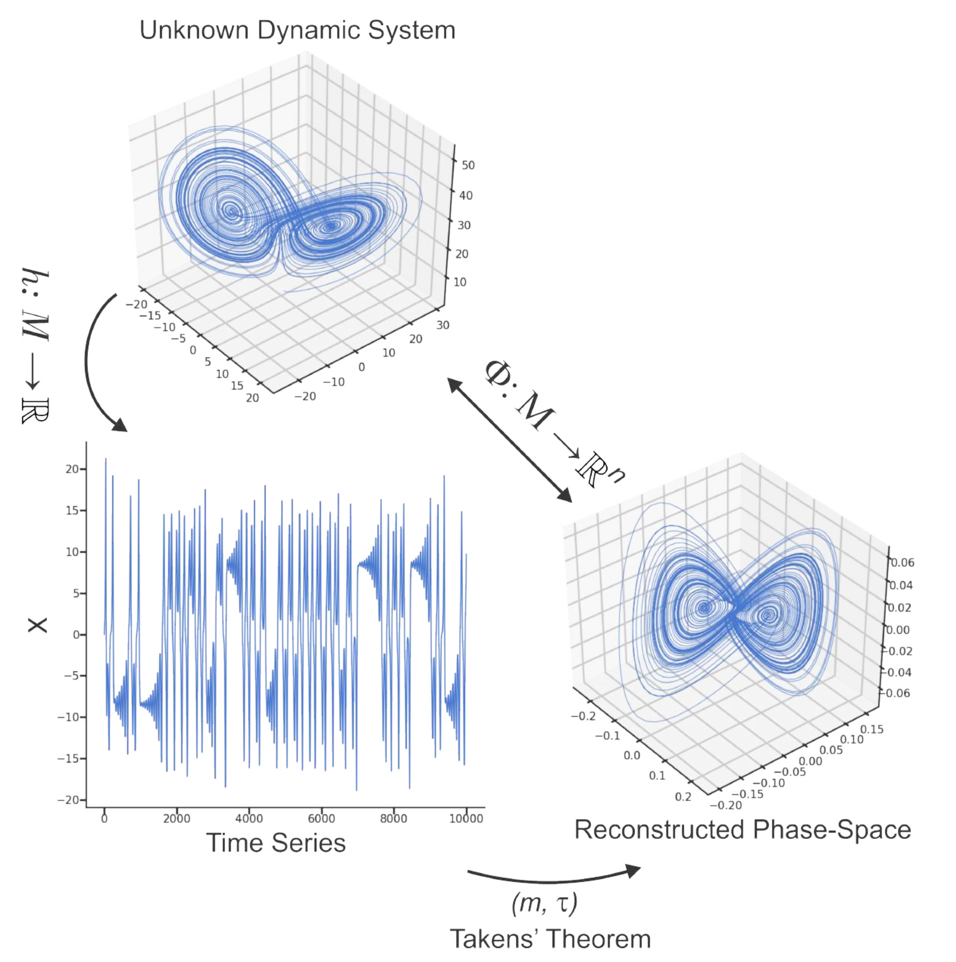
The dynamics of a system can be determined from a model of differential equations (assuming they are known) or through the analysis of data collected from the observation of the phenomenon. The Takens' embedding theorem [5] ensures that under certain circumstances it is possible to reconstruct the dynamics of a system from measurements of some variables. The time delay embedding method is used in this work to perform the reconstruction of the phase space. In this method, from a one dimensional time serie:

$$x(t_n), n = 1, \dots, N,$$

the reconstructed phase-space is given by:

$$[x_n, x_{n+\tau}, x_{n+2\tau}, \dots, x_{n+(m-1)\tau}], \qquad n = 1, \dots, N-(m-1)\tau,$$

where m is the embedding dimension and τ is the delay embedding.



Results

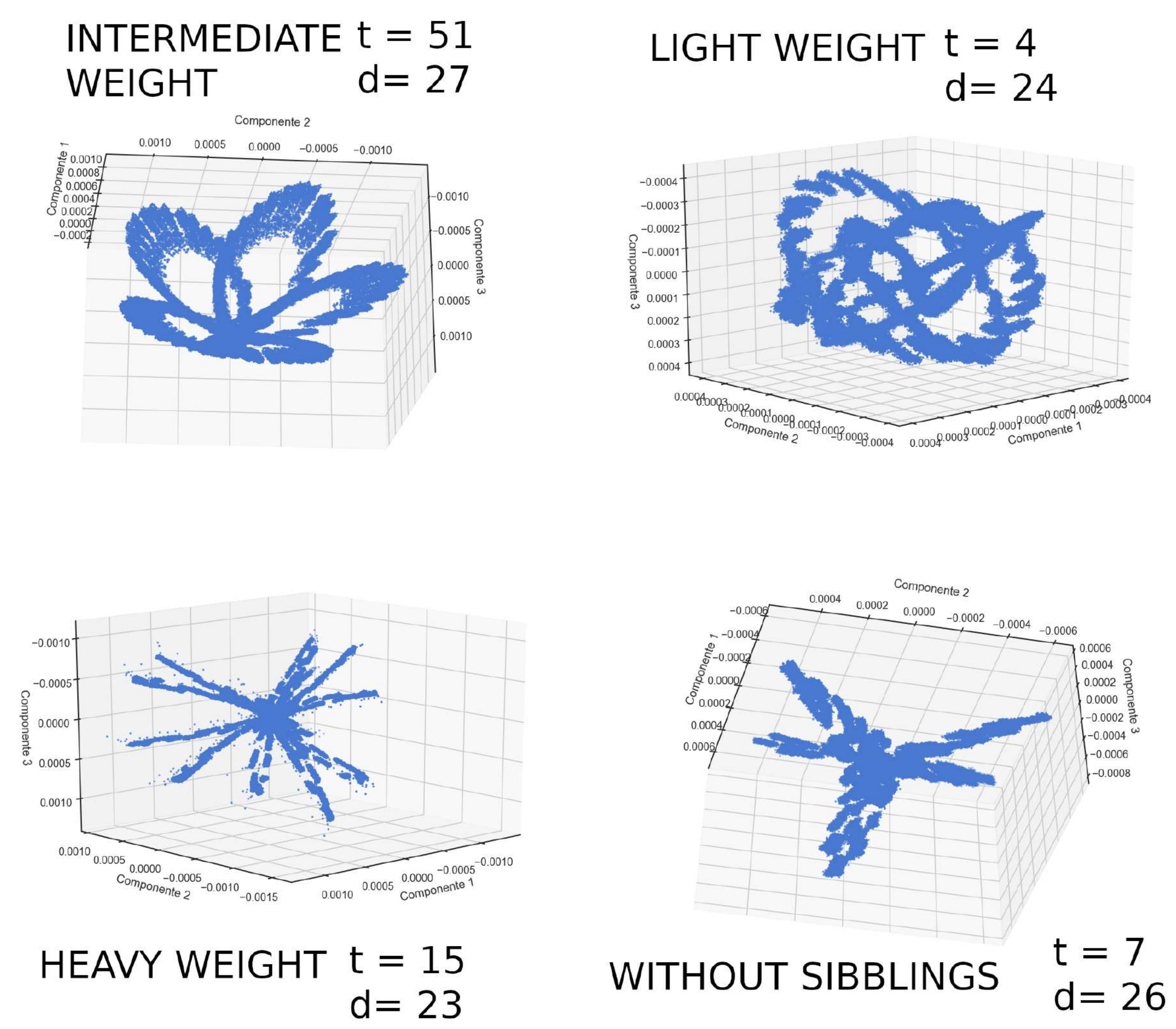


Figure 3: Reconstructed phase-space.

Estimating τ y m

The embedding can be achieved with almost any delay τ and embedding dimension m, however extreme values will cause problems in the reconstruction of the phase-space. There are different methods to calculate optimal values for delay τ and dimension m, the mutual information function is used [1] to compute the τ value and the False nearest neighbor algorithm [2] to determine the embedding dimension value.

Discussion

Our results show changes in the dynamics of the reconstructed orbits of sural nerves from light rats and without littermates as compared with those of intermediate and heavy animals, the latter being more symmetrical. In the case of heavyweight rats, the reconstruction of orbits showed much more background noise, even though eCAP recordings from all groups are overall quite similar. In this sense, control time series has the most redundancy (d), whereas a loss of redundancy was observed in the other times series, remaining at 8% in the lightweight group, 29% in the heavyweight group, and 14% in the group with no littermates.

Conclusions

Therefore, CAP time series from the lightweight and without littermates groups had the most redundant information loss. The lightweigth and without siblings rats present alterations in the transmission of sensory information from the periphery to the central nervous system.

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erikart@uaeh.edu.mx