Dynamic and Static simulations by Multi Agent Systems (MAS).

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INTRODUCTION

Among the most desirable features of any programming environment are a comprehensive manual and a wide range of solved, exemplary problems. Both expectations are fully met by the materials included in the “Netlogo” package [1], a freeware software conceptually derived from the Logo paradigm and spanning a wide range of possible applications. We took advantage of that, and Figures 1 and 2 demonstrate a couple of interesting results concerning the dynamical behaviour of quite different cellular systems [2,3]. Quite recently we focussed on the collective properties of small neural networks as described by standard parameters from the Graph Theory, namely the “Average Path Length” (APL) and the “Clustering Coefficient” (CC) [for a comprehensive review, see Ref. 4]. In particular, our aim was to clarify the connection between the topological arrangement of links and the ensuing collective behaviour of the network by changing the links’ weight within a given topological arrangement. In such a context we tested: A) the reliability of an original program reckoning the network parameters under well characterized conditions (Figure 3); B) the relative influence of combined topological and functional parameters, averaged over whole, simple networks (Figure 4).

RESULTS

The APL and CC topological parameters are well suited for characterizing the ‘small word’ properties of the network at hand [4]. They are directly derived from the Adiacency Matrix $\{a_{ij}\}$ of the undirected graph associated to the network of N nodes. The binary a_{ij} for $\forall i$!= j indicates the presence (1) or absence (0) of a link connecting the i,j nodes. However, the integer l_{ij} is endowed with a more cogent physical meaning since indicates a geometrical distance. The Average Path Length (APL) and the Average Physical Distance (APD) are averages over the N(N-1) couples of, respectively, Shortest Path Length (SPL) and Shortest Physical Distance (SPD) values calculated over each single couple. Thus:

A) within a fully connected network (each node linked to any other node) as expected, the Average Path Length and of Average Physical Distance are both unitary (Figure 3). Notice that cutting any of the 36 bidirectionsl links of the 9-node network in the figure, both parameters increase to 1.028, while by any weight increase of any link, only the APL increases to 1.028 (not shown);

B) by relaxing the full connectivity condition both APL and APD (global parameters) become sensitive to changes in the link weight and location. Thus, in the network of Figure 4 (corresponding to a sparse Adiancency Matrix of 11 links), if the N_0-N_8 and the N_4-N_6 links swap their distance values, the APD value drops to 2.667, while APL is unchanged. To get a change in APL, changes the link(s) location are needed: for example, moving the N_0-N_8 link to the N_0-N_4 couple, APD goes to 13.194 (and APL to 2.5).

C) It is worth noting that the CC parameter, namely a signature of the local cluster density [4], reamins the same throughout the whole set of the above described changes.

CONCLUSIONS

Even in small networks single topological (location) and physical (distance) changes in the link pattern among nodes induce significant alteration in parameters related to global functional properties. The recognized efficiency of the MAS-based simulation strategies in the reproduction of complex population dynamics reveals helpful in exploring the time evolution of link patterns in neural populations upon asymmetric, random stimuli.

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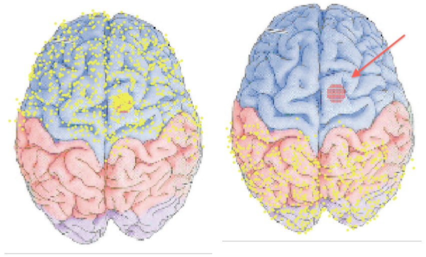

Figure 1. *Netlogo simulation of the synchronous neuronal activation in epilectic seizures. The left and right panels are snapshots taken at 0.5 sec time interval from each other. They show the ciclic recurrence of synchronous activation of neurons (in yellow) spreading from an epilectic focus (red arrow).*

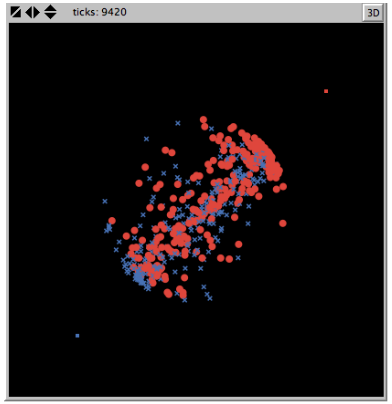

Figure 2. *Netlogo simulation of clustering of different cells population induced by external force fields [3].*

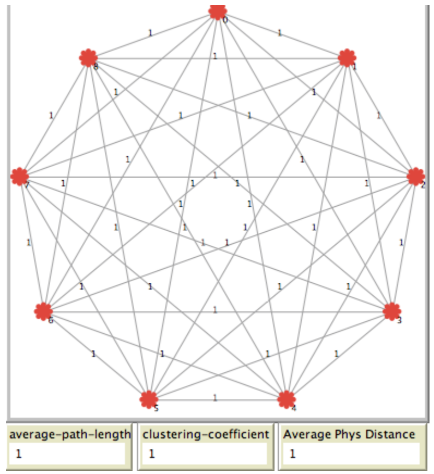

Figure 3. *Average topological and physical parameters in a fully connected 9-node network by links of identical weight (indicated).*

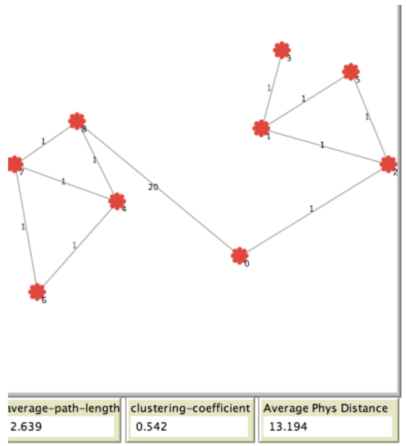

Figure 4. *Sensitivity of average network parameters to the link topology and weight (see the text).*