1 - Introduction

One of the central problems that has to be resolved in view of a better understanding of the functioning of CNS structures is that of the dynamic properties of its constituent neuronal nets. It clearly appears, indeed, to experimental as well as theoretical neurobiologists that albeit the wealth of knowledge accumulated on the properties of neurons at the molecular, membrane and cellular levels a great degree of cooperativity is present between neuronal elements and that it is therefore the collective properties of groups of neurons inside the structure that must be unveiled. This has at least two important consequences. The first is that it may be difficult to use general mathematical "models" to derive precise existing properties. Indeed there does not exist such a thing as a "general" CNS structure but on the contrary very differently organized morphological structures. The second is that if one takes into account the ultimate scope of the CNS, which is certainly related to an "adequate behavior" of the animal in its environment, then the temporal constraints imposed on the systems must surely be stressed.

Since the pioneering work of CAJAL (1) the cerebellar cortex has become the best understood part of the CNS, at least at the basic level of the properties and organization of the elements composing its circuitry. Compared to other central structures the cerebellar cortex has extremely specific features such as 1) a limited number of cellular types (five) with only one efferent cell axon, that of the Purkinje cell (PC); 2) a restricted number of inputs (two) each of which is distinctly identifiable at the morphological as well as physiological levels and 3) a topological organisation invariant along the two axes of its plane of extension. Another particularity is the importance of inhibitory interactions between the neuronal elements, four out of five cell types, including the efferent PC, using this modality of communication (2; 3). To gain insight on the transformation operated by the cerebellar cortex - essentially the molecular layer - on the incoming activity it is therefore necessary to analyze whether such
inhibitory interactions lead to specific modulatory operations. We have dealt indirectly with this restricted problem by a modelisation approach, whose results can be used for the interpretation of experimental data.

2 - Methodology

The analysis of complex systems presents a number of limits which arise from the difficulty of classifying data and variables whose dynamic interdependence are preponderant. This is exactly the case with the cerebellar cortex notwithstanding it's apparent morphological monotony. To overcome this problem we have subdivided the molecular layer neuronal net in subsystems hierarchically related. These include a) isolated PCs; b) PCs coupled by the recurrent collaterals of their axons; c) PCs coupled by interneuronal axons; d) PCs coupled by recurrent collaterals as well as by interneurons. Each of these subsystems can thus be modelized and the modulation of activity transiting through these circuits quantified. The first step, which will be detailed in this paper, was to compare activity in isolated PCs (control) and in PCs coupled by the inhibitory recurrent collaterals of their axons (test) (4; 5).

The model incorporates seven neuronal automata (NA) which can temporally evolve by sudden changes at random, through three different states namely 0, 1 and 2 for respectively "silent", "tonic" and "phasic" activity. The duration of each state can vary, also at random, between 1 and 20 ms for states 0 and 1, and 1 to 5 ms for state 2. In the control mode each of the NA has an independant functioning. In the test mode each NA is coupled to it's immediate neighbours with the following inhibitory-type rule. When a given NA is in state 2 for a time $\geq 3$ ms then, at the next ms, the two neighbouring NA are automatically forced into the state inferior to that in which it was (i.e. from state 2 to state 1; from state 1 to state 0) for the entire forecasted duration. If the original state was 0 then it's duration is prolonged by 20%. A number of constraints were also imposed. First and to minimize parasitic correlations we used a random number generator that was tested in the 5th dimensional hypercube (6). Second the simulation cycles were limited to 999 ms to stay in keeping with the "cerebellar time-constant" which is in the order of 200 to 300 ms. At last all statistical calculations were conducted on the five central NA so as to attenuate edge effects.

3 - Results

The dynamics of state shifts taking place at the level of a single NA