Event driven transitions between attractors in spiking networks

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Many complex cognitive tasks require the animals to go through several processing stages, each one representing a inner mental state which contains the information about past experiences, and the "instructions" to parse new events and to generate the proper motor response. Language in humans is one of the highest expression of the ability to generate these complex sequences of mental states. In [1] the authors propose a simplified network of Hopfield like neurons in which the inner mental states are represented by attractors of the neural dynamics, and external or internal events induce transitions between attractors. Furthermore they show that the observed diversity in the neural response (e.g. mixed selectivity), can be effectively harnessed to increase the number of transitions between attractors.

Here, by using a mean-field approach and simulations, we provide evidence that networks of leaky IF neurons can realize arbitrarily complex schemes of attractors and transitions. We show that the network can implement a simple task switch protocol, often used in psychophysics experiments, to test the ability of the system to respond to the same external stimulus with different motor actions, depending on the rule notified in effect. The Figure illustrates the network behavior during the presentation of the same event *A* associated to the left (L) and the right (R) movement depending on the active context (attractor 1 or 2). The above heterogeneity is implemented considering subpopulations reacting if an inner state of the network is active and an external event appears (see the last four populations in the middle panel). Transitions between the high firing rate states of the populations 1, 2, L and R, was possible only considering a hierarchy of connections, as observed in biology where close populations have a stronger connectivity with respect to the coupling between distant sets. Such feature allows the coexistence of distributed attractors also in more simplified network models [2].

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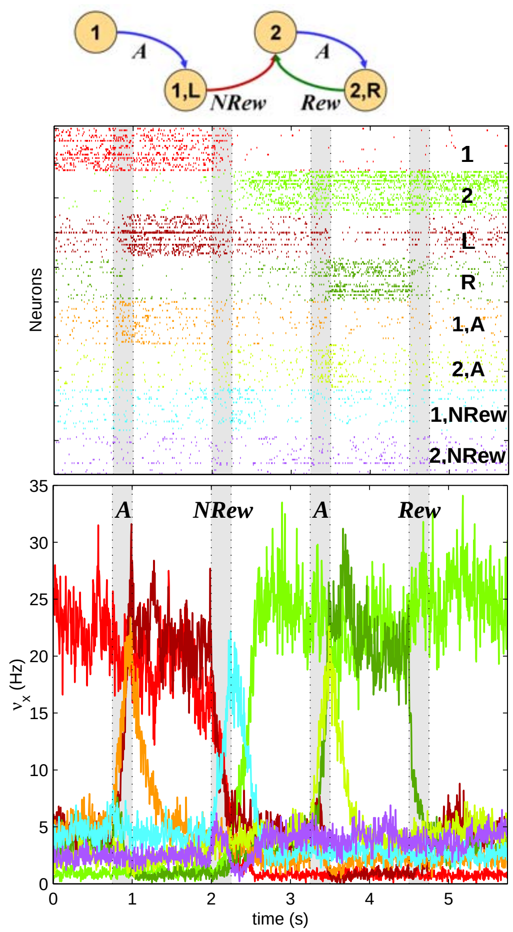

Figure 1: A sequence of four inner mental states driven by the same external event (*A*) when different contexts are active, as coded by the persistent activation of the subpopulations 1 and 2. A context switch is implemented providing a "not reward" signal (*NRew*), as sketched in the top panel. The middle and bottom panel show respectively a rastergram of a subset of neurons and the instantaneous firing rates (ν_x) of the relevant subpopulations involved. Different colors code different subpopulations, labeled on the left of the raster plot. External events are presented during the gray strips. *Rew* stay for "reward". The network contains 40000 excitatory and 16000 inhibitory IF neurons.