To remember or not to remember? An account of memory random walks

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From an evolutionary point of view, an important innovation that emerged at some moment of history is active adaptation, i.e., the capacity of living systems to use their cognitive systems to sense the environment and react to their changes correspondingly. While this capacity can exhibit different levels of complexity (from microorganisms to humans), it is clear that one essential ingredient it requires is memory (for pattern recognition, decision making, etc.).

A basic function of living systems that can be used to explore this active adaptation is spatial exploration for foraging. Actually, spatial exploration of Y-mazes by animals with reward is a recurrent experimental case of study for cognitive biologists and neuroscientists, one which has recently provided the first evidence of mental simulations prior to execution in cognitive processing of rats [1], a result which challenges the classical stimulus-response paradigm in biology.

The elementary toy models statistical physicists have to explore such spatial processes are random walks [2, 3]. So, introducing and analyzing the possibility of memory (as well as prospective simulations) on the behavior of random walkers, even at a very basic level, represents a topic of major interest in the frontier between physics and biology. In the present contribution we will try to (i) present a very brief account on the field of random walks with memory and/or with nonlocal time effects (e.g., 'elephant walks', 'reinforced walks', among other) that our group and others have recently explored [4, 5], and (ii) discuss what are the main challenges we face nowadays in order to take such models progressively to a level where direct comparison with biological data is possible [6, 7].

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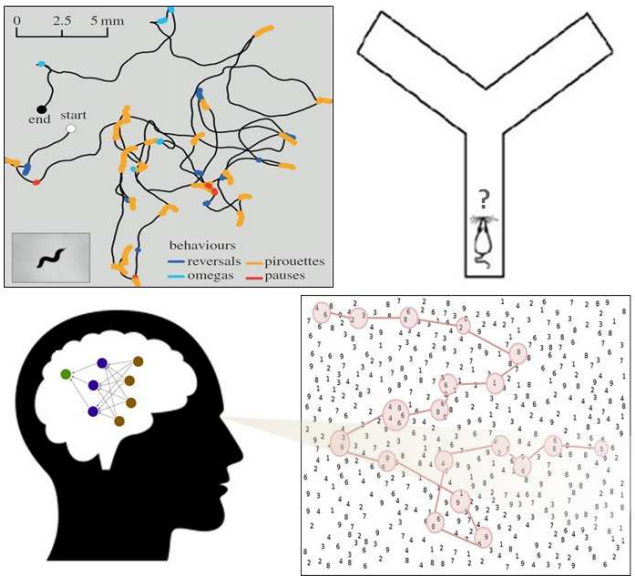

Fig. 1. Different levels of biological complexity in the use of memory for spatial exploration.