Emergence of Risk Sensitivity in a First-principles Agent-based model

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Risk aversion and risk-seeking are acknowledged features of human and non-human behaviour. Biology identifies risk-sensible behaviours in various species like non-human animals, plants and bacteria. Risk preferences also appear at a super-human level, such as in organizations. The risk sensitivity of different entities seems to be shaped by the same underlying principles. Thus, there could be a regularity concerning wherewith living entities originate risk-sensible behaviour. Some existent works examine this occurrence through computer simulations. They show that risk preferences can arise under evolutive forces when individuals interact in unsafe conditions. Other works propose a perspective that includes the role of cultural processes.

The goal of this work is to identify risk sensitivity emergence from both cultural and genetic adaptation. Moreover, it aims at finding relationships between this emergence, the adaptation styles and the environmental variables. It presents an agent-based model in which a single variety of agents exists on a two-dimensional toroidal surface divided into squared cells. Each cell can either contain an energy source or be empty. Energy sources have an initial level of energy, progressively drained by agents. Once an energy source is consumed, it disappears and another one appears in a different cell. Agents use a given amount of energy at each time step. When an agent terminates energy, it dies. It implies that agents necessitate recharging to survive. There are two alternatives to do it. An agent can head towards an energy source and supply from it. Otherwise, it can move towards a different agent and attack it with a given probability of success. Therefore, both attacking and defending agents can win. We analysed scenarios with various chances of victory. A winning agent subtracts a share of energy from the disputant. So, the model forces agents to decide between a risky and safe opportunity. For each possibility, agents compute a payoff, which is the distance from the option times the desirability of that specific event. Risk sensitivity is the difference between risk proneness and risk aversion of agents. Each agent has two risk sensitivities. One is genetic, and it is inherited from parents. The other comes from individual learning and the transmission (partial or complete) of the experience to offsprings. Distinct simulations consider populations that give different importance to knowledge and genotype (i.e. the adaptation style).

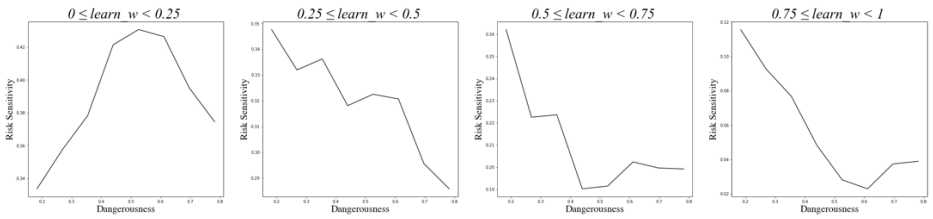

Figure 1: Risk sensitivity of population plotted on the dangerousness of the system with respect to different style of adaptation, from evolution (left) to learning (right)

The simulation of the model confirms both risk aversion and risk-seeking behaviours emerge from the interaction of agents. A relationship between environmental variables and the emergence of risk sensitivity is found. This link seems to be affected by the adaptation style. Besides, it seems to exist a non-monotonic non-linear relationship between environmental dangerousness and the emergence of risk sensitivity (Figure 1). We propose this is due to the combination of two elements: the existence of incentives to develop risk preferences, which varies with the dangerousness of the surroundings; the direct relationship between the harshness of the environment and how beneficial is the development of risk preferences. The simplicity of this model indicates that these findings could apply to different application fields. Future studies include the generalization of the results and the identification of connections between the pace of life and the emergence of risk preferences.