MODELING PARADIGM SHIFTS IN CULTURAL EVOLUTION

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Cultural transmission is a process of innovation and interaction between individuals that brings about changes in societies. These changes can occur either smoothly and gradually or suddenly and abruptly. Abrupt changes are collective phenomena referred to as 'paradigm shifts'.

Paradigm shifts, as well as some mechanisms responsible for them, have been described in Social Sciences. An example of such mechanisms is the interaction between cultural elements, that is, how the presence of an element facilitates or inhibits the presence of a second one[1].

Here, we present a simple mathematical model of cultural paradigm shifts. Instead of analysing how a trait or a certain set of traits compete and spread throughout a population, we explore how the interaction between cultural elements changes the dynamics of cultural transmission to the extent that it can explain the occurrence of paradigm shifts.

For this reason, rather than assuming an intrinsic adaptive value to the different cultural traits, we will assign a *coherence* value to the whole *cultural state*, which is comprised of all the individual cultural traits. An individual feels more inclined to change a cultural trait if the cultural state she ends up with is globally more coherent. Due to its biologic analogy, we also refer to this measure as *fitness*.

Individuals are defined by a vector of cultural traits, their cultural state. They meet in pairs and put a random cultural trait at stake. Also, they can spontaneously change one of their cultural traits. However, changes are more likely to occur if they increase the individuals fitness.

Small changes on fitness due to exogenous effects together with the interaction between traits are found to be the microscopic basis for the occurrence of paradigm shifts.

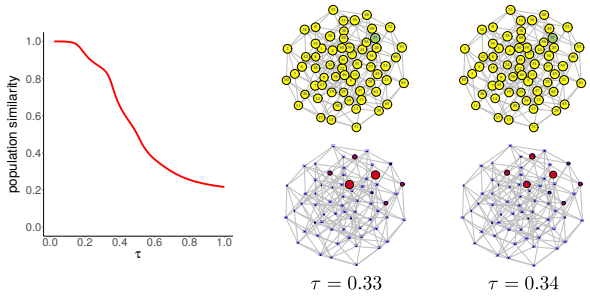

Figure 1: Left panel: Similarity between the population vectors at time τ and 0 as a function of τ when there is not interaction between traits. In spite that the population vector undergoes a large variation, no discontinuous jump can be appreciated. Right panel: Graph representing all cultural vectors. In the top row the size of the nodes is proportional to their associate cultural coherence. In the bottom row the size of the nodes is proportional to the corresponding fraction of population. No abrupt changes occur when there is not interaction between traits.

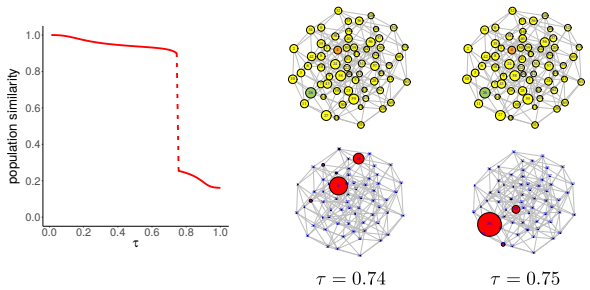

Figure 2: Left panel: Similarity between the population vectors at time τ and 0 as a function of τ when there is interaction between traits. An abrupt change in the population vector from some cultural vector to another one occurs at time $\tau = 0.75$, approximately. Right panel: Graph representing all cultural vectors. In the bottom row the size of the nodes is proportional to the corresponding fraction of population. The population jumps discontinuously to a different cultural state.

[1] Enquist, M., Ghirlanda, S. and Eriksson, K. Modelling the evolution and diversity of cumulative culture. Phil. Trans. R. Soc. B 366, 412423. (2011)