ODD protocol

Replication of the model made by Eerkens and Lipo (2005).

Purpose

This model aims to show the impact of small errors in the transmission of cultural traits on the big pattern of variation seen in the subsequent production of those traits. It also demonstrates that different types of transmission (vertical versus diagonal) affect differently the level of variation seen in given transferred traits over time. This model is used to obtain plausible explanations for certain types of variations found in the archaeological record.

Entities, state variables and scales

The model has three different states in which the variables are slightly different. In this document, the first state will be called 'test_error', the second 'conformism' and the third 'prestige'.

In all states, the agents modeled do not move, and have a memory of 1 given that each generation (tick) knows the attribute values of the previous generation. All agents can have variables in which they can record their own attribute value and the one they are inheriting during reproduction. For the 'prestige' state, agents can have a binary variable in which the observer records who is the prestigious individual.

The test_error model is composed of 10 agents, whereas the conformism and prestige states both have 40 agents. All states model runs of 400 ticks, each representing a generation of individuals (each agent reproduces and dies, therefore the number of agents stays constant over time). In both prestige and conformity, the level (%) of agents choosing the prestigious individual or choosing to conform to the population is a value that can be varied by the observer.

Process overview and scheduling
In all states, the agents are assigned a random attribute value at setup. The value is calculated following equation n.2 (see below).

In the test_error state, at reproduction, agents replicates their parent's attribute value with a certain level or error.

In the conformism state, a percentage of agents copy the mean average value of the previous generation; other agents copy their parent's value. The agents' probability to conform follows a value set at initialization and is the same for all agents.
All copying entails a certain level of error.

In the prestige state, for each generation (at each tick), one agent is chosen at random to be the most prestigious one of the population. Then, the agents choose if they take their

parent's value (previous generation in a vertical transmission pattern) or the value of the most prestigious agent of the previous generation (diagonal transmission). The agents' probability to choose the prestigious individual follows a value set during the initialization of the model. This probability value is the same for all patches.

In all states, the new value is calculated through the following equation:

$$Y(t) = N\,(Y(t\text{-}1),\ Y(t\text{-}1) * c) \qquad (1)$$

"where $Y(t)$ represents the attribute [value] at any time t" (Eerkens and Lipo 2005: 322), $Y(t\text{-}1)$ represents the attribute at previous generation, and N(x,y) is a normal random variable with mean x and variance y. Therefore, the new value $Y(t)$ is a function of the value of the individual(s) copied (be it the parent, the mean of the previous generation or the prestigious individual). The level of variation is mostly controlled by the variable c, which represents the error rate divided by 2. In this experiment, the error rate cannot be bigger than 3%. Given this equation, the amount of error added to the transfer of information between parent and child can be positive or negative.

Given that there is no interaction between agents, the order in which the values are calculated is not important.

In terms of the observer processes, the Coefficient of Variation (CV) of resulting values is calculated and projected in a graph at each run. This CV represents the generation standard deviation divided by the generation mean.

Design concepts

- Basic principles
    - This model is linked to the idea that errors through the transmission of cultural traits can create specific patterns of variation in the traits created.
    - This model takes into consideration the fact that humans cannot perceive differences in length that are smaller than 3% of the total length. For example, when looking at two different objects, one cannot perceive the difference in length if that one makes less than 3% of the total length of the object. This is the reason why the reproduction error (c in the equation) cannot be larger than 3%, as the errors are supposed to be (at least in this model) involuntary.
    - This model also explores the idea that strategies such as copying the or the most prestigious individual or conforming to the average value of the previous generation can reduce the amount of variation created through copying errors in following generations.
- Emergence
    - The pattern of change in the CV over time demonstrates that even very small variations can create big changes over time. However, those variations are smaller when people can conform to a population average or when they copy the most prestigious individual of the previous generation.

    - If the level of variation between agents is high from the start, the strategy of copying the most prestigious individual tends to reduce the variation over time.
- Learning
    - Given that the agents keep only a memory of one generation, there is not much learning.
- Sensing
    - All agents sense what the value of their parent or of the prestigious individual was at the previous generation. The sensing is accurate, but the reproduction of the attribute is not (where copying error enters the model)
- Interaction
    - Agents do not interact in a single generation; however they interact in a certain way with the previous generation as all agents need to take on the value of a given individual from that generation (parent or prestigious individual).
- Stochasticity
    - Given that the error value is scaled by a random value of z in a normal curve based on previous attribute values and error rate, stochastic cumulative results are created. All simulations have slightly different outcomes.
    - Moreover, the initialization of the model uses random attribute values for all agents. This contributes to the stochasticity of the results.
- Observation
    - The CV between attribute values of all agents in any generation is the output necessary to assess the level of variation over time. This can be projected in a line graph.

Initialization

As mentioned above, the different states of the model have some different initialization values. However, all states have the same error_rate value at the start (0.03 or 3%). Moreover, the attribute values assigned to all patches at the start are all defined through the following equation:

$$Y(t) = N(10, 10 * c) \quad (2)$$

See above for the significance of the symbols.

In the test_error state, the model is initialized with 10 agents, whereas it is set at 40 agents for the conformity and prestige states. The initialization values for the probability to conform or choose the prestigious agent's value are not defined and can vary from one researcher to the next.

Input data

There is no input data for this model.

Submodels

This model is simple enough to be described in the process section.

Reference cited:

Eerkens, J.W. and C.P. Lipo, 2005. Cultural transmission, copying errors, and the generation of variation in material culture and the archaeological record, *Journal of Anthropological Archaeology*, 24(4):316-34