

# ODD for the cultural transmission model

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## 1 Purpose

This model illustrates how theoretical models of social learning strategies (Boyd, 1985; Henrich and McElreath, 2003; Laland, 2004; Mesoudi, 2011) can easily be translated into an ABM, by exploring how different modes of transmission combined with different population sizes can affect cultural diversity.

## 2 Entities, state variables, and scales

### 2.1 Agents

Each agent is described by its spatial location  $x, y$  and an array composed by  $nTraits$  slots that can be one of the values defined by the vector  $traitRange$ . For example if  $nTraits = 3$  and  $traitRange = \{0, 1, 2, 3, 4\}$ , an agent can have traits  $\{0, 2, 0\}$  while another one might have  $\{0, 1, 1\}$ . This array of numbers represent the cultural traits possessed by each agent. Thus in the example just given, the two agent share the same cultural trait (the number 0) in the first slot.

### 2.2 Environment

Agents move within a bounded rectangular space sized with dimensions  $xDim \times yDim$ .

## 3 Process overview and scheduling

The simulation proceeds with a discrete number of time-steps, each where the following two processes update the location and the cultural traits of the agents:

1. Movement
2. Cultural Transmission

The order of agents' execution is shuffled every time step, and each phase is simultaneously executed for all agents before moving to the next one.

## 4 Design concepts

### 4.1 Basic principles

The array of cultural traits follows the classical model of Axelrod's dissemination of culture (Axelrod, 1997). Transmission mechanisms have been implemented based on the literature cited in the paper.

### 4.2 Emergence

The interaction of the agents follow 3 basic social learning system (unbiased, prestige-biased and conformist). Each model sees the emergence of a different level of diversity linked to the particular transmission dynamics.

### 4.3 Adaptation

There is no adaptation.

### 4.4 Objectives

There are no agent objectives.

### 4.5 Learning

There is no learning.

### 4.6 Prediction

There is no prediction.

### 4.7 Sensing

The agent engage into social learning only with individuals located within an euclidean distance *interactionRadius*.

### 4.8 Interaction

Agents copy cultural traits of the other agents following one of the four cultural transmission modes listed above. This leads to different types of populations and traits.

### 4.9 Stochasticity

The innovation mechanism and the different transmission modes, where cultural genes are changed based on probability, contain stochasticity in the probability of copy/innovate for a particular trait.

### 4.10 Collectives

Collectives affect agents whereby agents with specific cultural attributes will likely affect other agents that do not have those attributes.

### 4.11 Observation

We measure cultural diversity using Simpson's index of diversity  $D$ :

$$D = 1 - \sum_{i=1}^C \left( \frac{n_i}{N} \right)^2 \quad (1)$$

where  $C$  is the total number of possible combination of traits defined by  $nTraitRange$  and  $nTraits$  (equivalent to the length of the vector  $nTraitRange$  elevated by  $nTraits$ ),  $n_i$  is the number of agents for the  $i$ -the combination, and  $N$  is the total number of agents ( $nAgents$ ). The index ranges is bounded between 0 (low diversity) and 1 (high diversity).

## 5 Initialization

A parameter sweep is applied in the four scenarios and using specific parameters varied as referenced in the paper.

### 5.1 Agents

This model is populated by  $nAgents$  located at random spatial coordinates. Each of the traits in their cultural vector *traitRange* is randomly chosen from the values in *traitRange*.

### 5.2 Environment

## 6 Input data

There are text input files in the models' git repository.

## 7 Submodels

### 7.1 Movement

All agents move to a random location within an euclidean distance *moveDistance* of current position  $x, y$ .

## 7.2 Transmission

All agents engage into one of the following modes of social learning:

### 7.2.1 Unbiased Transmission

Each focal agent first defines its social teacher as a randomly chosen agents located within distance *interactionRadius*. If a social teacher is found, the focal agent choses a random index value from its cultural trait slots, and copies the corresponding value of the social teacher. Thus, for example, if the focal agents have  $\{3, 2, 0\}$ , the social teacher  $\{0, 1, 1\}$ , and the random index value is 2, the updated cultural traits of the focal agent becomes  $\{3, 1, 0\}$ . With probability *innovationRate* the newly acquired is swapped with a random value from *traitRange*.

### 7.2.2 Prestige-Biased Transmission

As in the unbiased transmission model, the focal agents selects a social teacher within distance *interactionRadius*. This time, the probability of being selected as social teacher is however proportional to the trait value at the index number *prestigeIndex*. More specifically the probability  $\pi$  of selecting a social teacher  $x$  from a the pool of potential social teachers  $P$  (so that all agents in  $P$  are located within distance *interactionRadius* from the focal agent) is given by:

$$\pi_x = \frac{T_{p,x} + 1}{\sum_{i=1}^P (T_{p,i} + 1)} \quad (2)$$

where  $T_{p,x}$  and  $T_{p,i}$  are respectively the prestige index values of the agent  $x$  and  $i$ . Thus if three agents located within distance *interactionRadius*, have respectively 3, 2, 0 as trait value at their *prestigeIndex*, the probability for the first agent to be selected is  $\frac{3+1}{(3+1)(2+1)(0+1)} = 0.5$ . As for the unbiased

model, the actual cultural trait slot being copied is randomly selected, hence portraying social contexts where the learners selects a teacher based on its prestige, but it is not always aware of which cultural trait determines such prestige. As in the other models, with probability *innovationRate* the newly acquired is swapped with a random value from *traitRange*.

### 7.2.3 Conformist Transmission

The focal agent defines the pool of social teachers (i.e. all agents located within distance *interactionRadius*) and a randomly selected index value for its cultural trait slots. Then it copies the most common value amongst the social teachers (randomly selecting between the most common ones in case of a tie). With probability *innovationRate* the newly acquired is swapped with a random value from *traitRange*.

## 8 References

### References

- Axelrod, R. (1997). The dissemination of culture : A model with local convergence and global polarization. *Journal of Conflict Resolution*, 41:203–226.
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