

Model description

We follow the ODD protocol, a standard format for describing agent-based models (Grimm et al. 2006; Grimm et al. 2010). Models were created in Netlogo (Version 5.1.0) (Wilensky 1999) and are available at OpenABM (<http://www.openabm.org>).

Purpose

The purpose of this study was to explore optimal network structures in situations where group members receive unreliable information about their environment. Our model was based on the SSEC (self-, social-, and exploration-based choices) model developed by Goldstone et al. 2008c and Mason et al. 2008, and, our methods followed theirs, except where noted below.

Network Types

We used four types of networks: fully connected, small world, lattice, and random (Figure 1). In the fully connected network, every agent was connected to every other agent. In the small world and lattice networks, all agents were connected to their immediate two neighbors, and some agents were also connected to a third agent at either a far distance (small world) or a close distance (lattice). In the random network, agents were connected randomly. Each network had 10 agents and a total of 12 connections, except the fully connected network, which had 45 connections.

Payoff Distributions

In each round, an agent chose a number between 0 and 100. Each number was associated with a specific payoff according to one of three continuous payoff distributions: unimodal, trimodal, and needle (Figure 2). Each distribution had a single global maximum, and thus one “correct” choice, but the trimodal and needle distributions had additional lower peaks. All three distributions can be mathematically described as:

$$f(x) = a_1 \exp(-(b_1(x - c_1))^2) + a_2 \exp(-(b_2(x - c_2))^2) + a_3 \exp(-(b_3(x - c_3))^2) \quad (1)$$

The parameter values for each distribution are summarized in Table 1. The unimodal, trimodal, and needle payoffs represent successively greater challenges to discovery of the best resource: for the unimodal distribution, agents will find the peak as long as they move up a gradient of performance. For the trimodal distribution, they face the risk of getting stuck on a local peak and missing the global maximum. For the needle distribution, the global maximum is still harder to find because it is much narrower than the competing local maximum.

In the first experiment, the payoff function determined the exact payoff received by an agent choosing value x . In the second experiment, the function’s output was added to a noise term drawn from a normal distribution with mean zero and standard deviation 10.

Agent Strategies

On every round, each agent probabilistically chose one of three strategies:

- 1) **Stay**: The agent chooses the same number it did on the previous round.
- 2) **Best**: The agent chooses the number that paid the most among its directly connected neighbors in the previous round.
- 3) **Random**: The agent chooses a number randomly.

In the first round, all agents used the random strategy. As the simulation progressed, agents updated their probabilities of choosing each strategy according to their own payoff history. That is, the higher the payoffs previously earned using a given strategy, the more likely that strategy was to be used again. Agents initially had equal probabilities to use the first two strategies (45% for each), and a lower probability to use the third (10%).

Process Overview and Scheduling

Each simulation started with creation of one of the four network types. It then progressed through 15 rounds, during which each agent in the network chose a decision strategy and then used it to make a choice. After each round, the agents updated their strategy probabilities according to the outcome of their choice. After every 15-round session, a new network was generated and all the parameters were re-initialized. For each network structure, 500 15-round simulations were run for each of the three payoff distributions.

At the end of each simulation, we measured the group's performance by counting the number of agents that came within a specified distance of the global

maximum. This distance was eight for the unimodal and trimodal distributions and four for the needle distribution.

We conducted two experiments. In the first experiment, there was no noise, and we measured performance of all four network types for all three payoff distributions. In the second experiment, we added noise and similarly measured network performance.