Group Formation through Indirect Reciprocity in Random Sparse Network

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Abstract

It is said that people are more cooperative to the other people in the same group. This tendency of humans is called in-group favoritism. Recently, we have found that, at least in a completely connected society where all individuals can interact each other, indirect reciprocity, a well-studied mechanism which as usual maintain mutual cooperation, may form some exclusive groups and promote in-group favoritism [1].

In our previous model [1], it is assumed that all individuals are connected with all individuals, and that any two individuals can interact. In reality, however, not all individuals in a society can meet. Moreover, since social interaction can be affected by the structure of social network, exclusive group formation through cooperative behaviors in indirect reciprocity can also depend on network structure between individuals. Therefore, to understand the effect of network structure on group formation, we performed a numerical experiment by using a game-theory-based model of indirect reciprocity in random network in which every two individuals are linked with the probability p.

Figure 1 shows the average number of groups after a large number of games. Here, all individuals are cooperative to only their in-group members, and not cooperative to out-group people. This is nothing but in-group favoritism. We found that, as is shown in Figure 1, the number of groups can get smaller than two around $p = 0.3$, whereas two exclusive groups can be formed in our previous model [1], which corresponds to $p = 1$ in Figure 1. This suggests that almost all individuals may belong to the same group when the network is sparse.

Figure 2 shows the average number of games until the system has reached a stationary state, in which no individuals will change their groups even if they play more rounds of games. Here, we call the number of games until a stationary state a relaxation time. We found that a relaxation time has a peak around $p = 0.6$, and it gets larger while the system size gets larger. It seems that frustration emerges during group formation though indirect reciprocity in random sparse network.

By analyzing a model of indirect reciprocity in random network, we found that sparsity of network helps almost all individuals to belong to the same group and to cooperate with each other, whereas the sparsity also causes a relaxation time until the system has reached a stationary state to get much longer.

References

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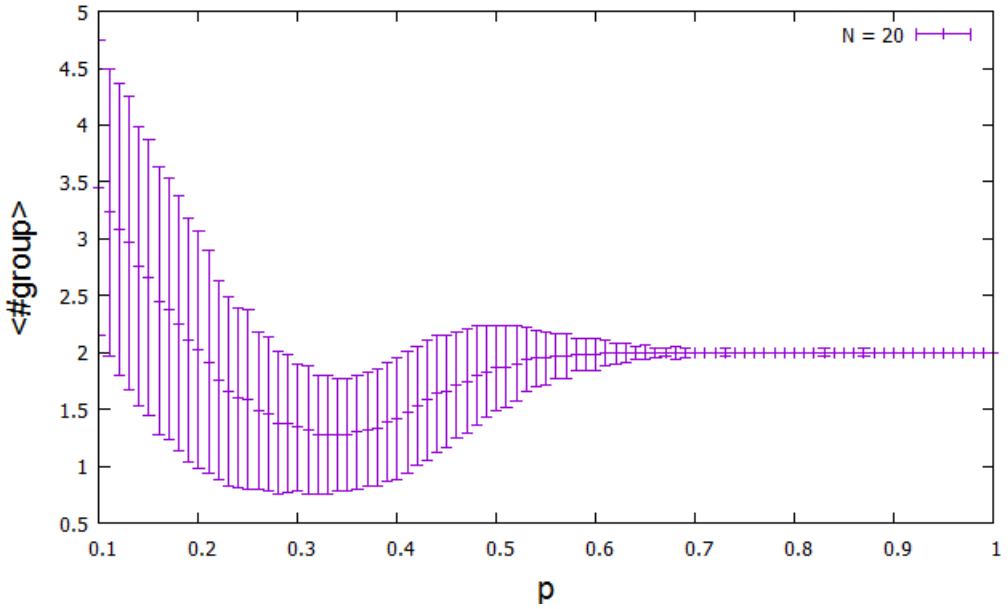

Figure1: The average number of groups in a stationary state.

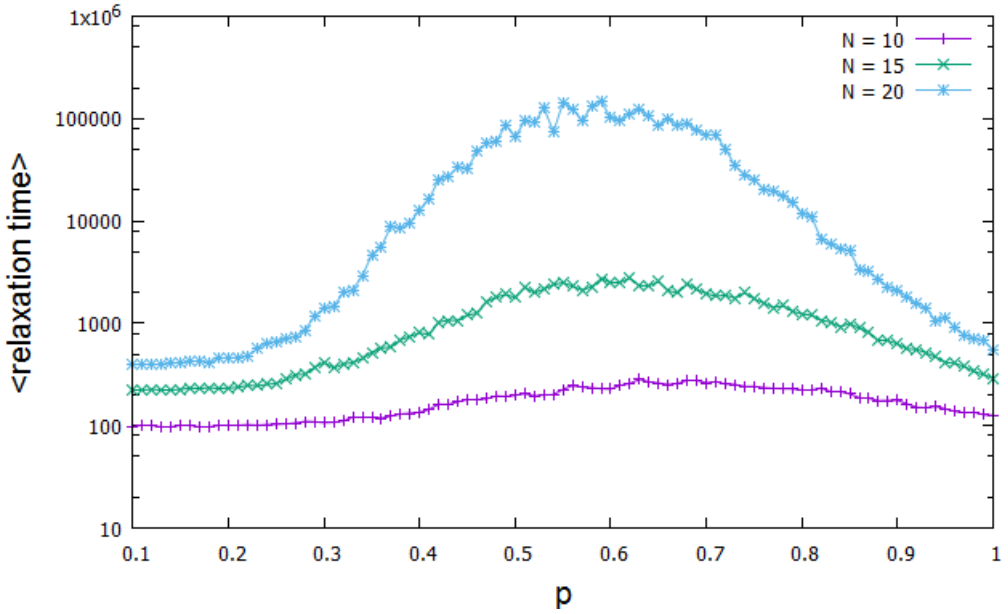

Figure2: The average of relaxation times until a stationary state.