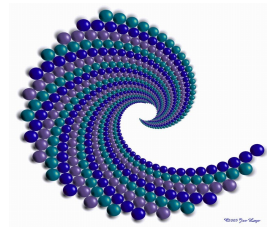


**Presentation for the IES Research  
Institutional Framework Workshop**

# **Individual and Collective Action in Minority Game**

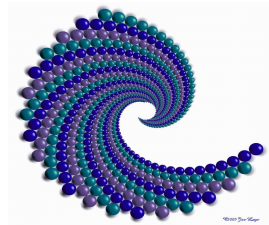
PhDr. Petr Švarc

2006



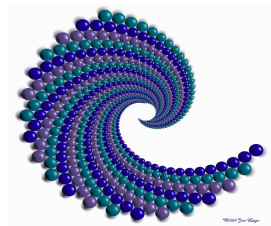
# Motivation

- Observed *rationality* on private markets and *irrationality* on political markets (or in collective action)
- Explanations:
  - Rational Ignorance (Downs 1957)
  - Rational Irrationality (Caplan 2001)
- Problems:
  - Rational ignorance is not enough (Caplan 2001)
  - Rational Irrationality – existence of duality – assumption that people are perfectly rational about price of the irrationality



# Our Solution

- We study behavior of agents in the evolutionary environment simulated as Minority Game
- Agents acting both as
  - individuals and
  - collectives
- Agents learn to act rationally
- Behavior of agents face evolutionary pressure
  - worst agents change their strategies (individual or social learning)



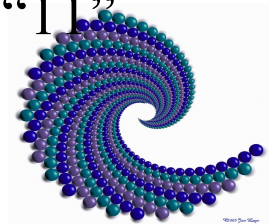
# Related Literature

- Rational Irrationality
  - Caplan, B.: Rational Irrationality: A Framework for the Neoclassical-Behavioral Debate, Eastern Economic Journal 26(2), Spring 2000, pp.191-211.
  - Caplan, B.: Rational Ignorance vs. Rational Irrationality, Kyklos 54(1), 2001, pp.3-26.
  - Caplan, B.: The Logic of Collective Belief, Rationality and Society 15(2), May 2003, pp.218-42.
- Minority Game:
  - D. Challet and Y.-C. Zhang, Emergence of Cooperation and Organization in an Evolutionary Game, Physica A 246, 407 (1997).
  - N. F. Johnson et al., Enhanced winnings in a mixed ability population playing a minority game, (1999).
  - Ricardo M. Araujo and Luis C. Lamb: On the Evolution of Memory Size in the Minority Game. (extended abstract), IJCAI-05 proceedings.



# Minority Game (MG)

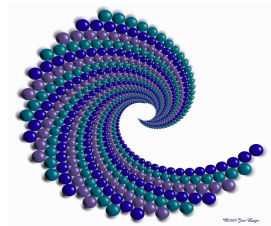
- A binary model of competing population
- $N$  agents competing to be in minority group
  - option „0“ or „1“
- Agents who take the minority decision are rewarded after each round, that is if the number of agents playing 1 is higher than the number of those playing 0 then all 0-players are rewarded and vice versa
- History of previous winning groups is common knowledge
  - history is a bit string
  - possible histories (last two turns): “00”, “01”, “10” and “11”



# Minority Game (MG)

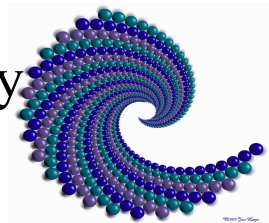
- Example of strategy for memory  $m = 3$

| signal | prediction |
|--------|------------|
| 000    | 1          |
| 001    | 0          |
| 010    | 0          |
| 011    | 1          |
| 100    | 1          |
| 101    | 0          |
| 110    | 1          |
| 111    | 0          |



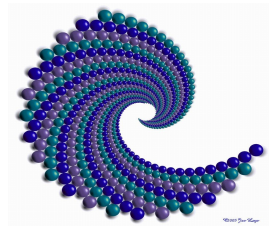
# Minority Game (MG)

- In order to take their decisions agents are each equipped with a pool of  $s$  strategies
- Agents can remember the correct minority decisions of the last  $m$  rounds, that is they can resolve  $P = 2^m$  different histories of the game, a strategy  $a_{is}$  provides a map from all possible  $m$ -step histories onto the binary set  $\{0,1\}$ ,  $a_{is} : \{1, 2, \dots, P\} \rightarrow \{0,1\}$
- At each time step each agent has to choose which of his strategies to use
- Agents follow an inductive learning dynamics by learning from past experience
- At each time step agents choose the best performing strategy



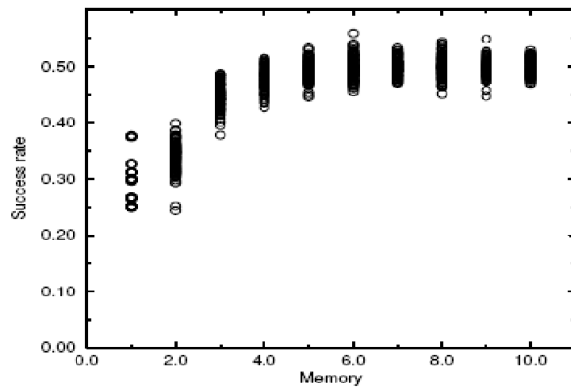
# Minority Game (MG)

- A score  $U_{i,S}$  is assigned to each strategy table and updated at each step of the game as follows:
  - $U_{i,S}(t+1) = U_{i,S}(t) + 1$  for a correct prediction
  - $U_{i,S}(t+1) = U_{i,S}(t)$  for a wrong prediction
- Each agent then at each time step uses the strategy in his pool of strategies with the highest score
- In case of equal scores between some strategies, the agent chooses between those at random





# Rationality vs. Irrationality



- For mixed population of agents with different memory size (or invested intellectual capacity) low-memory agents are exploited by larger-memory agents
- Rational agent will use information that ensures him highest probability of success

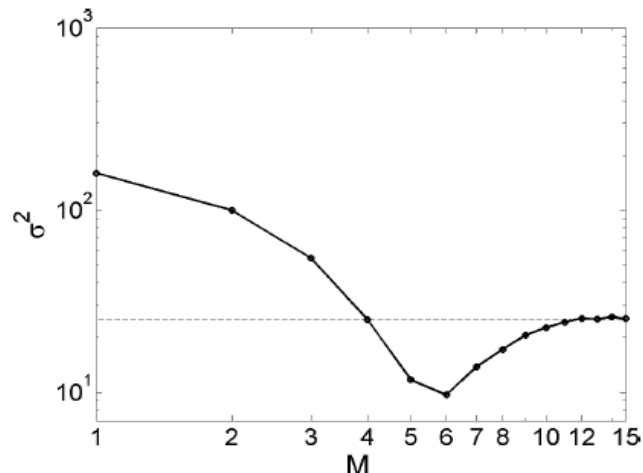


Figure 1: Variance versus memory size

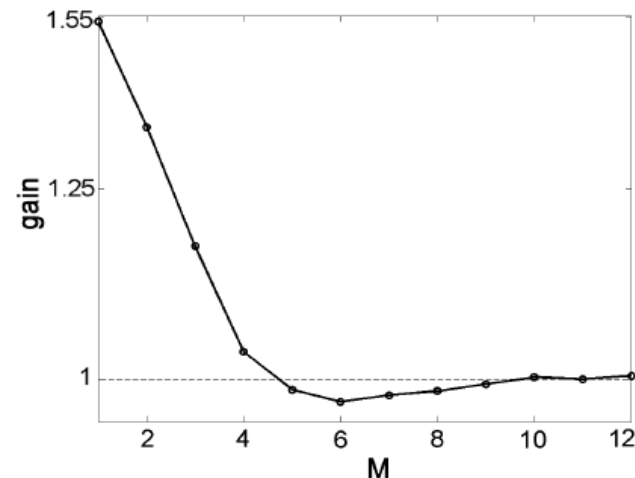
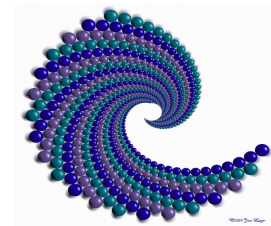
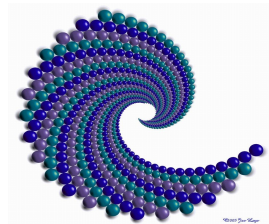


Figure 4: Gain of a target-agent with  $m=M+1$ .



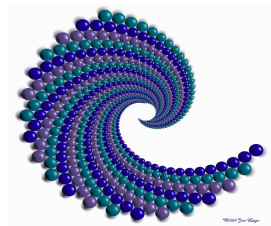
# Case 1: Agents acting as individuals

- Traditional MG played by population of agents
  - Starting with homogeneous population with memory  $m = 1$
  - But possible evolution of memory size (max.  $m = 6$ )
- After some time (each 200<sup>th</sup> period) agents are sorted based on their average winnings
- Worst agents (the worst 10 percent of agents) revise their strategies:
  - Leave strategies without change
  - Experiment – change memory to arbitrary value from [1,6]
  - Copy strategies from best agents (the best 10 percent of the agents)
- Our interest is in evolved average size of memory



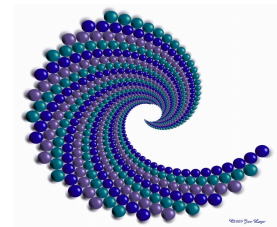
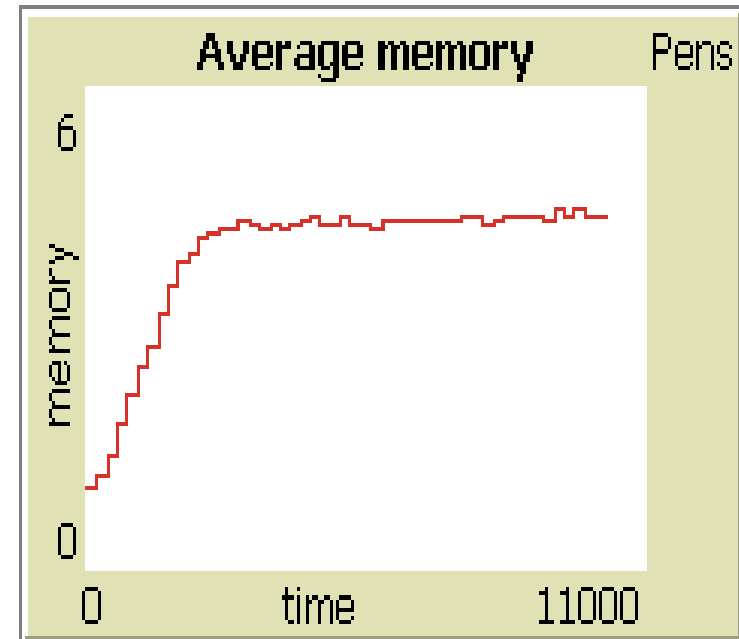
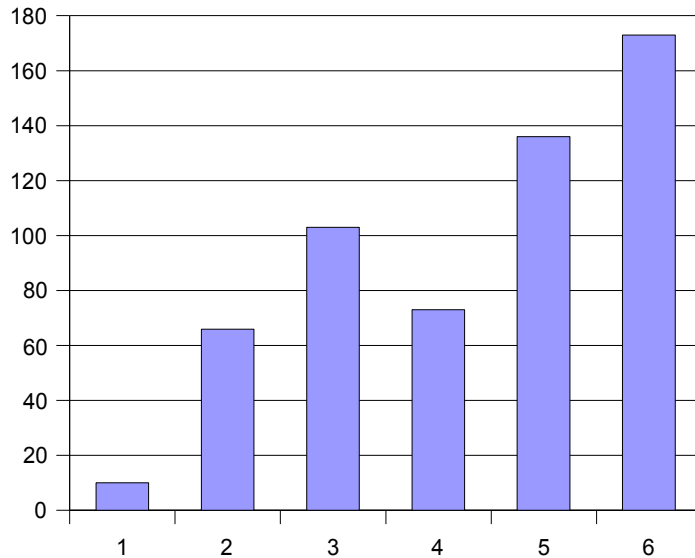
# Case 2: Agents acting as collectives

- Same setup as in previous case but now agents are members of collectives and these collectives play MG
- Strategy of the collective equals majority of votes of the members of the collective
  - The strategy of the collective is either „0“ or „1“
- Each vote has again the binary form
  - Options „0“ or „1“
- Each agent choose strategy independently based on the history of previous winning groups
- Each agent is rewarded if he is in the collective that is in the minority – so there is only indirect relation between agent's action and reward
- Again worst agents could change their strategies

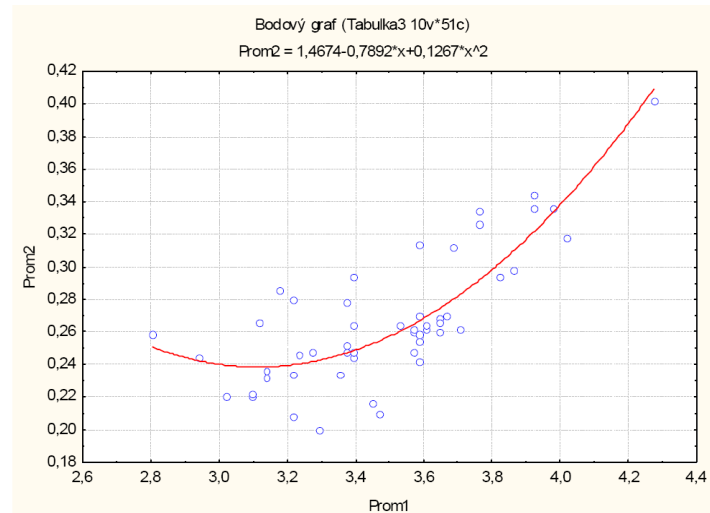
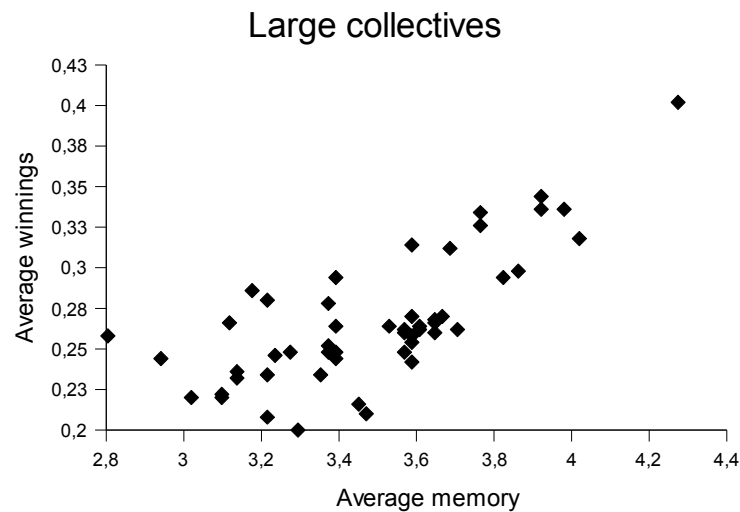
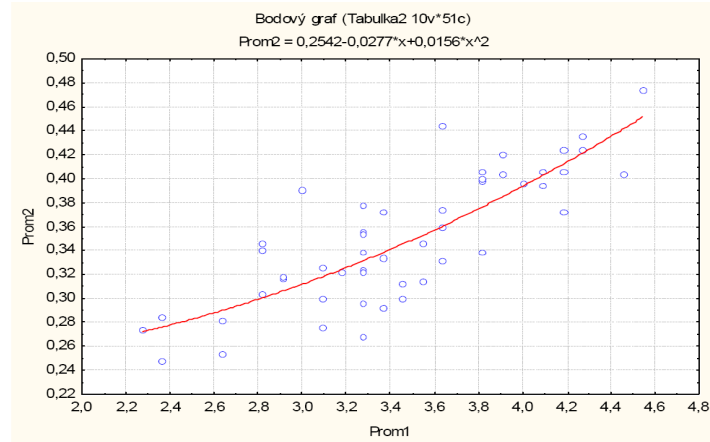
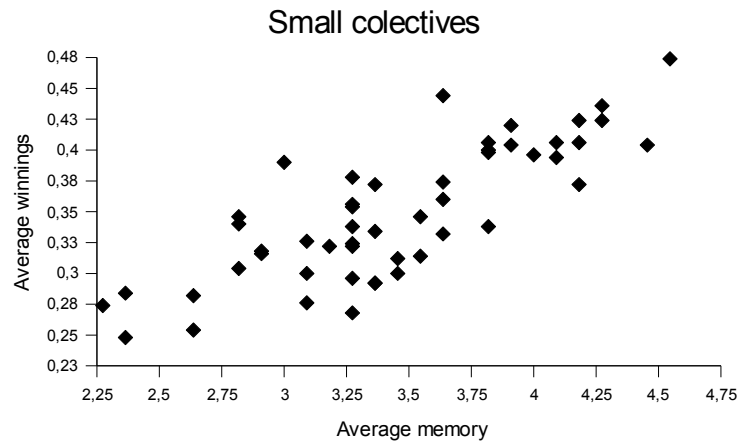


# Case 1: Results

Memory size histogram

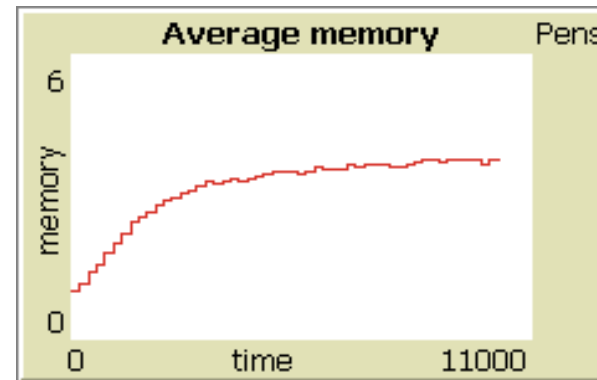
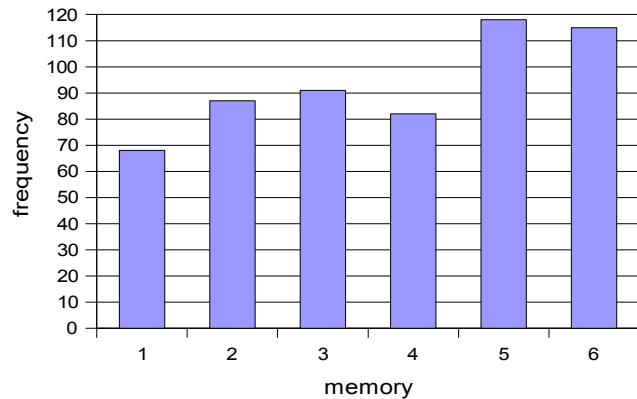


# Case 2: What dynamics we could expect?

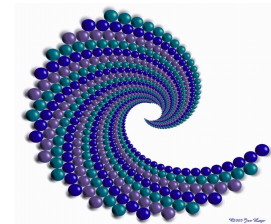
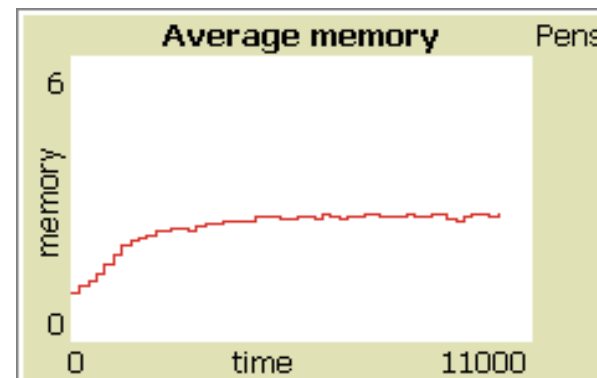
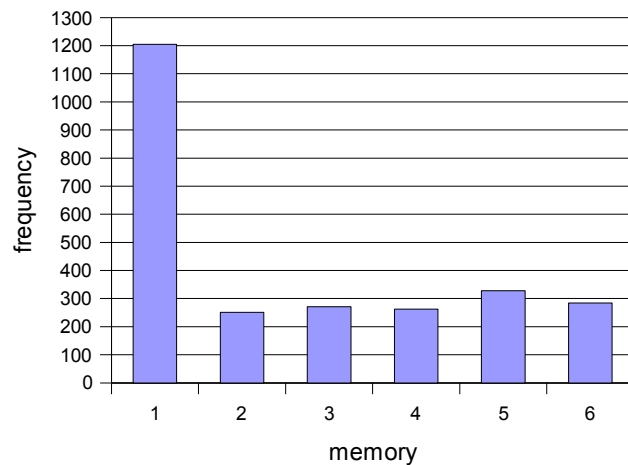


# Case 2: Results

Memory size histogram - small collectives

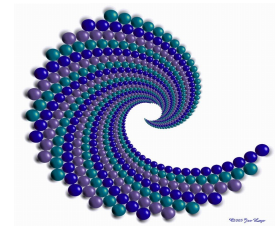
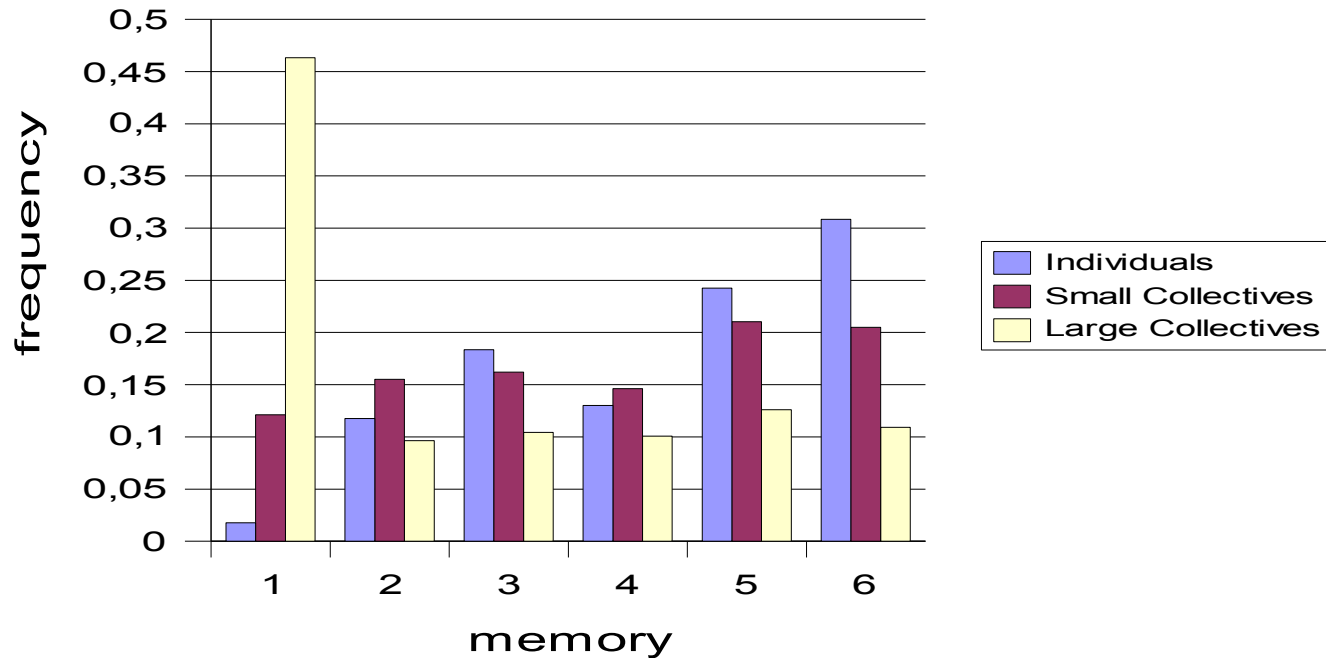


Memory size histogram - large collectives



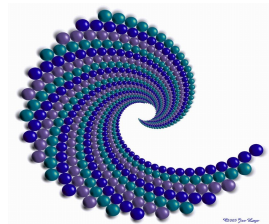
# Results comparison

## Memory size histogram



# Conclusions

- We can expect high level of rationality on the markets where the relation between agents own actions and rewards is strong – private markets
- On collective markets we can expect (under some conditions) persistence of high level of irrationality
- Possible causes:
  - On private markets small number of agents (even one agent) can exploit large number of agents – we observe strong red queen effect on the market
  - On collective markets coordination failure can result in weakening of the red queen effect and evolutionary pressure on the agents





# Questions?

