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Modelling the effect of individual differences in punishment sensitivity on the behaviour in a public goods game

Tuong Manh Vu
Peer-Olaf Siebers
Anya Skatova
Theodore Turocy

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Introduction

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How this research came about …

How this research came about …

BEMooSSIG

www.cs.nott.ac.uk/~pszps/bemoossig/

Search

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School of Computer Science

ima Intelligent Modelling & Analysis

Behavioural Economics Meets object oriented Simulation Special Interest Group (BEMooSSIG)

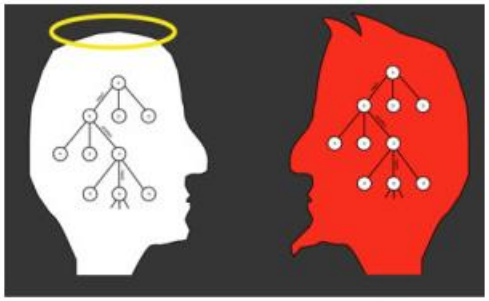

Image courtesy of QuickEconomics (http://www.quickienomics.com/?p=444)

BEMooSSIG (formerly known as GTMooSSIG) is a local discussion forum at the University of Nottingham for people interested in studying how to use games (lab experiments) as a data collection tool or as a mechanism to inform/support modelling the decision making of actors in object oriented social or socio-technical system simulation models and how the simulation results can be used to cross-validate game results.

We meet on a monthly basis. If you would like to join us, please email Peer-Olaf Siebers (pos@cs.nott.ac.uk). If you are a member you can make use of our mailing list (games-and-simulation@cs.nott.ac.uk)

Next BEMooSSIG Meeting

We are not meeting at a regular basis any more. Instead we decided to organise a conference track "The Interplay between Behavioural Game Theory and Agent-Based Social Simulation" [url] at the 14th International Conference on Modeling and Applied Simulation [MAS2015], 21-23 September 2015, Bergeggi, Italy. This will be a great opportunity for intensive discussions.

General Aim and Approach

- Find novel and meaningful ways of linking the ideas of game theory and agent-based social simulation
  - Using simulation for stimulation
  - Using simulation for cross validation
  - Using simulation for gaining additional insight
  - Using game theory for cross validation
  - Using game theory to drive agent behaviour and decision making
  - Using game theory to support model calibration
- Case Study: Public Goods Game (PGG)

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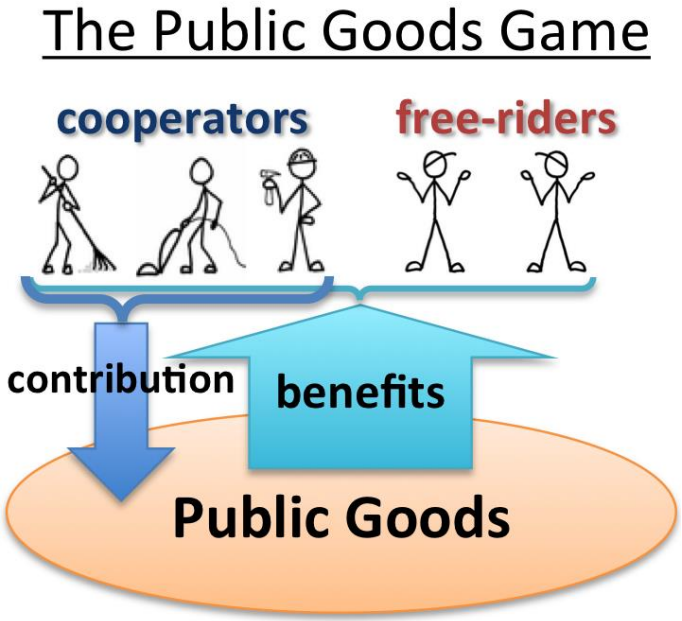
The idea behind the PGG

- A game of pure public goods:
  - A person cannot be prevented from enjoying the benefits
  - Benefits are the same for everyone

- Social dilemma:
  - Problem of free-riders



The formal definition of the PGG

- Standard of experimental economics.
- In the basic game, subjects secretly choose how many of their private tokens to put into a public pot. The tokens in this pot are multiplied by a factor (greater than one and less than the number of players, N) and this "public good" payoff is evenly divided among players.
- Each subject also keeps the tokens they do not contribute.

Lab Experiment (Skatova and Ferguson 2013)

- PGG with expected but not implemented punishment

- Players in groups of four
  - Initial endowment: 20 Money Unit
  - Contribution: g_i
  - Profit is half of group investment: $0.5 \sum_{j=1}^{4} g_i$
  - Payoff: $\pi_i = 20 - g_i + 0.5 \sum_{j=1}^{4} g_i$
- Punishment
  - If individual investment < group investment
    - punish with 3 times the difference
    - $\pi_i = \pi_i - 3\ (\sum_{j=1}^{4} g_i - gi)$

Lab Experiment (Skatova and Ferguson 2013)

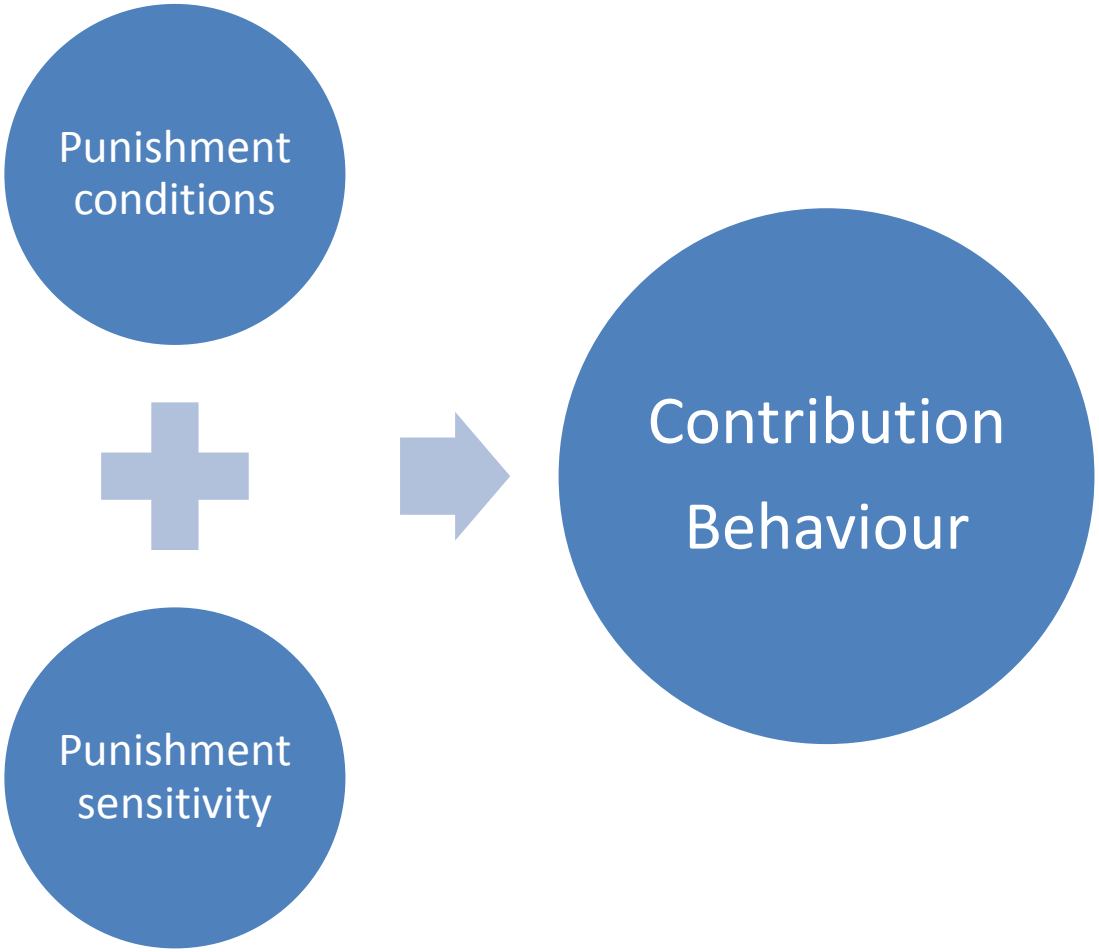
- Example

player	p1	p2	p3	p4
type	C	C	C	F
contribution	15	15	15	5
profit (half the group investment)	25			
payoff	30	30	30	40
payoff with punishment	0	0	0	-20

player	p1	p2	p3	p4
type	F	F	F	C
contribution	5	5	5	15
profit (half the group investment)	15			
payoff	30	30	30	20
payoff with punishment	0	0	0	20

Lab Experiment (Skatova and Ferguson 2013)

- Non-punishment
- Implemented Punishment
- Non-implemented punishment



- Assessed through Behavioural Inhibition Scale (BIS)
  - BIS-anxiety score

Lab Experiment (Skatova and Ferguson 2013)

- Findings:
  - Participants contribute more under threats of punishment compared to no threat of punishment
  - People with higher punishment sensitivity provide higher contributions (free ride less) even when punishment is not certain

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Model Development

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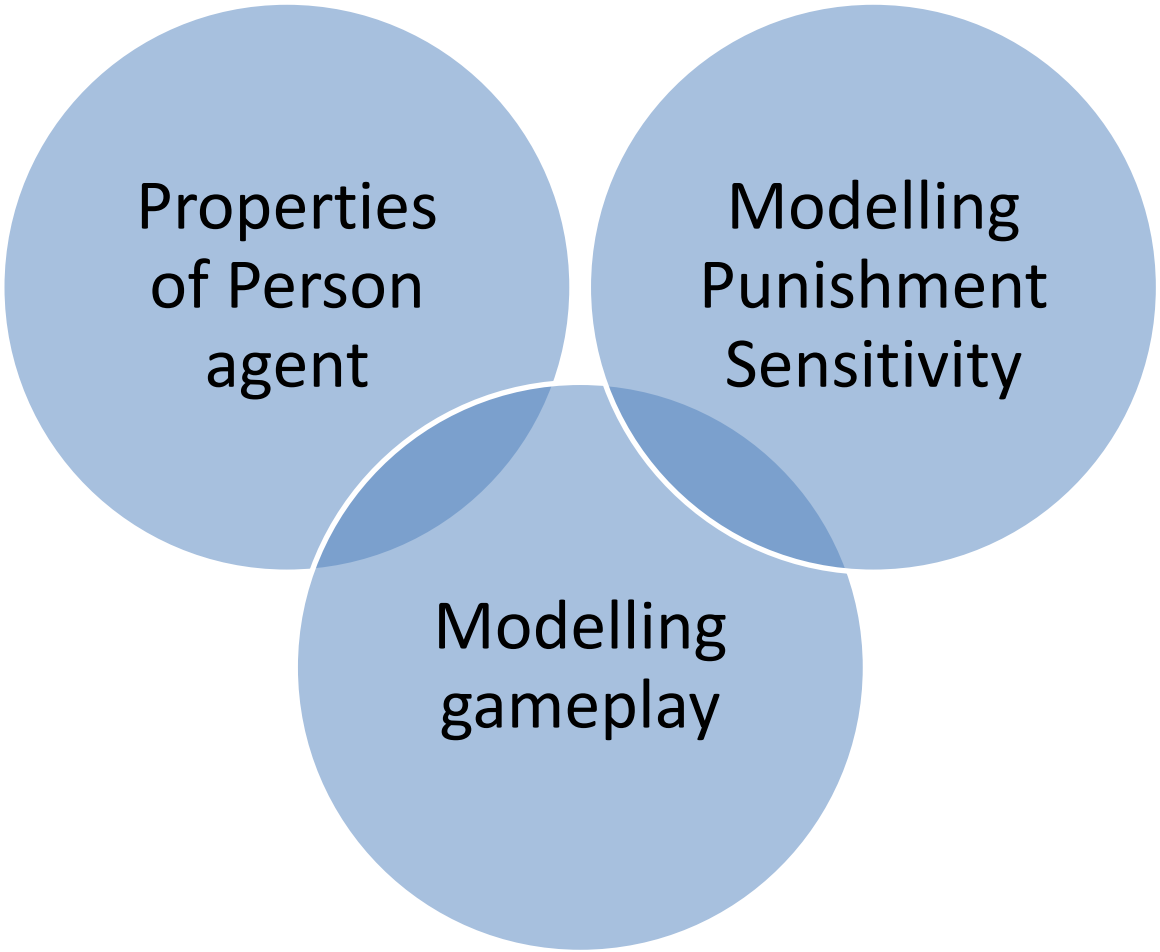
Specific Aim

- Aim
  - Validate the findings from Skatova and Ferguson (2013) by modelling the effect of punishment sensitivity on contribution levels in a PGG using an Agent-Based Modelling (ABM) approach

- Method
  - Create an artificial lab
  - Create artificial lab players

The Agent-Based Model



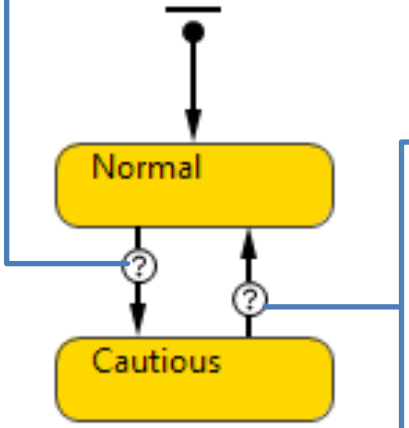
Properties of the Person Agent

- Strategy:
  - Full Cooperation (FC): always contributed 20 MUs
  - Strong Conditional Cooperation (SCC): contributed 3-4 MUs more than average group investment in previous round
  - Normal Conditional Cooperation (NCC): contributed the same or difference of 1 MU with average group investment in previous round
  - Weak Conditional Cooperation (WCC): contributed 3-4 MUs less than average group investment in previous round
  - Full Defection (FD): always contributed 0 MUs
- Anxiety:
  - High Anxiety
  - Low Anxiety

Modelling Punishment Sensitivity

- Punishment sensitivity state chart (part of the Person agent)

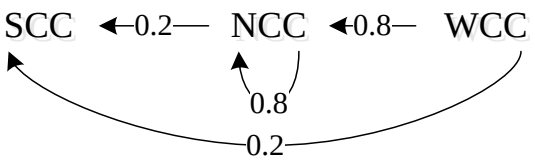
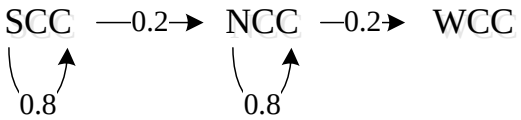
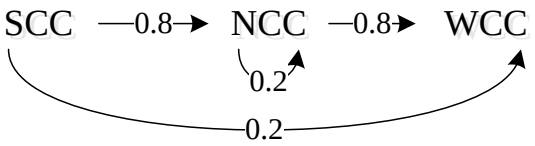
If
(high-anxiety agent AND there was threat of punishment
AND the agent had not been in cautious state)
OR
(the agent got punished)



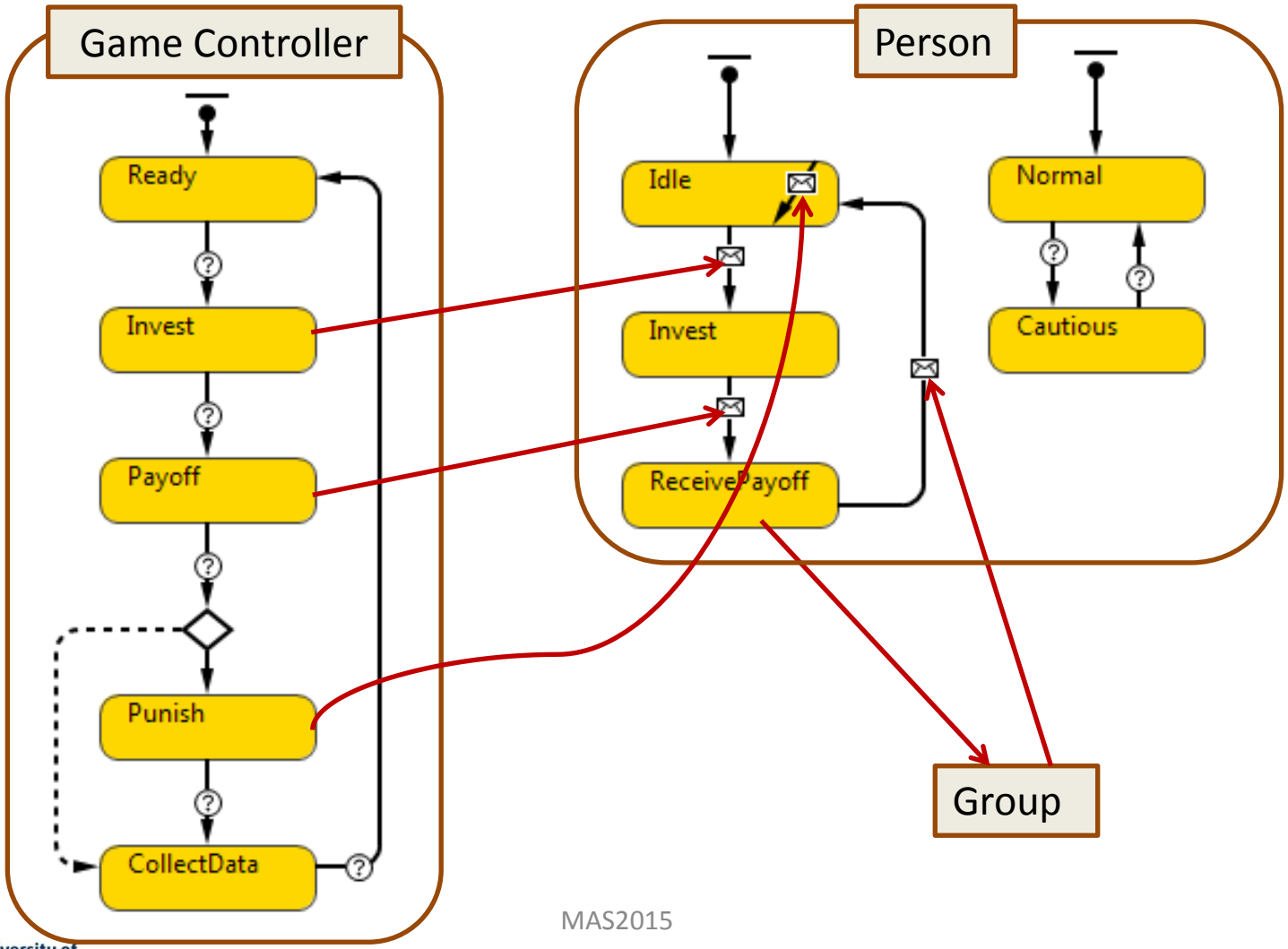
If
(there was no threat of punishment)
OR
(a low-anxiety agent had been in “Cautious” state for 3 rounds)
OR
(a high-anxiety agent had been in “Cautious” state for 10 rounds).

Modelling Punishment Sensitivity

- Strategy change of conditional co-operators

High Anxiety	
Normal to Cautious	
Cautious to Normal	
Low Anxiety	
Normal to Cautious	
Cautious to Normal	

Modelling Gameplay



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Experimentation

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Experimental Setup

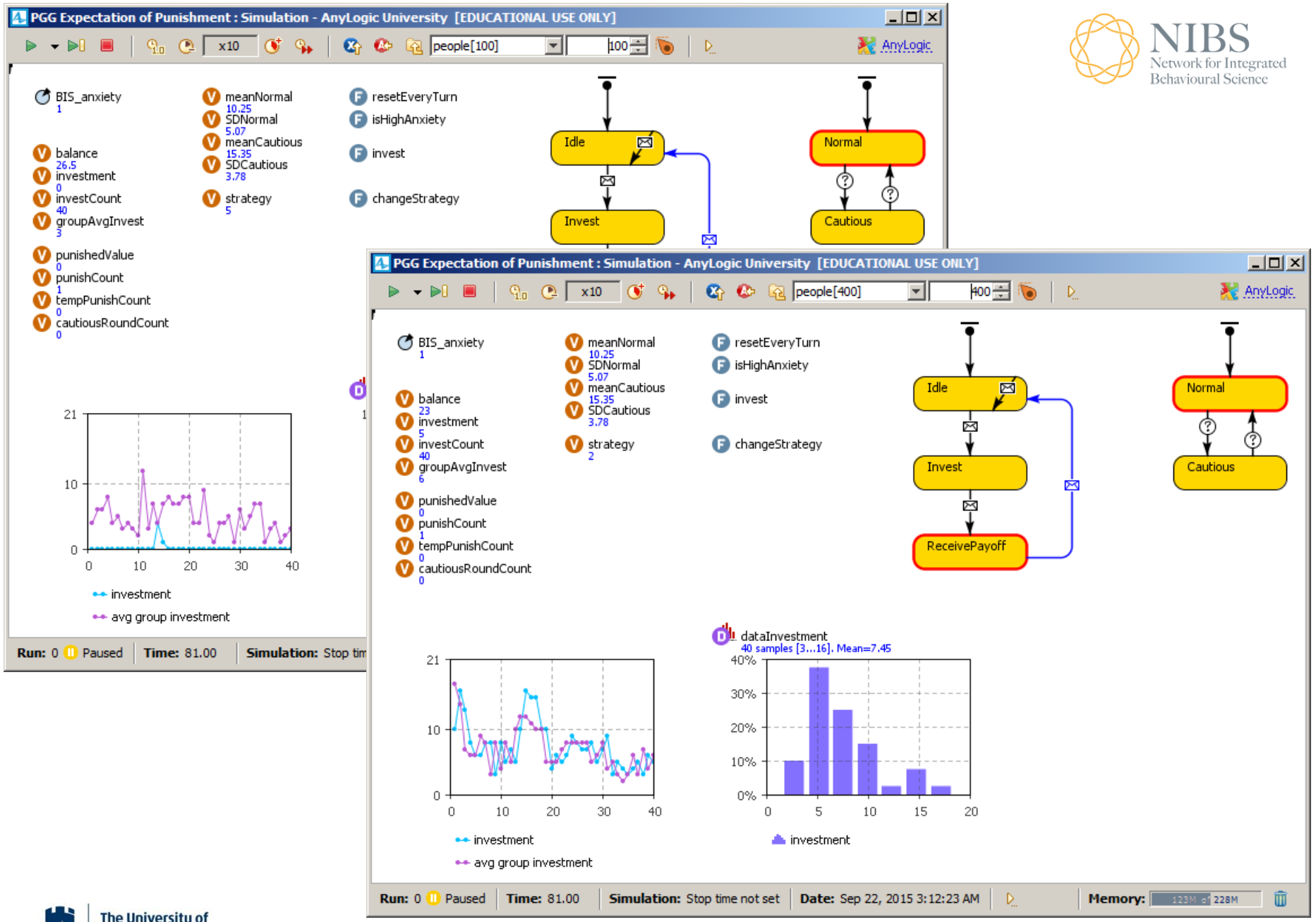
- Our Agent Population

Percentage of agents	Strategy	Anxiety
5%	Full Cooperation (FC)	100% High
20%	Strong Conditional Cooperation (SCC)	80% High, 20% Low
50%	Normal Conditional Cooperation (NCC)	50% High, 50% Low
15%	Weak Conditional Cooperation (WCC)	20% High, 80% Low
10%	Full Defection (FD)	100% Low

Experimental Setup

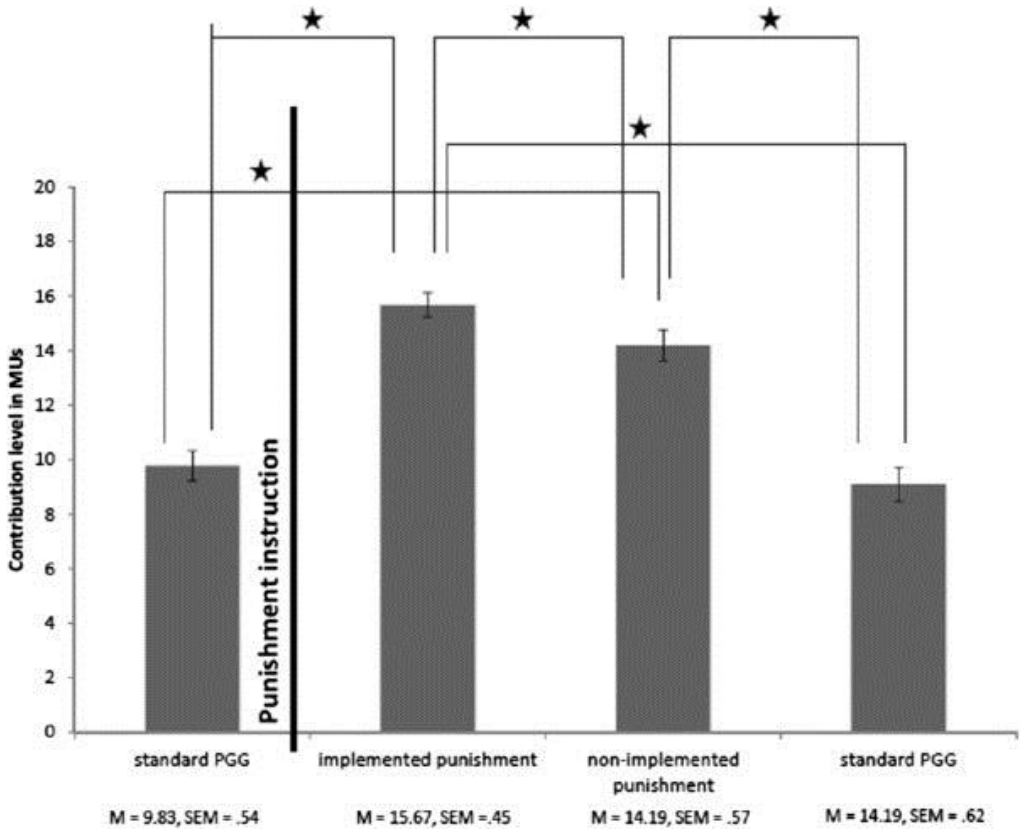
- Person agents play four blocks (10 trials each block):
  - A non-punishment block
  - A implemented punishment block (implement in 2 out of 10 games)
  - A non-implemented punishment block
  - A non-punishment block


PGG Expectation of Punishment : Simulation - AnyLogic University [EDUCATIONAL USE ONLY]
x10
root:Main
AnyLogic
numberOfPeople 1,000
totalGame 40
punishImplementation [40]
punishAllowByBlock [4]
people Person [1000]
indexList {1000}
groups [250]
allowPunishment false
updateInvest
investCount 40,000
totalInvestment 301,037
totalGameInvestment 0
totalBlockInvestment 0
totalGameInvestmentH 0
totalGameInvestmentL 0
actionCountPerGame 0
gameNo 41
blockNo 4
countHigh 225
countLow 775
countCooperator 182
countReciprocator 496
countDeflector 172
countDD 100
countCC 50
countNormal 1,000
countCautious 0
dataInvestment
40,000 samples [0...20], Mean=7.526
all investments
avg investment per block
all
high-anxiety
low-anxiety
Normal
Cautious
Ready
Invest
Payoff
Punish
CollectData
Run: 0 Paused
Time: 81.00
Simulation: Stop time not set
Date: Sep 22, 2015 3:12:23 AM
Memory:

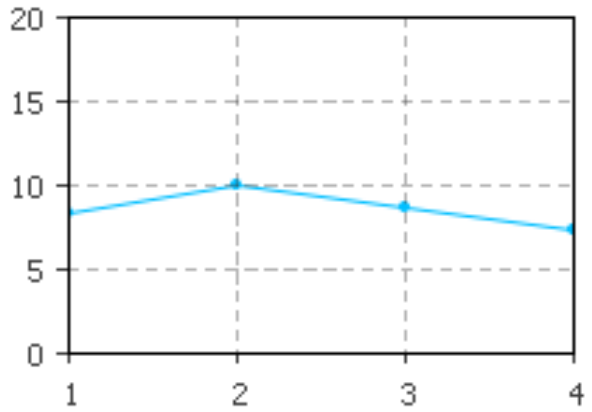

PGG Expectation of Punishment : Simulation - AnyLogic University [EDUCATIONAL USE ONLY]
x10
people[100]
100
AnyLogic
BIS_anxiety
1
meanNormal
10.25
SDNormal
5.07
meanCautious
15.35
SDCautious
3.78
resetEveryTurn
isHighAnxiety
invest
changeStrategy
balance
26.5
investment
0
investCount
40
groupAvgInvest
3
strategy
5
punishedValue
0
punishCount
1
tempPunishCount
0
cautiousRoundCount
0
Idle
Invest
Normal
Cautious
21
10
0
0
10
20
30
40
investment
avg group investment
Run: 0 Paused
Time: 81.00
Simulation: Stop tim
PGG Expectation of Punishment : Simulation - AnyLogic University [EDUCATIONAL USE ONLY]
x10
people[400]
400
AnyLogic
BIS_anxiety
1
meanNormal
10.25
SDNormal
5.07
meanCautious
15.35
SDCautious
3.78
resetEveryTurn
isHighAnxiety
invest
changeStrategy
balance
23
investment
5
investCount
40
groupAvgInvest
6
strategy
2
punishedValue
0
punishCount
1
tempPunishCount
0
cautiousRoundCount
0
Idle
Invest
ReceivePayoff
Normal
Cautious
dataInvestment
40 samples [3...16]. Mean=7.45
40%
30%
20%
10%
0%
0
5
10
15
20
investment
21
10
0
0
10
20
30
40
investment
avg group investment
Run: 0 Paused
Time: 81.00
Simulation: Stop time not set
Date: Sep 22, 2015 3:12:23 AM
Memory:
123M of 228M

Experimental Results

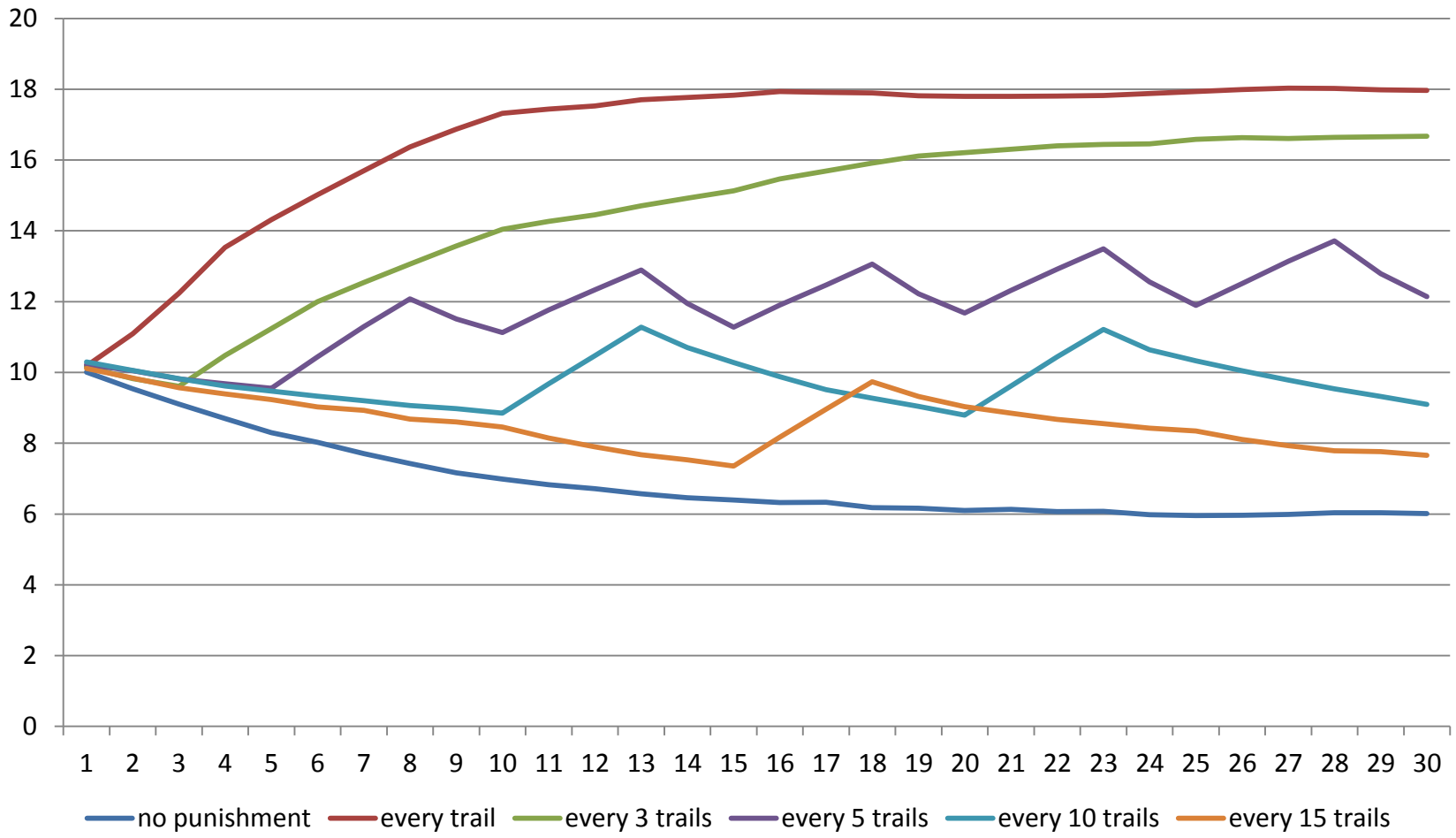
Skatova and Ferguson (2013)



Our Simulation



Experimental Results



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Conclusions

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Conclusions

- Achievements
  - In regards to the specific aim: Validated the findings from Skatova and Ferguson (2013) using an ABM approach.
  - In regards to the general aim: Found a novel and meaningful way of linking the ideas of game theory and agent-based social simulation

- Future
  - Look at additional factors like fear or trust
  - Reverse procedure: Build the model first and use it as a hypothesis generator; then validate interesting model outcomes in the lab

References

- Skatova and Ferguson: Individual differences in behavioural inhibition explain free riding in public good games when punishment is expected but not implemented. Behavioral and Brain Functions 2013 9:3.

Acknowledgment

The financial support of the ESRC (NIBS Grant ES/K002201/1) and the RCUK Horizon Digital Economy Research Hub grant EP/G065802/1 is gratefully acknowledged.