MODELING SOCIAL AND ECONOMIC GROUP DYNAMICS WITH MACHINE LEARNING AND EVOLUTIONARY GAME THEORY

Elías Fernández Domingos – PhD student[1,2,3]

Juan Carlos Burguillo Rial – PhD, Associate Professor[1], Tom Lenaerts – PhD, Associate Professor[2,3]

[1]E.E. de Telecomunicaciones, Universidad de Vigo (Vigo – Spain), eliasfernandez@uvigo.es, [2]Vrjie Universiteit Brussels (Brussels – Belgium), [3]Université Libre de Bruxelles (Brussels – Begium)

MOTIVATION OF THE WORK

How do we **choose** with whom to interact? How does this choice **influence** our actions? How do we **decide** to finish the interaction?

Beliefs

Benefits

Behaviour
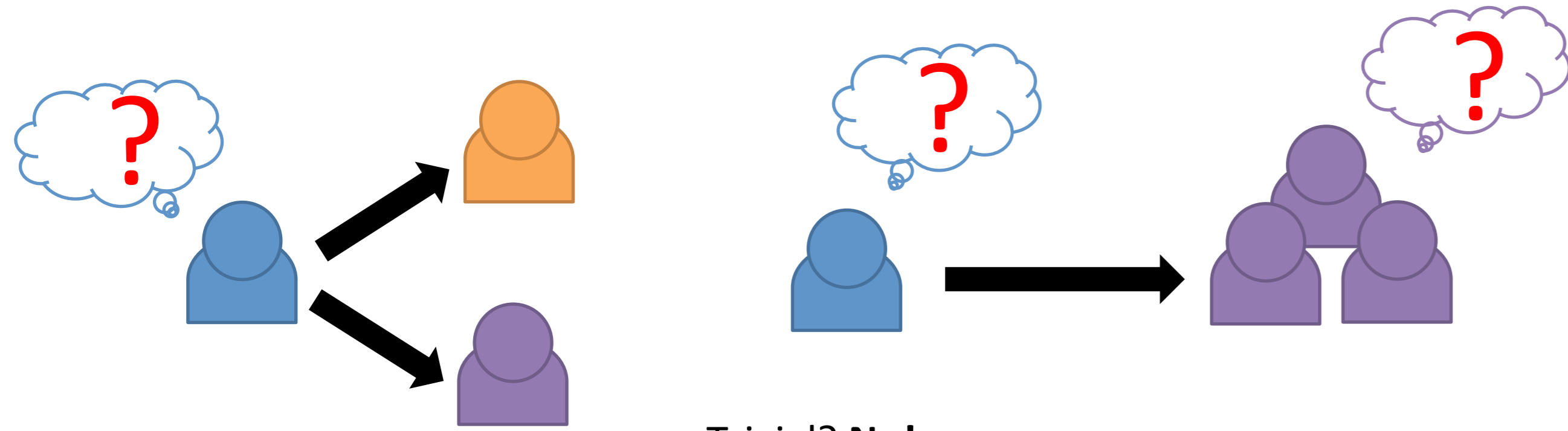
Trivial? **No!**
➤ The dynamics of groups are shaped by many different elements. The formulation of collective dynamics constitute a **complex system**.
➤ Entering a group or interacting with other groups are part of our daily life!

Too Abstract? **NO!!**
There are many **real world applications**:
- Traders on markets have to choose trading partners.
- Firms have to choose which workers to employ
- Workers have to choose at which firm they want to work
- Parents have to choose schools for their children
- And popular schools have to select among the applicants.
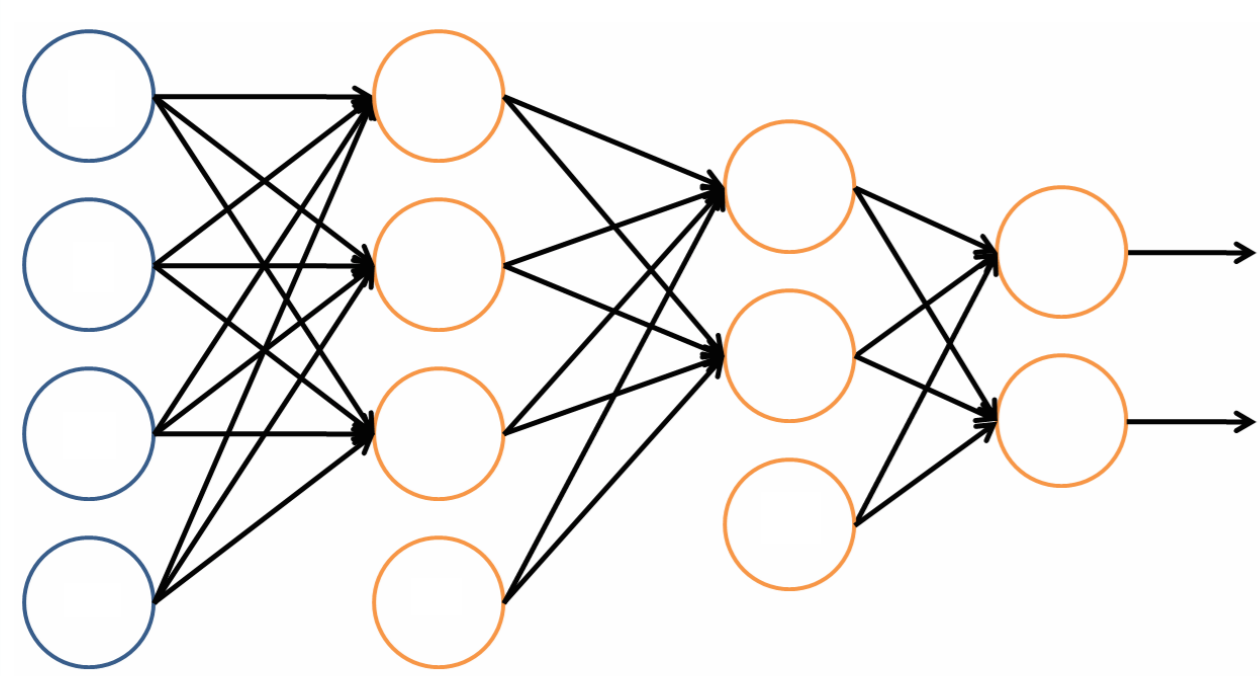
And also for the **artificial world**:
- Prediction of the evolution of stock markets.
- Recommendation systems
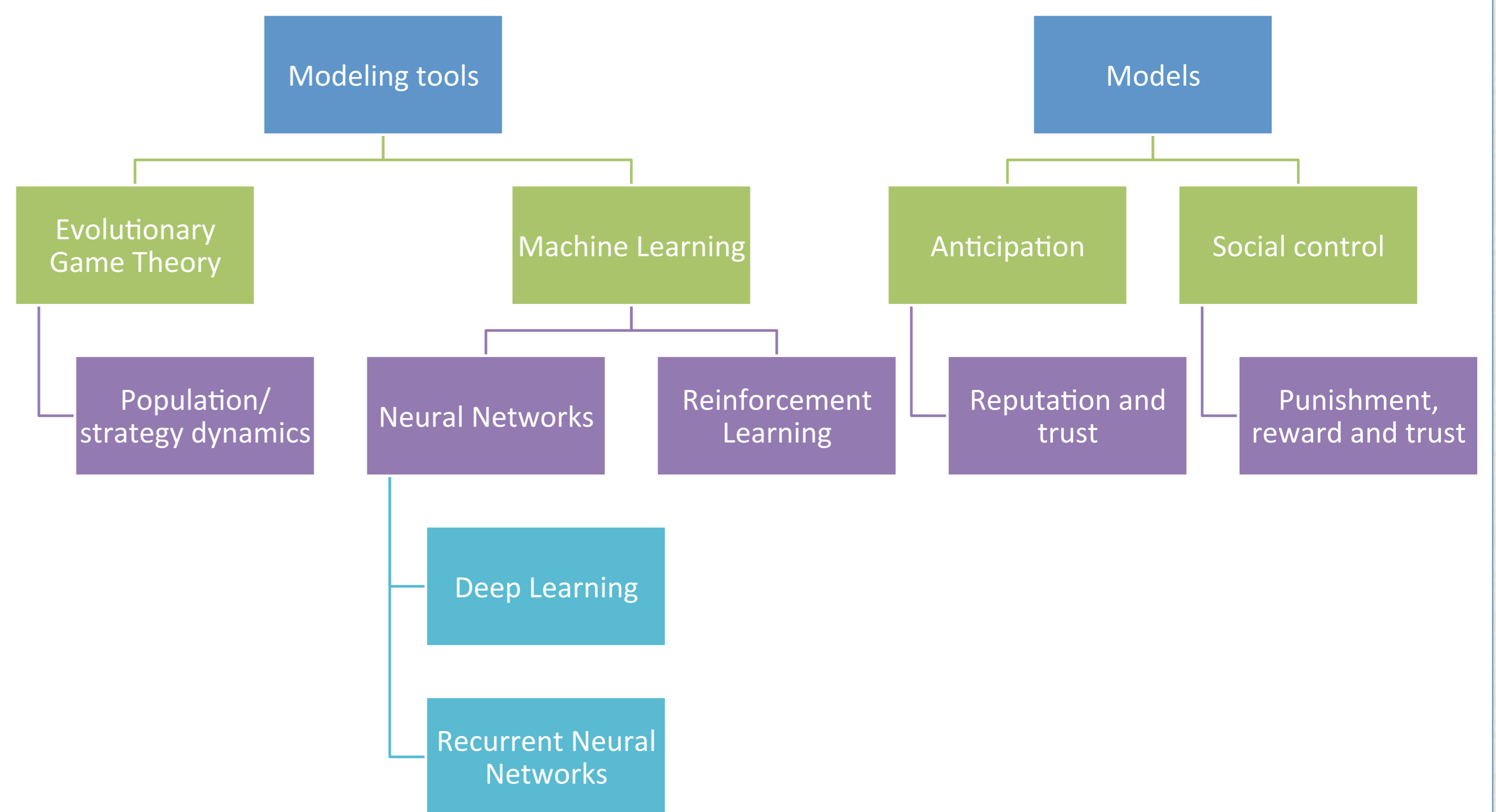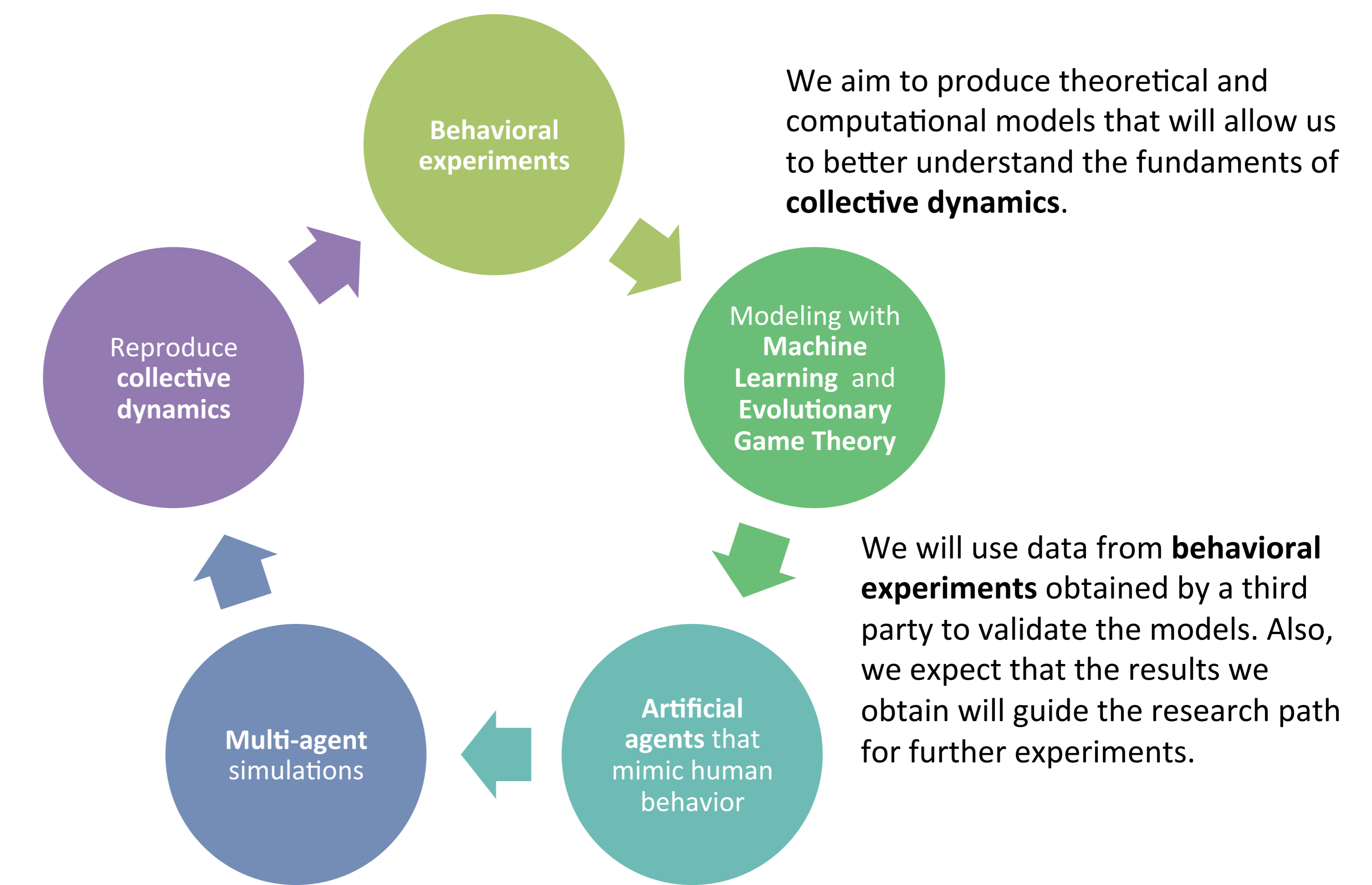- Artificial agents that are able to mimic human behavior.
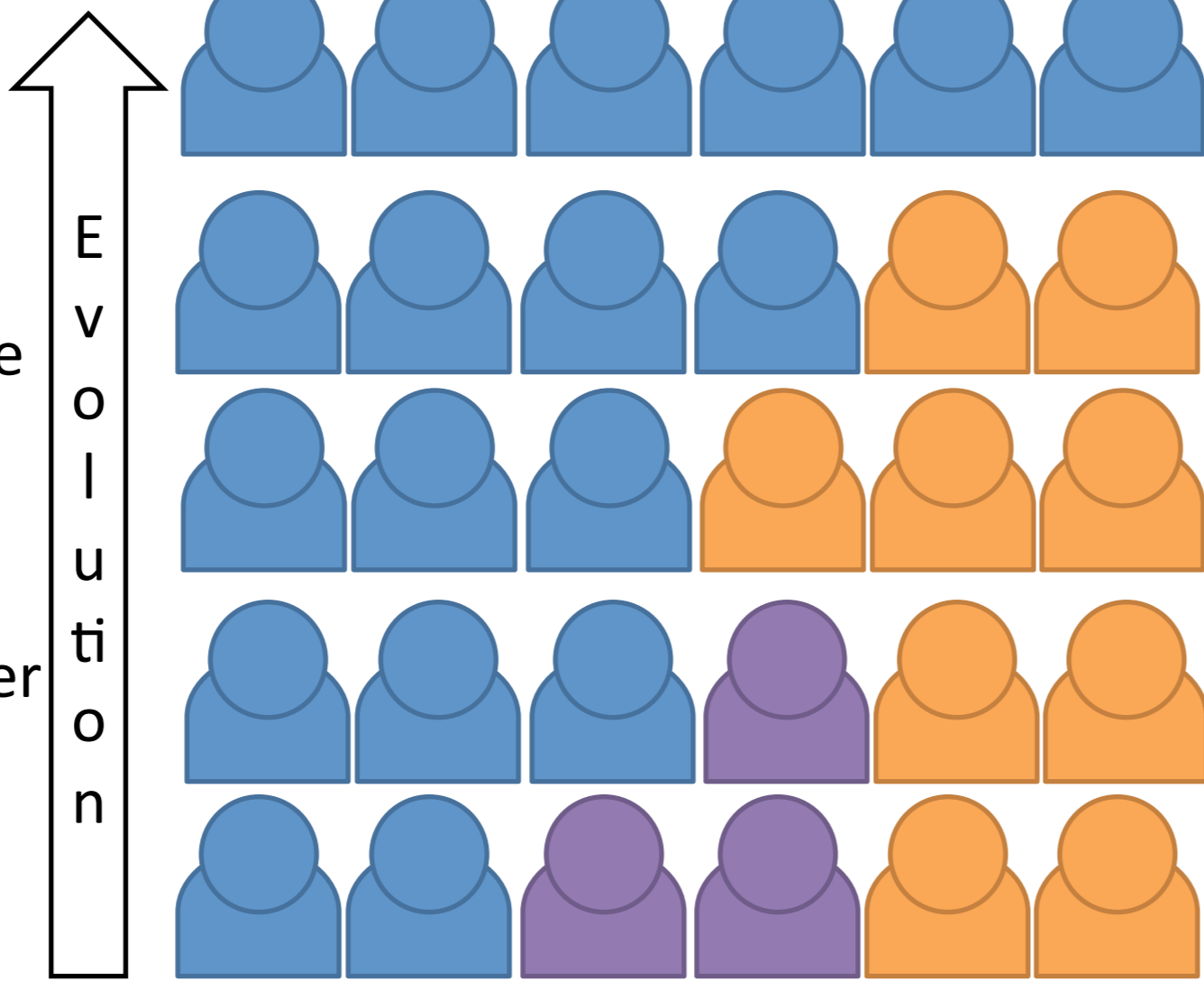
How will we do it? We investigate and combine techniques from different areas:
- **Evolutionary Game Theory** (EGT) [1,3,4],
- (Behavioral) **Economics** [2,3,8],
- Belief and Preference **Modeling** in Computer Science and **Anticipatory** Systems [5,6],
- **Multi-agent** Systems [3],
- **Machine Learning** [7].

Evolution

STRATEGIES

THESIS OBJECTIVES

The objectives of this thesis can be represented in the following way:

We aim to produce theoretical and computational models that will allow us to better understand the fundaments of **collective dynamics**.

We will use data from **behavioral experiments** obtained by a third party to validate the models. Also, we expect that the results we obtain will guide the research path for further experiments.

Behavioral experiments

Modeling with **Machine Learning** and **Evolutionary Game Theory**

Artificial agents that mimic human behavior

Multi-agent simulations

Reproduce collective dynamics

Modeling tools
- Evolutionary Game Theory
  - Population/ strategy dynamics
- Machine Learning
  - Neural Networks
    - Deep Learning
    - Recurrent Neural Networks
  - Reinforcement Learning

Models
- Anticipation
  - Reputation and trust
- Social control
  - Punishment, reward and trust

RESEARCH PLAN

		1	2	3	4.1	4.2	5	6	7	
1st Year	OD15									1 Read bibliography
	JM16									2 Objectives and requirements
	AJ16									3 Review state of the art
	JS16									4 Design and build models
2nd Year	OD17									4.1 Anticipation
	JM17									4.2 Social control
	AJ17									5 Multi-agent simulations
	JS17									6 Disseminate results
3rd Year	OD18									7 Write and defend the PhD
	JM18									
	AJ18									
	JS18									

NEXT YEAR PLANNING

- Start the second phase of the analysis of the models and study its applications in simulation with multi-agent systems.
- Find synergies between the model and Control theory, in particular an area of machine learning dedicated to control: reinforcement learning models.
- Extend the group formation analysis to n-player situations.
- Implement other architectures of neural networks and study the effect of deep learning systems on the prediction model used in anticipation.
- Disseminate the results in conferences and journals.

REFERENCES

[1] Nowak, Martin A. *Evolutionary dynamics*. Harvard University Press, 2006.
[2] Camerer, Colin. *Behavioral game theory*. New Age International, 2010.
[3] I. Zisis, S. Di Guida, T. A. Han, G. Kirchsteiger, & T. Lenaerts. *Generosity motivated by acceptance - evolutionary analysis of an anticipation game.* Scientific Reports, 5, 18076, 2005
[4] Moniz Pereira, L., Lenaerts, T., & Han, T. A. *Avoiding or restricting defectors in public goods games?* Journal of The Royal Society Interface, 12(103), 2014
[5] Rosen, R. Anticipatory Systems. PhD Proposal (Vol. 1), 2012
[6] Lalev, E., & Grinberg, M. *Backward vs. Forward-Oriented Decision Making in the Iterated Prisoner's Dilemma: A Comparison Between Two Connectionist Models. Anticipatory Behavior in Adaptive Learning Systems*, 345–364, 2007
[7] Hinton, G. E. *Learning multiple layers of representation.* Trends in Cognitive Sciences, 11(10), 428–434, 2007
[8] Cox, J. C. *How to identify trust and reciprocity.* Games and Economic Behavior, 46(2), 260–281, 2004

Universida de Vigo   AtlantTIC   Vrije Universiteit Brussel   ULB UNIVERSITÉ LIBRE DE BRUXELLES   CoMo