

The topic of our third meeting is game theory - which might be better described as strategy theory, or theory of interactive decision making. We humans, cannot survive without interacting with other humans, and ironically, it sometimes seems that we have survived despite those interactions. Many human interactions carry the potentials of cooperation and harmony as well as conflict and disaster.

A strategic situation involves two or more interacting “players” who make decisions while trying to anticipate the actions and reactions by others. The concepts of game theory provide a common language to formulate, structure, analyse and eventually understand different strategical scenarios. Generally, game theory investigates conflict situations, the interaction between the agents and their decisions. Game theory can be used either to explain existing behaviour or to improve strategies, and consequently, there are many applications.

As last time, we hope for an interesting discussion and give you the reign where the discussion leads. Any contribution is welcome, be it a specific question, a worked out example, a psychological detail, a specific application, ... It doesn't have to be perfect, simply let your curiosity and creativity lead you.

It will be helpful, if you let us know beforehand - in zoom or via email - what you find interesting, what you want to know more about, what you would like to contribute...

Here are some suggestions, remarks and resources:

- (a) There is a great series of short lectures by William Spaniel, called “Game theory 101”:
https://www.youtube.com/playlist?list=PLKI1h_nAkaQoDzI4xDIXzx6U2ergFmedo
- (b) Here is a short introduction to game theory by Heiko Hotz:
https://www.theorie.physik.uni-muenchen.de/lsfrey/teaching/archiv/sose_06/softmatter/talks/Heiko_Hotz-Spieltheorie-Handout.pdf
- (c) Here are lecture notes for an introductory course in game theory by Levent Koçkesen and Efe A. Ok:
<http://home.ku.edu.tr/~lkockesen/teaching/econ333/lectnotes/uggame.pdf>
- (d) Here is a great (german) website on game theory with many everyday-life examples (however with little mathematics): <http://www.spieltheorie.de/>
- (e) As game theory plays an important role in economics, there are various websites with introductions, such as the following:
<https://www.investopedia.com/terms/g/gametheory.asp>
- (f) Some basic and important definitions:
 - **A game** can be characterised as a set of circumstances that has a result dependent on the actions of two or more decision-makers (players).
 - **A player** is a strategic decision-maker within the context of the game.
 - **A strategy** is a complete plan of action a player will take given the set of circumstances that might arise within the game.
 - The payoff is the payout a player receives from arriving at a particular outcome.
 - The information available at a given point in the game is called **information set**.
 - The point in a game where both players have made their decisions and an outcome is reached is called **equilibrium**.
 - The **best response** is the strategy (or strategies) which produce the most favorable immediate outcome for the current player, taking the other players' strategies as given.
 - A **strategic form game** is composed of
 - a set of players: N
 - a set of actions : A_i for each player i
 - a payoff function: $u_i : A = \times_{i \in N} A_i \rightarrow \mathbb{R}$ for each player i

If there are finitely many players and finitely many actions available for each player, one can represent a game by means of a matrix.

- An **extensive form game** is described such that the players of the game execute their moves consecutively.
If there are finitely many players and finitely many actions available for each player, an extensive form game can be represented by a tree.
- (g) To illustrate the definitions, can you give examples of games and describe them in the terms introduced above?
- (h) How can we analyze games mathematically?
<https://plato.stanford.edu/entries/logics-for-games/>
- (i) A famous concept of game theory is the **Nash equilibrium**.
- What is the definition of Nash equilibrium?
 - Explain using an example how to determine the Nash equilibria in a game.
<https://www.economics.utoronto.ca/osborne/2x3/tutorial/NEFEX.HTM>
 - Why do competitors open their stores next to one another?
https://www.youtube.com/watch?v=jILgxeNBK_8
 - What are some other real world examples of the Nash Equilibrium? Think about economics, evolutionary biology, psychology,...
- (j) John Forbes Nash Jr. was a famous mathematician who made contributions to game theory, differential geometry and partial differential equations. In his thesis he defined and studied the Nash equilibrium which won him the Nobel price in 1994.
- Read up on his life and mathematical contributions, particularly those on game theory.
 - Here is an excerpt of a talk given by John Nash:
<https://www.youtube.com/watch?v=qY0XKSzjBKI>
 - This video claims that the movie “A beautiful mind” got the Nash equilibrium wrong. Can you explain the problem?
https://www.youtube.com/watch?v=DTcmmD_MWas
 - Here is a delightful talk by Cédric Villani about Nash. <https://www.youtube.com/watch?v=iHKa8F-RsEM>
 - In his thesis, Nash proved the existence of the Nash equilibrium. Most of the known proofs use fixed point theorems. Here is a nice tutorial based on Brouwer’s fixed point theorem:
<https://www.cs.ubc.ca/~jiang/papers/NashReport.pdf>
 - While the existence of the Nash equilibrium is proven, is it possible to reach it?
<https://www.quantamagazine.org/in-game-theory-no-clear-path-to-equilibrium-20170718/>
- (k) We all know the game rock–paper–scissors.
- How can we describe the game mathematically?
 - What does a Nash equilibrium for this game look like?
<https://www.quantamagazine.org/the-game-theory-math-behind-rock-paper-scissors-20180402/>
 - Where is this game “played out” in the real world?
<https://www.quantamagazine.org/biodiversity-may-thrive-through-games-of-rock-paper-scissors>
<https://www.math.upenn.edu/~chhays/lecture23.pdf>
- (l) Evolutionary game theory originated as an adaption of game theory to biology.
- What are the limitations of classical game theory that lead to the introduction of evolutionary game theory?
<https://www.youtube.com/watch?v=HxgVYhhArSk>
 - What is evolutionary game theory?
 - What is the Chicken game? What are applications of it?
https://psychology.wikia.org/wiki/Chicken_game

- Can one use evolutionary game theory to model past societies' social organization?
https://www.mitpressjournals.org/doi/pdf/10.1162/isal_a_020
 - Application to norm change in society:
<http://www.ifaamas.org/Proceedings/aamas2017/pdfs/p1433.pdf>
- (m) The Prisoner's dilemma is a famous setup in game theory.
- What is the Prisoner's dilemma?
<https://plato.stanford.edu/entries/prisoner-dilemma/>
<https://www.youtube.com/watch?v=t9Lo2fgxWHw>
 - Can you describe it mathematically?
 - What is the rationality assumption in game theory?
 - Can you explain using the Prisoner's dilemma why rational individualistic play might lead to inferior outcome from the perspective of the players?
 - Where does the Prisoner's dilemma occur in real life?
- (n) There are many aspects of game theory that are linked to psychology.
- Here you find listed and explained several situations that illustrate this. Choose one and explain it.
<https://www2.le.ac.uk/departments/npb/people/amc/articles-pdfs/oxfobibl>
 - What is behavioral game theory?
- (o) Game theory and war.
- What can game theory teach us about war?
<https://www.youtube.com/watch?v=0bFs6ZiynSU>
 - Game theory and the cold war:
<https://science.howstuffworks.com/game-theory5.htm>
 - What is hypergame theory?
<https://www.hindawi.com/journals/gt/2015/570639/>
- (p) What different types of games are there? What are examples for each type?
<https://www.economicdiscussion.net/game-theory/5-types-of-games-in-game-theory-with-diagram/3827>
- (q) Game theory and COVID-19:
<https://scienceblog.com/515980/game-theory-and-covid-19-major-defense-project-pivots-to-explore>
<https://www.br.de/mediathek/podcast/aktuelle-interviews/hamster-in-coronazeiten-was-die-spieltheorie-1794726>
<https://finanzmarktwelt.de/coronakrise-das-verhalten-der-ezb-anhand-der-spieltheorie-164439/>