Programming the Cooperation Tournament

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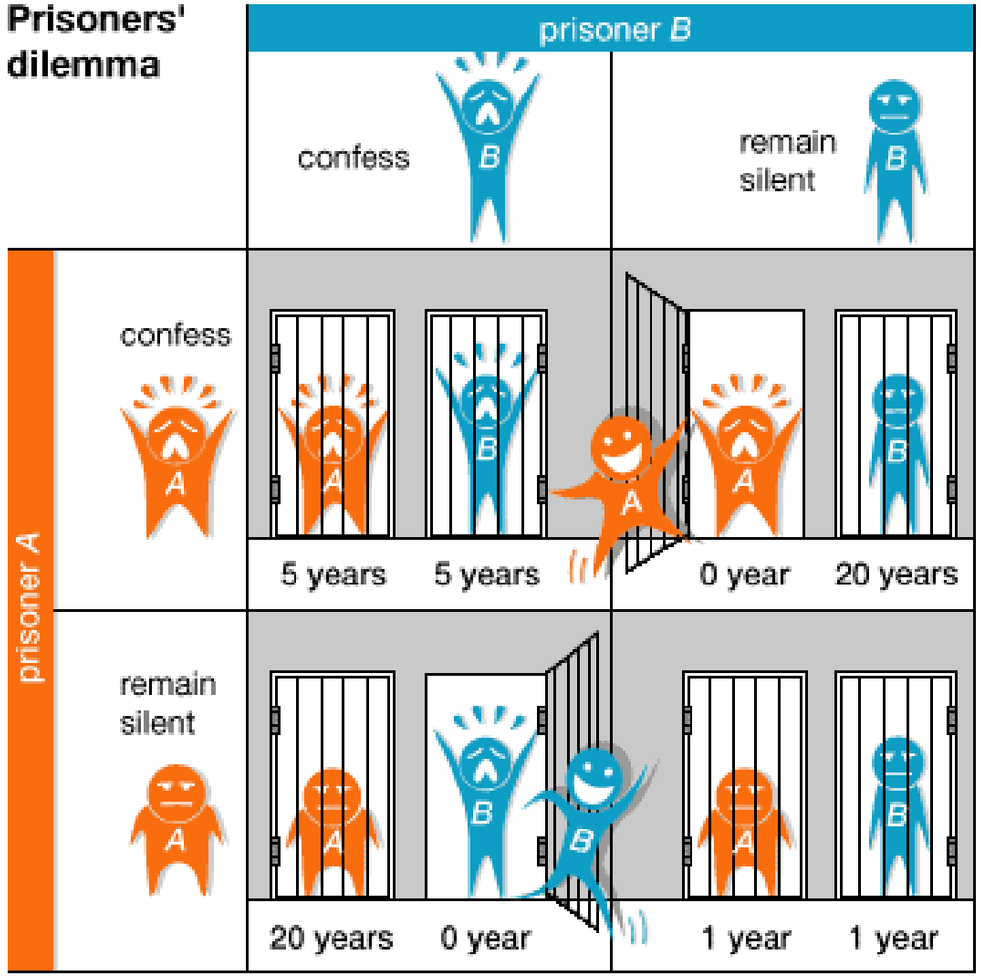
Game Theory

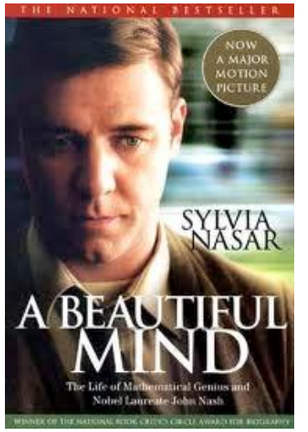
- Mathematical framework to model **strategic interactions** of individuals
- Formalizes the notion of finding a "best strategy" (**Nash equilibrium**) when facing a well-defined decision situation (**games**)
- Underlying assumption is that individuals optimize their ‘payoffs’ (or more precisely: ‘utility’) when faced with strategic decisions
- **Repeated interactions** are interesting for simulations (results can be completely different from one-shot games)

Human Cooperation: Prisoner Dilemma (PD)



Nash Equilibrium

- Is the strategy that players always play with no regrets: **best response**
- No player has an incentive to deviate from a Nash equilibrium
- In many circumstances, there is **more than one** Nash equilibrium



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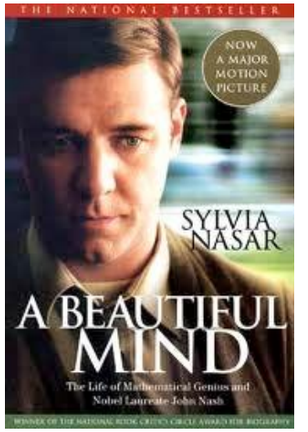

Some Questions:

- Is Nash an **optimal** strategy?
- What is the difference between a Pareto-efficient equilibrium and a Nash Equilibrium?
- Why do players play Nash? Do they?

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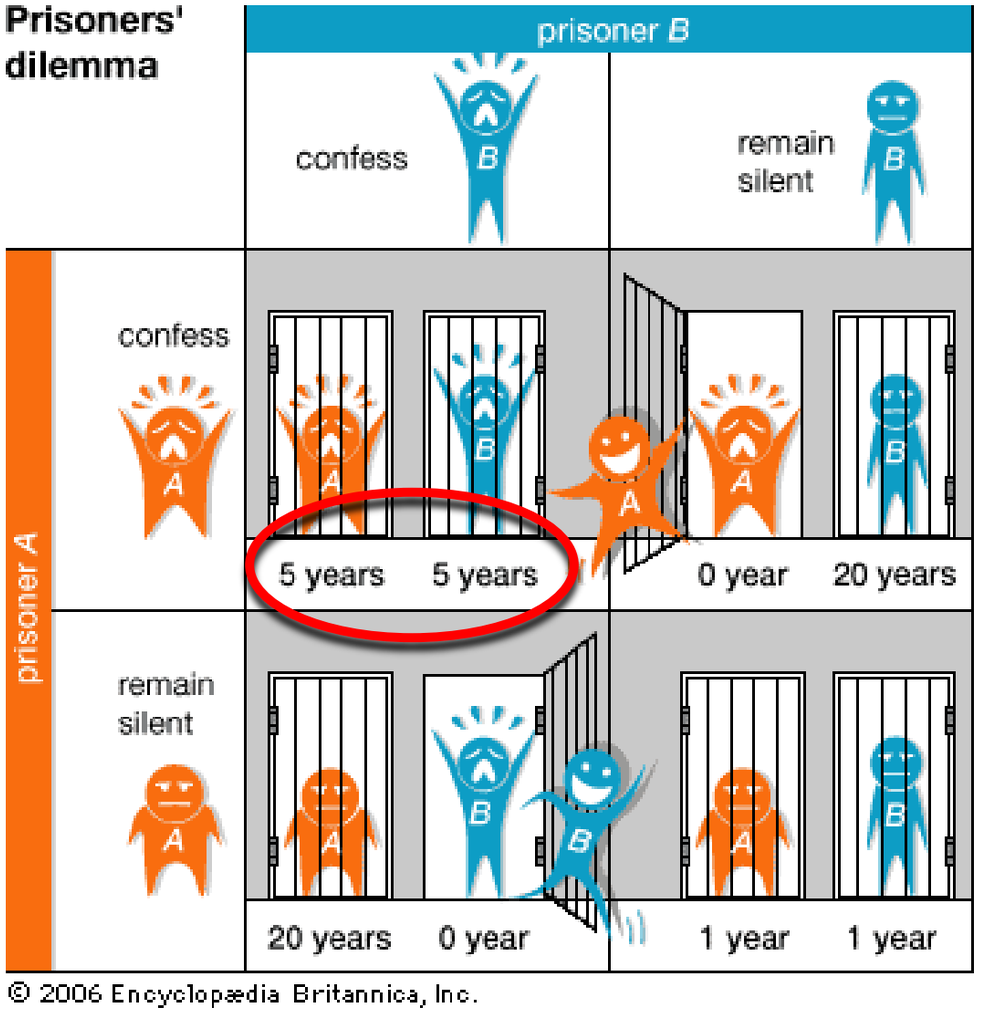

Why Cooperating in a Prisoner Dilemma?

- If the a Prisoner Dilemma is played only once, there is ***no reason to cooperate*** *(for rational individuals)*

- **Shadow of the future** (discount parameter)
  - if the probability of meeting again is large enough, it is better to be nice…

The Evolution of Cooperation (Axelrod, 1984)

- Axelrod organized two *computer tournaments*:
  - A number of experts were invited to submit a strategy
  - Each strategy had to play one iterated PD against itself, every other strategy, and the RANDOM strategy
  - The total score of a strategy was the average payoff of all these iterated PDs.

- Different rules for ending the game:
  - *Finite game*: game ends after 200 rounds (*first tournament*)
  - *Indefinite game*: game continues with a probability of $w = 0.99654$ (*second tournament*).

The Evolution of Cooperation (Axelrod, 1984)

- Winner of the tournament: **Tit for Tat**
  - **be nice**: cooperate first
  - then do what **your opponent did in the last round** (punish defection; reward cooperation)
- Other possible strategies:
  - Always cooperate / always defect
  - Tit for tat, but defect on first round
  - Win–Stay, Lose–Shift: repeat behavior if successful
- Shadow of the future
  - probability that there will be a next round

The Evolution of Cooperation (Axelrod, 1984)

Nice:

- A nice strategy never defects without being provoked by an opponent's previous defection.
- Nice strategies can realize mutual cooperation with other nice strategies.
- Wouldn't it be better to exploit nice players?
- Yes, but only if nice players do not retaliate!

The Evolution of Cooperation (Axelrod, 1984)

Retaliatory (Provocable):

- A retaliatory strategy (immediately) defects after an “uncalled for” defection of the opponent
- A retaliatory strategy protects itself from exploitation
- “Challengers” do not profit from a retaliatory strategy
- How can cooperation be restored after a retaliatory reply?

The Evolution of Cooperation (Axelrod, 1984)

Forgiving:

- A forgiving strategy returns to cooperation after the opponent stopped to defect.
- Avoid “lock-in effects” after a single defection of its opponent.
- Tit for Two Tat

The Evolution of Cooperation (Axelrod, 1984)

- Cooperation is possible in a Prisoner's Dilemma (PD) and it is based on **reciprocity**
- Cooperative strategies can be successful in the repeated 2-person PD if these strategies are:
  - nice,
  - retaliatory,
  - forgiving
- and if the (expected) duration of the game is long enough ("shadow of the future").