Emerging cooperation

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Trench warfare, World War I

> *We were astonished to observe German soldiers walking about within rifle range behind their line. Our men appeared to take no notice. I privately made up my mind to do away with that sort of thing when we took over; such things could not be allowed. These people evidently did not know there was a war on. Both sides apparently believed in the policy of "live and let live".*

— *"Langemarck" and "Cambrai": A War Narrative, 1914-1918*, Geoffrey Dugdale, 1932, p. 95.

(Famously quoted by Robert Axelrod in *The Evolution of Cooperation*, 1984.)

Trench cooperation

- How could this ‘live and let live’ behaviour develop spontaneously outside of major battles in trench living?
- Each side has two options:
  - they could ‘cooperate’ by not shooting;
  - they could ‘betray’ by shooting.

Trench cooperation

- So there are four possibilities, shown in the following table:

		Side 2: Cooperate	Side 2: Betray
Side 1	Cooperate	$(1, 1)$	$(-2, 2)$
	Betray	$(2, -2)$	$(-1, -1)$

- We might conclude that, between major battles, C C is the best outcome for both sides.
- However, in this C C situation, either side could gain an advantage by switching their strategy to betray.

A famous game – Prisoner's dilemma

- Two prisoners have been caught and are kept in separate cells with no means of communicating.
- There is not enough evidence to convict either of the principal charge, but there is enough evidence to convict both of a lesser charge.
- Both are simultaneously offered a bargain, to testify that the other committed the principal crime, such that:
  - If both cooperate by remaining silent, both will serve 1 year in prison on the lesser charge;
  - If Player 1 betrays Player 2 by testifying, Player 1 will go free and Player 2 will go to prison for 3 years (and vice versa);
  - If both betray the other, both will serve 2 years in prison.

Prisoner's dilemma

		Player 2: C	Player 2: B
Player 1	C	$(-1, -1)$	$(-3, 0)$
	B	$(0, -3)$	$(-2, -2)$

- In pairs, decide who will be player 1 and who will be player 2 and play a round of the Prisoner's dilemma.
- (I mean play in the usual sense of 'analyse and work out the best strategy'.)

Prisoner's dilemma – finding equilibria

		Player 2: C	Player 2: B
Player 1	C	$(-1, -1)$	$(-3, 0)$
	B	$(0, -3)$	$(-2, -2)$

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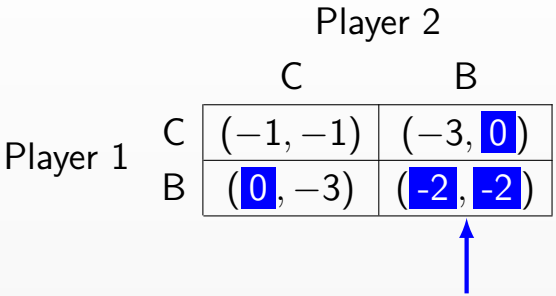
Prisoner's dilemma – finding equilibria



Prisoner's dilemma – finding equilibria

- So both players betray, and go to prison for 2 years.
- However, if both had cooperated, both would have got a better outcome.

		Player 2	
		C	B
Player 1	C	$(-1, -1)$	$(-3, 0)$
	B	$(0, -3)$	$(-2, -2)$

Golden Balls

- Prime time televised Prisoner's dilemma.
- A typical round:

Video Visit the URL below to view a video:

`https://www.youtube.com/embed/yM38mRHY150`

Golden Balls

- Jackpot: £100,150.
- Two players.
- Options: split or steal.
  - If both split (cooperate), they win half the money each.
  - If both steal (betray), both go home with nothing.
  - If Player 1 chooses to steal and Player 2 chooses to split, Player 1 takes all the money. (And vice versa.)

		Player 2	
		Split	Steal
Player 1	Split	$(50075, 50075)$	$(0, 100150)$
	Steal	$(100150, 0)$	$(0, 0)$

Golden Balls

- An interesting approach:

Video Visit the URL below to view a video:

`https://www.youtube.com/embed/S0qjK3TWZE8`

Iterative Prisoner's dilemma

- In pairs, play Prisoner's dilemma repeatedly.
- What is the best strategy to adopt?

		Player 2	
		Cooperate	Betray
Player 1	Cooperate	$(-1, -1)$	$(-3, 0)$
	Betray	$(0, -3)$	$(-2, -2)$

Iterative Prisoner's dilemma

- The Prisoner's dilemma gets interesting when played with a very large number of rounds, the Iterative Prisoner's dilemma.
- This is a standard algorithmic programming challenge.
- Several strategies emerge:
  - *Constant choice*: You make the same choice every time. The problem is your opponent will realise this and exploit the fact.
  - *Random choice*: You choose at random, with some probability (say $\frac{1}{2}$). You can calculate the probabilities of the four outcomes if both players do this.
  - *Tit-for-tat*: In this, you do the same thing as your opponent did last time. Once your tit-for-tat strategy becomes clear to the other player, their best move is to always cooperate.

Iterative Prisoner's dilemma

- A famous experiment reported by Robert Axelrod in *The Evolution of Cooperation* involved a competition of 62 computer programs each playing all the others for 200 rounds of Prisoner's dilemma.
- The most successful strategies had certain characteristics:
  - they were all *nice*, they did not betray before the opponent did;
  - they would always *retaliate* when an opponent betrayed;
  - they were *forgiving*, returning to cooperation when the opponent ceased to betray;
  - they were *non-envious*, seeking to maximise their own benefit rather than to reduce that of their opponents.

One more trip to the trenches

- The point about the trench warfare story is that the soldiers faced this choice repeatedly, so it is really Iterative Prisoner's dilemma.
- And Iterative Prisoner's dilemma is a situation in which cooperation can naturally occur.

		Side 2	
		Cooperate	Betray
Side 1	Cooperate	$(1, 1)$	$(-2, 2)$
	Betray	$(2, -2)$	$(-1, -1)$