

LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

STRATEGIC MINDS: THE GAME THEORY OF COOPERATION, COORDINATION AND COLLABORATION DRECT RECIPROCITY OR WHAT IT FEELS LIKE TO BE A BAT

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Assuming a nice strategy like Tit-for-Tat (TFT) gets fixated in a population, does it resist invasion by



WILLIAM D. HAMILTON In other words, when is TFT evolutionarily stable?

Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. Science, 211 (4489), 1390–1396. Nowak, M. A. (2006). Evolutionary Dynamics: Exploring the Equations of Life. Harvard University Press.

ROBERT AXELROD nastier strategies?



Consider the one-shot Prisoner's Dilemma



Consider the one-shot Prisoner's Dilemma

iterated over an indeterminate number of rounds

where the probability of a next round is δ

meaning that the average number of rounds played is:

$$\mu = \frac{1}{1-\delta}$$





WHEN IS TFT EVOLUTIONARILY STABLE?

TFT is an ESS if the occasional ALLD, thrown in a world where TFT is dominant, does worse against a TFT than a TFT against itself.

This happens if:

$$\begin{split} b < (b-c)\mu \text{ iff } \mu > \frac{b}{b-c} \\ \text{ iff } \frac{1}{1-\delta} > \frac{b}{b-c} \\ \text{ iff } \frac{1}{1-\delta} > \frac{b}{b-c} \\ \text{ iff } b-c > b(1-\delta) \\ \text{ iff } \delta > \frac{c}{b}. \end{split}$$



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In other words, TFT is an ESS if relationships last long



WILLIAM D. HAMILTON And what about ALLD?

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WHEN IS ALLD EVOLUTIONARILY STABLE?

ALLD is an ESS if a population of ALLDs cannot be invaded by TFTs.

This happens if a TFT against an ALLD does worse than an ALLD against another ALLD, which is equivalent to:

-c < 0.



So, in the long run, populations can reach two different outcomes.



WILLIAM D. HAMILTON Either no cooperation, or full cooperation, depending on initial conditions.

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In TFT, altruistic behavior (i.e., cooperation) is dependent on the other player returning the favor: an example of reciprocity.



WILLIAM D. HAMILTON Altruism makes sense between close relatives.

WILLIAM TRIVERS But also, as the game theory suggests, between nonrelatives: as long as they can establish a reciprocal relationship.

Trivers, R. L. (1971). The Evolution of Reciprocal Altruism. *The Quarterly Review of Biology*, 46(1), 35–57.



How do reciprocal relations get established in the real world?

WILLIAM TRIVERS There are some biological parameters that encourage selection of reciprocal altruism.

Length of life: the longer one lives, the more chances for mutually beneficial interactions.

Dispersal rate: if individuals live near each other, they are more likely to interact.

Mutual dependence: if individuals need each other to survive, they are more likely to interact.

For instance, in the way babies need their parents.

Whereas if I can tell you what to do, it is less likely reciprocity will evolve.

Trivers, R. L. (1971). The Evolution of Reciprocal Altruism. *The Quarterly Review of Biology*, 46(1), 35–57.



More generally, you need to be able to identify other individuals.

Plus a memory of their past actions.

Plus a high enough probability that you'll see them again.



We can see reciprocity in the animal world.

Vampire bats often share blood meals with unlucky



LEE ALAN DUGATKIN Apart from sharing with close kin, it seems that vampire bats are more likely to share with bats that have shared with them in the past.

Dugatkin, L. A. (2020). *Principles of Animal Behavior, 4th Edition*. University of Chicago Press.



Reciprocity is also a strong feature in humans: how might it have influenced our psychology?

WILLIAM TRIVERS It is likely humans will have evolved subtle tendencies to cheat, i.e., give back less than they received.

And a system for *detecting* cheaters.

People have likely evolved to seek, and like, other people with whom they can establish reciprocal altruistic relationships: aka, friends.

Moral feelings (e.g., righteous indignation, gratitude, sympathy) have probably evolved to regulate altruistic

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- behavior.