Mathematicians may have found an answer to the longstanding puzzle as to why we have evolved to cooperate

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Why do we feel good about giving to charity when there is no direct benefit to ourselves, and feel bad about cheating the system? Mathematicians may have found an answer to the longstanding puzzle as to why we have evolved to cooperate.

An international team of researchers, publishing in the *Proceedings of the National Academy of Sciences*, has found that altruism is favoured by random fluctuations in nature, offering an explanation to the mystery as to why this seemingly disadvantageous trait has evolved.

The researchers, from the Universities of Bath, Manchester and Princeton, developed a mathematical model to predict the path of evolution when altruistic "cooperators" live alongside "cheats" who use up resources but do not themselves contribute.

Humans are not the only organisms to cooperate with one another. The scientists used the example of Brewer's yeast, which can produce an enzyme called invertase that breaks down complex sugars in the environment, creating more food for all. However, those that make this enzyme use energy that could instead have been used for reproduction, meaning that a mutant "cheating" strain that waits for others to do the hard work would be able to breed faster as a result.

Darwinian evolution suggests that their ability to breed faster will allow the cheats (and their cheating offspring) to proliferate and eventually take over the whole population. This problem is common to all altruistic populations, raising the difficult question of how cooperation evolved.

Dr Tim Rogers, Royal Society University Research Fellow at the University of Bath, said: "Scientists have been puzzled by this for a long time. One dominant theory was that we act more favourably towards genetic relatives than strangers, summed up by J. S. Haldane's famous claim that he would jump into a river to save two brothers or eight cousins.

"What we are lacking is an explanation of how these behaviours could have evolved in organisms as basic as yeast. Our research proposes a simple answer - it turns out that cooperation is favoured by chance."

The key insight is that the total size of population that can be supported depends on the proportion of cooperators: more cooperation means more food for all and a larger population. If, due to chance, there is a random increase in the number of cheats then there is not enough food to go around and total population size will decrease. Conversely, a random decrease in the number of cheats will allow the population to grow to a larger size, disproportionally benefitting the cooperators. In this way, the cooperators are favoured by chance, and are more likely to win in the long term.

Dr George Constable, soon to join the University of Bath from Princeton, uses the analogy of flipping a coin, where heads wins £20 but tails loses £10:

"Although the odds winning or losing are the same, winning is more good than losing is bad. Random fluctuations in cheat numbers are exploited by the cooperators, who benefit more then they lose out."

More information: Strength in numbers: Demographic noise can reverse the direction of selection, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1603693113

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