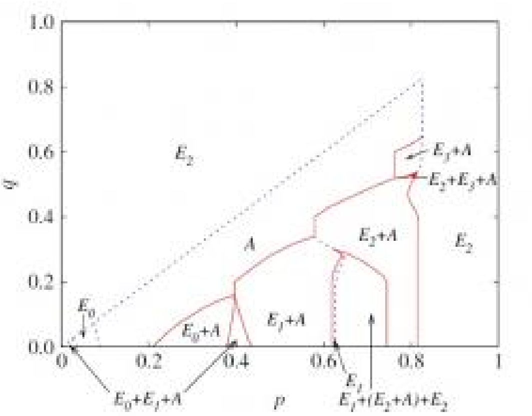
Fairness can evolve by imitating one's neighbor: physicists

August 30 2012, by Lisa Zyga



Phase diagram showing dominant strategies as a function of offers (p) and acceptance levels (q). The main finding is that a rich array of single- and multi-strategy phases emerge when p>q. Image copyright: Szolnoki, et al. ©2012 American Physical Society

(Phys.org)—As humans, we have a strong sense of fairness that often causes us to go out of our way to punish an unfair person, even when such an action comes at a cost to ourselves. This desire for fairness is epitomized by the ultimatum game, in which two players must share a sum of money. One player offers a certain nonnegotiable portion to the other player, who either accepts or declines, but declining means neither player gets any money.

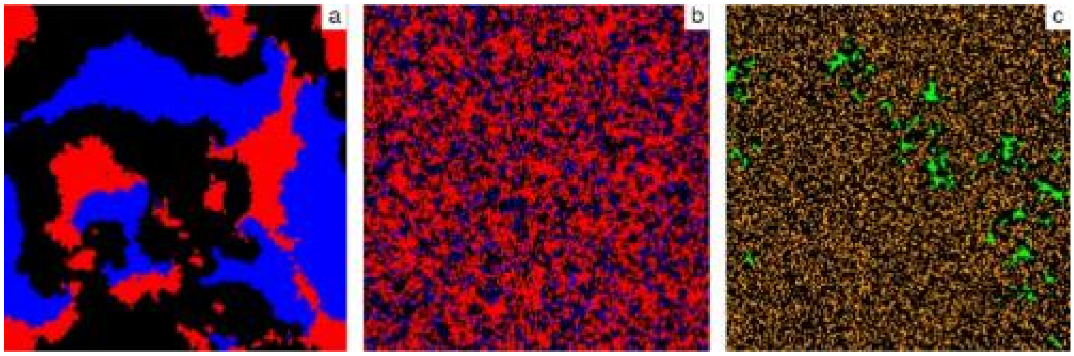
Although a rational player – sometimes called *Homo economicus* –

should accept any offer no matter how small so that they at least gain something, experiments show that this is not what happens in reality. Instead, people act more like an emotional *Homo emoticus*, refusing to accept offers they perceive as too small. Experiments show that people reject offers of less than 33% half the time. But low offers aren't very common in the first place, since about two-thirds of the time the offer made by the first player is very close to a fair 50:50 split.

Researchers have proposed many explanations for the underlying psychology that causes people to demand fairness. Studies have shown that, while models of natural selection favor the evolution of the rational *Homo economicus* who accepts anything and offers little, arranging the game spatially can lead to the evolution of fairness. In spatial games, players have restricted connections with other players and can only interact with players in close proximity to themselves.

In a new study, researchers have used statistical physics techniques to support this idea. They show that, in a spatial ultimatum game in which one player adopts its neighbor's strategy when it has worked better than its own, the fair 50:50 strategy can evolve. Results reveal hidden complexity in the pursuit of fair play, with various strategy combinations dominating in cycles.

The researchers, Attila Szolnoki and György Szabó at the Hungarian Academy of Sciences in Budapest, along with Matjaž Perc at the University of Maribor in Slovenia, have published their study on the results of the spatial ultimatum game in a recent issue of *Physical Review Letters*.



Examples of the spatial patterns that emerge for different combinations of p and q, where colors represent strategies. Image copyright: Szolnoki, et al. ©2012 American Physical Society

While many versions of the ultimatum game have already been proposed, the new version differs in that it limits the offers and acceptance levels that players can use to discrete values rather than a full continuum. As the scientists explain, this discreteness reflects real life situations, since we often haggle over a price by increasing or decreasing it by certain amount. Accordingly, each player employs one of six strategies, which are characterized by both the offer (p) and acceptance level (q). Five of the six strategies are considered empathetic, where p = q; that is, players accept the same amount they offer. The value of 50% is considered the perfectly fair strategy, while values greater than 50% are considered "superfair" and those less than 50% are considered rational. In the sixth strategy, p and q are chosen arbitrarily.

To begin the game, each player is randomly assigned a strategy. Then a randomly selected player plays the ultimatum game with its four nearest neighbors, acting once as proposer and once as responder with each neighbor. Then one of the four neighbors engages in the same interactions, and the payoffs of this player and the first randomly selected player are compared. One player will adopt the other's strategy with a certain probability depending on which player performed better. After many iterations, the idea is that better-performing strategies will grow in popularity and come to dominate the game.

What the researchers found, however, was not a single strategy emerging to dominate. Instead, as the game evolved, one strategy might dominate for a time, then an alliance of two or three strategies would arise and dominate for a time, then one of these strategies would dominate single-handedly, only to be taken over later by one or more other strategies. Although the fair 50:50 strategy could survive and occasionally co-dominate, it never dominated by itself, suggesting that the evolution of fairness is rather complex because the fair strategy elevates the survivability of the other strategies. Another highlight was the survival and occasional co-domination of the "superfair" strategy, in which a player offers and accepts amounts greater than 50%.

"Although it has been reported before that spatial structure can promote the evolution of fairness, the discreetness of strategies introduced in our case reveals just how many paths to this particular scenario there are," Perc told *Phys.org*. "Pattern formation can be crucial for the outcome of human bargaining, and we present many different solutions, including up to three-strategy dominance cycles and self-organizing spatial patterns, such as traveling invasion fronts and rotating spirals, that are representative for the studied system. While spatial structure is already established as a means for resolving social dilemmas, it has thus far not been considered so crucial in the context of human bargaining. We show that the discreteness of strategies changes this rather drastically, as it unleashes the full complexity of human bargaining. From experience, everybody knows that bargaining can be a rather complex undertaking. Our work accounts for this complexity."

By modeling fairness in a realistic way, the study could provide insight into the nature of fairness and human bargaining in real life.

"The importance of fairness really cannot be overstated," Perc said. "Just as the evolution of cooperation, the evolution of fairness is one of the central pillars of successful human societies. Accordingly, we need all the insights we can get to understand how fairness emerges, what promotes it, and what prevents it from vanishing from our moral compass. In addition to these rather practical reasons, there are further incentives as to why study this. As some experimental works already reported, our brain 'rewards' fair behavior and also makes us 'punish' immoral acts by not accepting unfair offers. Such brain activity, which 'drives us' to a globally more successful solution, is probably a result of an evolutionary process of human interactions. A theoretical work like ours helps to understand and reveal the evolutionary origin of this behavior."

More information: Attila Szolnoki, et al. "Defense Mechanisms of Empathetic Players in the Spatial Ultimatum Game." *Phys. Rev. Lett.* 109, 078701 (2012). DOI: 10.1103/PhysRevLett.109.078701

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