COMPETITION AND COLLABORATION: THE ROOTS OF ALTRUISTIC BEHAVIOURS

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> "Let us try to teach generosity and altruism, because we are born selfish. Let us understand what our own selfish genes are up to, because we may then at least have the chance to upset their designs, something that no other species has ever aspired to do."
>
> Richard Dawkins, The Selfish Gene

In an ocean of fortunes and dangers

The universe is a continuous flow of interactions between entities, whether in the infinitely big of stars and galaxies or the infinitesimal small of atoms and molecules.

Interestingly, life as we know it stands in the middle, subjected, as anything else, to the same rules, but, in a way, it has been able to give birth to new rules only obeyed by its participants; it's not at all illogical to consider the creation of life as a result of a collaboration, a fundamental one, between particles, atoms and then molecules, driven by the rules of energy minimization.

This tendency towards stability and reduction of costs is exactly the same reason at the base of collaboration mechanisms in nature, although, with stability and prosperity, in a context of limited resources, competition also inevitably comes to play. So we, as humans, but, in general, as living beings, find ourselves in this ocean of fortunes and dangers, in which we can navigate alone on a raft, in the fear of waves and sharks, or together on a galeon, compelled in mutual collaboration with other sailors.

This work aims to illustrate the basic foundations of human (and animal) competition and collaboration, in an attempt to unfold the (still-remaining) mystery of altruistic behaviours.

A life in competition

Since its early age, each living being finds itself surrounded by others individuals, sometimes similar but, more often than not, very different, at least in biological terms. The coexistence of multiple (continuously reproducing) agents in the same habitat leads to an inevitable competition between singles, that, as a consequence of organization techniques, becomes a competition between families, groups, villages, cities and even countries.

Competition in nature

Animals are always in competition, whether with others of the same species (**intra-species**), for the acquisition of territory, mates, food, water and shelter, or with other species (**inter-species**), for, mainly, authority on food, water and shelter, although generally **inter-specific** competition is less critical. Even something as seemingly immobile as plants compete for nutrients, sunlight and water: taller trees reach for sunlight obscuring the area beneath them, as a result, lower plants adapt by flourishing faster, in periods during which the taller trees' leaves are not entirely formed.

Strictly speaking, we say that organisms live within an **ecological community** defined as an "assemblage of populations of at least two different species that interact directly and indirectly within a defined geographic area" (Agrawal et al. 2007).

There are three major forms of competition: the first two, **interference** and **exploitation**, are considered *real* competitions, while the last, **apparent competition**, is not. While **interference** refers to direct alteration of the resource-attaining behaviour of other individuals, **exploitation** occurs when agents interact indirectly as they compete for common resources. In the long term, a superior exemplar can completely exclude an inferior one from an area, resulting in **competitive exclusion** (Hardin 1960).

Mathematical models show that in many cases, because of **intra-specific** competition, each species will eventually inhibit their own population before they inhibit that of their competitors, this proves the (objective) observation that, in almost all habitats, there is a coexistence of different species and not a prevalence of just one.

Finally, **apparent** competition occurs when two individuals that do not directly compete for resources affect each other indirectly by being prey for the same predator (Hatcher et al. 2006), though it's very difficult to observe this in nature, given its intrinsic indirect essence.

Human competition

As much as someone may try to elevate human beings to superior creatures, the irrefutable reality is that we are more similar to other animals than we think, not only biologically, but even in the way we act and interact.

One could argue that, differently from other animals, the human species has had two types of evolution: the former, and way more lasting, has been a biological evolution dictated by the same rules of natural selection as the ones still followed by other species, the latter, the one we are living as for today, much briefer but richer in progress and diversification, governed by mechanisms of cultural and technological evolution and differentiation.

We turned our interactions from deeply **inter** specific (with preys, predators, plants) to a mixture of **intra/inter** specific (between groups of humans and animals), to what we see today, where **inter** specific interaction has been basically entirely replaced by intercommunication in the context of complex societies and rules.

It is indeed true that the most evident form of competition in human society is represented by sports, but, in reality, it permeates the majority of the areas of our lives like academics, work, social exchanges etc.; in many situations (especially in highly capitalistic contexts) being remarkably competitive it's even considered an admirable quality.

According to Sigmund Freud (Freud, 1955), humans develop early instinctual competition behaviours for the attention of their parents, that may change form and scopes once in adult form, but remains present nonetheless. With the rising of Charles Darwin's theory of the *Origin of Species*, it became clear that competition was a natural mechanism for the survival of animal species, and that it has without doubt been part of our (ancient) life for the same reason, although, it still remains unclear if competitive behaviours in humans have genetic roots, or if they derive from cultural evolution.

As for this, there have been some studies that tried to free the human biological nature from the concept of competition. In 1937, anthropologist Margaret Mead published a work with title: *Cooperation and Competition among Primitive Peoples* (Mead M., 1937), where she investigated several societies that did not prize competition. One such society was the Zuni Indians of Arizona, and they valued cooperation far more than competition. For example, the Zuni held a ritual footrace that anyone could participate in, the winner of which was never publicly acknowledged and, if one person happened to win multiple times, he or she was prevented from participating in the future. After studying dozens of such cultures, Mead's final conclusions suggested that competitiveness is a culturally created aspect of human behavior, and that its prevalence in a particular society is relative to how that society values it.

The rise of collaboration

From what we have seen so far, nature seems to be a frightening world full of competitors and potential predators, in which the only way to survive is to become stronger, faster, more resistant; but what if the key to success was not competition, instead it was collaboration? How is collaboration possible in an habitat with limited resources and where the fundamental rule of evolution is that of "survival of the fittest"?

Well, it turns out that the famous quote just cited has always been a misinterpretation of Darwin's theory, who only literally believed in the "success in leaving progeny", success obtainable not only through excellent personal skills but also through clever strategies.

Living in a herd

Cooperation has been commonly defined as an adaptation to increase (at least partly) the probability of genetic success, and, likewise competition, it can happen **intra** (more often) or **inter** species. While some state that collaboration behaviours arise only between akin individuals, studies suggest that more direct gains can be achieved by assisting others, for example, protection from predation (Clutton-Brock, 2002).

Apparently these type of attitude may seem counterproductive, nevertheless, there have been multiple hypoteses to explain them, all rooted in W. D. Hamilton's models based on **inclusive fitness**, conjecting that collaboration is favoured by natural selection due to either an increase in reproductive success of the individual (**direct** fitness) or of other individuals who carry the same genes (**indirect** fitness), the latter often referred to as **kin selection**, where individuals help others of the same kin, resulting in an overall reproductive success of the same genetic makeup.

The most extreme example of animal collaboration can be found in many species of insects (e.g. ants, bees, termites etc.), where, usually, workers are sterile and thus do not reproduce, while the queens and the males specialize in reproduction.

Unus pro omnibus, omnes pro uno

The motto *"All for one, and one for all"*, popularized by the french writer Alexandre Dumas, perfectly summarizes the adfirmed nature of human succesful teamwork strategy; with the help of cultural transmission of knowledge, it has been arguably the main source of the human development and evolution.

Studies (Tomasello, Michael, and Amrisha Vaish. 2013) highlight that the evolutionary origins of human morality and cooperation are undoubtedly to be found in our primate cousins, which demonstrated to have well defined collaborative behaviours; yet human are vastly more cooperative compared to other

primates, being more egalitarian, and taking advantage of solid norms and institutions.

So, is collaboration an effective success strategy or did we evolve like this by pure chance? McLoone (McLoone, B., Smead, R., 2014) tries to answer this question by implementing a game theoretic model of the evolution of learning called *Stag Hunt Game*, which suggests us to expect a naturally emerging, unlearned tendency towards collaborative tasks. This result is also supported by other studies on the ontogeny of collaboration, that justify it by highlighting how children of different cultures and social/geographic context develop the same strategies in a systematic and temporally regimented manner, revealing how, even hypothetically giving up on innateness, the human tendency and ability to collaborate is deeply engrafted in our psychology and insensitive to cultures or learning environments.

Tomasello (2009) and Sterenly (2011) stressed the importance of "apprentice learning", which states that a child (or adult's) ability to participate in a collaborative activity requires active and prolonged instruction, that can be both explicitly taught by expert individuals or learned through observation.

All this collaborative evolution is only made possible if one makes a shift from the concept of evolution acting on behaviours, to acting, instead, on learning mechanisms, proving how close evolution of human collaboration really is to its ontology.

Interestingly, a recent work by OpenAI scientists (Baker, Bowen et al., 2020) demonstrated that simple game rules (hide-and-seek) multi-agent competition and reinforcement learning algorithms can induce AI agents to learn complex strategies and collaborative skills. Something arguably as impressive the team found was that agents were extremely skilled in exploiting small inaccuracies in the design of the environment and of the rules, something that reminds us the fundamental abilities of humans of adaptation and problem solving.

This work further demonstrates how collaboration is a fundamental mechanisms of success, independently of the human and animal psychological nature, suggesting that these types of systems had to be necessary to human evolution.

Social decisions and game theory

For centuries philosophers and scientists have been sure that the choices of humans were generated after a logical, rational, stream of consciousness, which calculated in a deterministic way the best possible alternative (the one with better outcome, less risk or better utility) among all the possibilities. Only recently this conception was accepted to be false, given the paradoxes it creates and the limitation of the human mind; it has been proposed that not only people often resort to heuristics and biases, but they also take into account personal emotions (which are the first engine that starts in the presence of a decision) and the social context in which one finds themselves, where many of our decision are influenced by those of others.

Game Theory (J. von Neumann, O. Morgenstern, 1947) is a collection of rigorous models that attempt to understand and explain situations in which

(generally competing) decision makers have to interact with each other in order to find an optimal solution. This approach is often used in economic contexts with the intention of predicting the behaviour of different agents (e.g. people, companies, governments), where the goal of each participant is to maximize its income. If everyone acts with a rational mind, the natural tendency of the game is to arrive to a **Nash equilibrium**, in which no player can increase his or her payoff unilaterally. As powerful as these models may be, it goes without doubt that humans quite always don't reason with a rational mind (as it was pointed earlier), instead, they are generally less selfish and take into account social factors as reciprocity and equity. It turns out that Game Theory can be a powerful tool to investigate for the psychological nature of altruistic behaviours.

Altruistic Paradox

The concept of altruism seemingly gives birth to an even bigger paradox then the one of collaboration: if cooperation of individuals quite certainly results in an advantage in the reproductive success of each participant, genuine altruism almost seems to be an error, an exaggerated extension of collaboration. After all, why would anyone help other possible competitors without having anything as reward, or any long term benefit?

It turns out that this is exactly how all animals still "think" today, with the exception of human beings, that seem to systematically make use of altruistic behaviours, deviating (as often happens) from the rational reasoning that we faithfully chased for millennia.

The nature of Human altruism

Society as we know it today is a complex, evermutating and evolving flux of relationships between altruistic and egoistic individuals, it is based on division of labour and cooperation between genetically unrelated individuals, differently from the animal kingdom, where it is limited to small groups, or to highly populated communities (i.e. insects) where the majority of individuals share similar if not identical genes.

Human altruism extends, in this sense, from **reciprical altruism**, it remains strong even when anonymity comes into play; humans have **strong reciprocity**: a combination of altruistic rewarding and punishment, which makes them **strong reciprocators**: they reward or punish even if they don't gain anything from it, while **reciprocal altruists** (such as other animals) do it only if they expect a future benefit in the long term.

Many researches try to use Game Theory models and games to investigate the nature of human altruism, and how much it deviates from the predicted rational choices. One of the most useful games used in this kind of works is called the **Ultimatum Game**: one player, the *proposer*, has to manage a starting sum of money; he or she is asked to decide how to split it with another player, the *responder*, in a way that will make him or her accept the split; if the receiver

refuses the agreement, no one gets the money. This game demonstrated to be an excellent proof of human non-rational reasoning, because a rational responder will accept any amount of money, as anything is better than nothing, consequently, the proposer will split the money in the most advantageous manner for him/her self. What studies found was quite the opposite: proposals giving below 25% of the total sum resulted almost every time in a refusal, while the most frequent split was the intuitive 50/50.

A variant of the Ultimatum Game that highlights even more the altruistic nature of humans is the **Dictator Game**, where the offer has to always be accepted, and, as anticipated, the split has been found in great favour of the proposer, but almost never with the totality of the money, in fact, a small sum was often given to the receiver from pure altruism.

In its simplest form, altruism indeed seems more disadvantageous than effective, this is caused by the inevitable existence of selfish individuals that exploit altruistic actions; this problem, though, can be solved if rewards and punishments are added into the equation.

A rejection in an Ultimatum Game is, in a sense, an altruistic act: it is costly for the responder, but aims to punish the offerer because he violated a social norm, as a result, the offerer is more likely to make a more equal offer in the future. This was also true in ancient times: in the enforcement of social norms (like sharing of food in a hunter-gatherer society) people punished trasgressors not for what they did to the punisher, but for what they did to other individuals that could not be related at all to the punisher him or her self.

Again departing from other animals, strong reciprocivity in humans is not only **bilateral** (i.e. between two individuals), but also **multilateral** (i.e. it happens in large communities). In such societies, in which goods are shared equally between individuals, altruistic rewarding implies that an individual's contributions increase if the expected contributions from the other group members increase as well. Individuals are rewarded if they are expected to raise their cooperation in the future.

In collaborating games a peculiar result is found (Fehr et al. 2003): if the game is played multiple times in the context of anonymity, cooperation tends to become unstable and deteriorates. This instability is caused by the minority of selfish individuals, demonstrating that even if a society has a majority of strong reciprocators, the minority of egoistic individuals will eventually lead to the only equilibrium point of zero cooperation.

This shows that, in order to maintain a collaborative environment, the belief that all members will cooperate is essential; such belief needs to be granted by adopting mechanisms of direct reward and punishment, in order to promote collaboration and discourage selfishness.

It is well known that people in the past were far more aware of the consequences of punishments led by social norms' evasion. Long time ago the most important aspect of the life of an individual was their belonging to a community, with it's own morals and laws; exclusion from the community was both a dangerous outcome and a profound dishonour, one could just refer to, as an example, the ancient Roman society, where exile (latin *exsilium*) was even given

as an alternative to death sentence.

There are also evidences that **reputation** plays an important role in altruistic environments: it was demonstrated that in repeated, non-anonymous, interactions, people that could acquire reputation helped in twice the cases than people who couldn't, suggesting that humans are attentive to the possible benefits of reputation. In addition, repeated interaction with the same partner also rises the cooperation rate considerably, showing how the refinement of trust can enhance collaboration.

In summary, a combination of selfishness and altruism motivates humans, the former more persistent in one-shot interactions, and the latter prevailing when rewards, punishments and reputation are introduced. In general, it is demonstrated that every (theoretical) game, given long enough time, becomes basically an assurance game with only two equilibrium points: mutual cooperation or mutual defection, which of these two is picked depends on the individual's belief of the other players' actions.

Not just social advantages

The benefits of altruism go beyond social accommodations, on the contrary, neurobiology (Fehr et al. 2003) proved that individuals experience subjective rewards from cooperating with other humans (and not from collaborating with computers). Other studies (de Quervain et al., 2004) showed that, in fMRI experiments, altruistic actions correlate with brain activity, suggesting that they derive from some sort of intended or motivated behaviour and are not an expression of mere decision error.

Our social brain developed in an environment where repetitive interaction with the same individuals was far more frequent than in modern times, giving us a glimpse of answer for why altruistic behaviours seem to be so radically marked in our behaviours, even in a (contemporary) society where interactions with strangers may lead to significant economic downsides.

In this sense, these procedures could be similar to other instinctual controls, characterised by emotions correlated with actions; if the action of altruism is linked to a feeling of pleasure or satisfaction, these behaviours would be elicited because they are personally satisfying.

Evolution of human altruism

It was previously suggested that altruism could have been engaged in early development of humankind as a successful survival strategy, but how did it specifically happen? The starting point, as always, would be found in our ancestral cousins, the great apes. Studies (Silk JB, House Br., 2016) suggest that, in the wild, primates cooperate in a relatively limited number of contexts, are not inclined to give in high costs when they provide services to others, show strong biases in favour of kin and reciprocating partners, and limit cooperative activities to pairs or small groups of familiar group members, something

very different from our case, suggesting that their cooperation may always be motivated by an expectation of personal benefit.

So why did humans evolve in much more altruistic and collaborative communities? What went differently?

Humans rely more on foods that are difficult to obtain and process than other great apes, for this reason, women and their offsprings are dependant on the help of others. Hrdy (2005) argues that the growing importance of allomaternal care favoured a number of changes in human emotions and cognition, thus cooperative breeding may have favoured the evolution of empathy and prosocial preferences. A link between cooperative breeding and prosocial behaviours was first supposed after studies on commons marmosets: when individuals were proposed a dictator game that contemplated either giving food to another of the same species or give them nothing, older marmosets tended to choose to release food if the other was a younger individual. More accurate experiments proved that the correlation between prosocial behaviours and cooperative breeding is the strongest between all the previously hypothesized, suggesting that, in non-human primates, high levels of both allomaternal care and prosociality may be a product of selection favouring altruistic behaviour toward kin. This could also have happened to early hominins, however, the contexts in which the two cooperative breeding processes developed are extremely different, so something else should be investigated as the origin of the evolution.

The power of culture

The real big difference between humans and other animals rests in the possibility of **cultural transmission** of information and knowledge. If some essential skill is difficult to learn and master, it would be profitable for individuals to specialize and set up a division of labour, while, when needed, exchange the products of each own work. Cultural transmission comes in handy when the need for complex tasks arises, and cultural changes can give birth to complex habitat adaptations a lot quicker then natural selection, but, at the same time, it makes different population group evolve towards different equilibria, extending the groups diversities.

Natural competition between these groups may favour cultural laws that increase the general welfare of the single group; emotional responses to altruistic interactions will thus strengthen cooperative norms, while rewards and punishments would decrease variability in conformity of social norms, ending with a superior group overall.

This suggests that the true origin of human altruism and technological as well as sociological progress is really a coevolution of genetic and cultural traits.

Conclusions

Even with the most recent discoveries and studies, it is still not fully clear how and why humans developed such a counter intuitive behaviour as altruism, but, even in our ignorance, we can't but thank Mother Nature for giving us such a powerful tool, which arguably acted as protagonist in our brilliant evolution. In the darkness of unknown, collaboration and trust have been the torch illuminating our path, with their certain shadows of selfishness and exploitation but with likewise accommodating warmth. Who can say what the future will reserve to us, maybe in a decade we will experience a new step of collaboration with Artificial Intelligence, or, hopefully, we will realise that it still possible to experience an easy and rapid evolution with just the help of altruism.

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