Ullica SEGERSTRALE*

COOPERATION AS A SOCIAL TECHNOLOGY

Abstract: Social technologies have to do with the organization of social life and the solution of human problems. One of the most important social technologies is cooperation. This essay discusses an ongoing multi-disciplinary effort by evolutionarily oriented anthropologists, sociologists, political scientists, psychologists, historians and economists to examine the contribution of cooperation to human evolution. Experiments, field research and modeling have increasingly demonstrated that people are in fact concerned about the common good. Evolutionary game theory has been instrumental in investigating the conditions for the emergence and sustainment of cooperation. A new paradigm of cooperation seems posited to replace the old one postulating individual selfishness.

INTRODUCTION: WHAT IS A SOCIAL TECHNOLOGY?

Technologies are often seen as involving the development of things, typically machines of various sorts. The focus is on the product and what it can do. But technologies can be defined much more broadly. They can be regarded as strategies for doing things. This means they have to do with the organization of social life and the solution of various human problems. These are what I call social technologies. And one of the most important social technologies is cooperation.

One can actually find agreement with such a view among researchers on technology. For instance, my favorite historian of technology Rudi Volti whose textbook is now in its 7th edition, defines technology as follows:

„A system created by humans that uses knowlede and organization to produce objects and techniques for the attainment of specific goals" (Volti, 2007, p. 6).

It is even more encouraging to see his endorsement of Lewis Mumford's view of the first machine:

„There is considerable merit in Lewis Mumford's assertion that the first „machine" was not a physical object, but the organizational structures that the Egyptian pharaohs employed to build the pyramids" (Volti, 2007, p. 5).

* Illinois University, Chicago; WAAS fellow

In this essay I will look at recent developments which I believe represent an important paradigm shift in behavioral research. What has been emerging over the last two decades or so is an implicit — or sometimes explicit — collaboration between different types of social scientists interested in evolutionary reasoning about the origin of cooperation: anthropologists, sociologists, political scientists, psychologists, historians and — importantly — a new brand of economists. We see an upswing in game theoretical modeling, which demonstrates under what conditions cooperation is likely to take place, comparative field studies of the norms underlying cooperation in small scale societies, and ingenious experiments of individual choice in economics laboratories. One scientist whose whole life in fact has been dedicated to finding ways to improve the human situation, both the conditions for achieving cooperation and the strategies for resolving conflict, is political scientist and game theorist Robert Axelrod, who recently received the Presidential Medal for Science from President Obama.

A NEW CLIMATE FOR RESEARCH — BEYOND „THE SELFISH GENE"

Towards the end of the twentieth century, the social climate was increasingly turning away from the environmentalist explanations of „culturism" and the post-World War II taboo on biological explanation of human behavior. By 2000 the taboo had been broken. With the Human Genome Project and the promise of biotechnology, genetics was becoming practically a household word. „Gene talk" even became popular, and the media started reporting ever new discoveries of a „gene for risk taking" and the like.

In other words, the climate had become much more receptive to the idea of a biological foundation of human nature, a human „species nature" (a basic point of E O Wilson's treatises on sociobiology, 1975 and 1978).

Instead of the significant cultural differences that Margaret Mead and other anthropologists had so vividly described, new anthropological studies now documented the existence of human cultural universals (Brown, 1991). The nature of animals also was reinterpreted. During the sociobiology controversy (from 1975 onwards, see Segerstrale, 2000), there had been great unwillingness to draw parallels between humans and animals, because of the emphasis on such traits as aggression (ever after Konrad Lorenz' *On Aggression*, 1966). Of course, Hamilton (1964) had famously shown that it had indeed been possible also for a trait such as altruism to evolve, but that was typically regarded as limited to helping close relatives („kin selection"). But in the 1990 s, research on both ape language and culture presented chimpanzees as much more similar to humans and considerably 'nicer' than depicted in the 1960's (de Waal, 1996 and later). Important new connections between nature and culture in both animals and humans could also be found in the interdisciplinary field of nonverbal communication (Segerstrale and Molnar, 1997).

So the general climate had become more open to biological explanations of human behavior. But what was the language that was being used like? The discussion was still stuck in the language from the sociobiology controversy and Richard

Dawkins' *The Selfish Gene* (1976). There seemed to be no getting away from the talk about selfish genes — especially since the leading research paradigm (which focused on the survival of genes, rather than individual organisms) was often called „selfish gene theory".

Of course, the title *The Selfish Gene* was a kind of tongue-in-cheek title — genes can obviously not be 'selfish' in a human sense. But genes can be seen as self-replicating, and Dawkins' added anthropomorphic twist made for a very vivid explanation, even for his biological colleagues. (In fact, Hamilton himself had used the „gene's-eye" perspective in his early papers to illustrate how altruistic behavior could be explained by gene-centered reasoning; this Dawkins later took to new pedagogical heights).

The problem was that the title was misunderstood from the very beginning. It takes a pre-existing background acceptance of evolutionary theory to be able to play along with ideas such as the selfish gene in order to improve one's scientific understanding. For those who do not have such a background, „selfish" just makes a direct connection with the psychological and moral realm, which is what happened in many instances. Many did see the book as condoning selfish behavior, and approved. Some academics, too, criticized the book just because of its perceived exhortation to individual selfishness (including Karl Popper, the famous philosopher of science), and especially during a time of Thatcher's Britain and Reaganomics in the United States.

Was Dawkins guilty of anything else than using a catchy, though easily misunderstood metaphor? Well, a new check of his book produces the following uncomfortable citation:

„We are survival machines — robot vehicles blindly programmed to preserve the selfish molecules known as genes.… Let us teach generosity and altruism, because we are born selfish" (Dawkins, 1976, p. 7)

This quote would seem to suggest that our selfish genes make us selfish, which is of course nonsense, but it does indicate that the author believes that human nature is primarily selfish. He is here rather adopting a Thomas Henry Huxleyan view of the world: nature is basically amoral, or bad, and this is why we need culture and education to teach us to be moral. This view may in fact represent a larger undercurrent in the British biological tradition, which probably goes hand in hand with the view of competition as the driving force in evolution.

But not everybody was buying into this kind of metaphor. „Selfish" didn't sound good in everyone's ears. „Kin selection", when you thought of it, didn't sound much better. Were we supposed to primarily stick to our kin and ignore others? In any case, „selfish" and „kin" did not necessarily have positive social connotations.

Moreover, some biologists had early on reasoned that what seemed to be altruism was not really so: a donor that helped an individual that shared its genes was just indirectly promoting its own fitness. Or as biologist Michael Ghiselin (1974) put it: „Scratch and altruist, and watch a hypocrite bleed".

Was there, then, an alternative? Yes, cooperation! What a welcome and intuitively positive word, and with plenty of good examples that could be brought in. This was a satisfactory term for both scientists and non-scientists who wanted a change of language and emphasis. And of course, cooperation as a scientific topic was awaiting further exploration. Its turn had come.

EXPANDING EARLIER THEORIES OF COOPERATION

Kin selection could be seen as a type of cooperation, but it is limited to some kind of genetic relatedness. This relatedness typically involves relatives, hence the term „kin selection". However, this term (launched by his colleague Maynard Smith) limited Hamilton's initial vision of „inclusive fitness" (having to do with the fact that social individuals affect each others' life chances), because he interned it to apply also to individuals that were not formally relatives, but happened to share the same gene „for" altruistic behavior. But how would they find each other? He suggested that the altruistic gene could be connected to a „superkinship trait", that is, some kind of phenotypic identification which would make it possible for such individuals to identify fellow altruists) (Hamilton, 1964; 1975).

A more obvious candidate for cooperation is the theory of „reciprocal altruism" (or rather, reciprocity), proposed by Robert Trivers (1971). This was a theory that Hamilton welcomed as an important complement to his own theory involving altruism based on relatedness („kin selection"). It is in principle more general, since it does not expect that the interacting parties are related. The theory's basic idea is „I'll scratch your back, you'll scratch mine", exemplified for instance by mutual grooming among many bird and mammal species, or coalition-forming by animals, or mutualism (mutual assistance between members of different species, for instance cleaner fish and their hosts).

But later research has suggested that reciprocal altruism may in fact be rather rare among animals. For it to be direct reciprocity, individuals would have to recognize each other and also remember their earlier encounters; this is not easily achieved. It is now believed that reciprocity appears mostly among humans and higher primates.

A typical problem in regard to reciprocity is *cheating*, that is, taking advantage of a benefit that has been offered, but then not paying back. Evolutionary psychologists believe that humans for this reason are particularly adept at cheater detection. (So are also higher primates, to some extent). But later extensions of the idea of reciprocity have expanded the possibility of cooperation to include much bigger groups. One such idea is *indirect reciprocity* (Alexander, 1987; Nowak and Sigmund, 1998). Indirect reciprocity has to do with building one's reputation, and using *reputation* as a proxy of sorts. This means that an individual with a reputation for helping would be more likely to be helped by others in the same community. (This can also explain why humans are so interested in gossip about others).

This was one attempt to expand reciprocity, but for many this did not yet provide a satisfactory explanation for the problem that needed an answer: what about situations in which it is hard for even indirect reciprocity to work? Especially: how can cooperation among strangers in large scale societies come about? Moreover, how might the problem of cheating be resolved there? The obvious answer would be to have some kind of *sanction for non-cooperation,* or „free-riding". Was this going on in real life? Anthropologists explored and documented the existing solutions to this in small scale societies (e. g., Henrich and Boyd, 2001).

Still, one question that arose was: Just how would this punishment system work? Who would do the punishing? Wouldn't meting out punishment be costly and unrewarding for individuals, and potentially give rise to a „second order free rider problem" involving those who shirked their duty to punish free-riders?

This is where the interesting concept of „*altruistic punishment*" was introduced into the discussion:

„The punishment of free riders constitutes a second-order public good. The problem of second-order public goods can be solved if enough humans have a tendency for altruistic punishment. That is, if they are motivated to punish free riders even though it is costly and yields no material benefit for the punishers" (Fehr and Gachter, 2002)

These two economists set out to investigate experimentally a) if people in fact engage in „altruistic punishment" of this kind, and b) how this affects achieving and sustaining cooperation. Their study involved a game of „investment" in a „public good" and the possibility of „punishing" participants who were deemed not to contribute their „fair share". The study showed, surprisingly, that *people were in fact willing to pay in order to punish free riders — and this in „one-shot" encounters where they would not reap any benefit from it themselves.* The researchers explained this seemingly irrational behavior by suggesting that free riding causes strong negative emotions, which trigger a wish to punish. In other words, *emotions* are an important proximate factor for altruistic punishment. And because we are aware of the anger that cheating and free riding causes, we are sensitive already to the mere threat of punishment, the researchers noted.

This was a controlled economic experiment, but was this related to real life? The answer was yes. Anthropologists found a number of ingenious solutions in small societies, the evidence from the experiment agreed with data from studies of public goods, and was also consistent with historical studies of collective action (Bowles and Gintis, 2004).

Looking into this evidence Bowles and Gintis concluded: „cooperation is maintained because many humans have a predisposition to punish those who violate group-beneficial norms, even when this reduces their fitness relative to other group members". In other words, there was more to human nature than self-interest.

But who would be doing the punishing? Here entered a new concept: *strong* reciprocity (Gintis, 2000). Strong reciprocators do not only cooperate themselves but they also punish non-cooperators. To demonstrate the feasibility of this idea as a factor in human evolution, Bowles and Gintis decided to do an agent-based modeling to do a dynamic simulation over a span of 100,000 years. They showed how high levels of cooperation could be sustained in a population containing a mixture of cooperators and selfish types, as long as it also contained at least a few strong reciprocators. The model showed that the latter would be increasing over time (Bowles and Gintis, 2004).

So this research further supports the idea of human predispositions for fairness and adherence to norms, in this case expressed as a wish to punish those who deviate from what is good for the group.

THE CONDITIONS FOR COOPERATION: GAME THEORY AND TIT FOR TAT

Game theory was originally developed in the 1940 s and 1950 s by the mathematician John von Neumann and the economist Oskar Morgenstern. In game theory the realization is that the interests of individuals („actors") involved in an interaction (a „game") are not necessarily compatible. At the same time, each actor's best move is dependent on what the other actors do. Many aspects of social life can de described by game theory.

The prototypical two-person game is the famous Prisoner's Dilemma. The proto-typical multi-person game is The Tragedy of the Commons. Both models illustrate how the lack of cooperation between interacting individuals produces a result that makes everyone worse off than if they had cooperated. The Tragedy of the Commons is perhaps the more immediately obvious model. The „commons" is any shared resource for a group of individuals, and the tragedy is the short-sighted over-use of this resource by each individual without consideration for how this will affect the eventual outcome if everybody did it. (This leads to over-grazing, over-fishing, pollution, destruction of the environment, traffic jams, etc). But in principle this tragedy can be avoided in various ways: through better information, getting people involved, incentives and punishments, norms, regulations, laws, etc.

The Prisoner's Dilemma model applies to many situations in real life as well. Two prisoners are arrested for a crime for which there is insufficient evidence. Each one is separately invited to confess („defect"), being promised a greatly reduced prison sentence. If both keep quiet („cooperate"), there is little evidence to keep them in prison. If both confess, both will get a severe penalty. But the worst penalty would come about if one kept quiet (cooperated) while the other one confessed (defected). This was typically the case with individuals in laboratory experiments with Prisoner's Dilemma-type games played by economists and political scientists in the past. There each partner reasoned separately that he would be better off defecting — and so both ended up worse off than if they had cooperated.

We are acquainted with Hamilton as the person who solved Darwin's puzzle about altruism through his idea of inclusive fitness („kin selection"). But later, he moved on to the question of cooperation between unrelated individuals as well. He was particularly concerned about what he saw as the inevitability of Prisoner's Dilemma situations in social life. It was hard for him to imagine how cooperation between unrelated individuals could ever evolve. There didn't seem to be any obvious way out of the dilemma, and this depressed him. But later, together with game theorist Robert Axelrod, Hamilton was able to show how cooperation between unrelated individuals could, in fact, come about. Their joint paper, „The Evolution of Cooperation", was later awarded the American Association for the Advancement of Science's (AAAS) Newcomb-Cleveland prize for the best paper published in *Science* in 1981.

Their classic paper aimed at demonstrating how game theory could be used to formalize various potential strategies for social actors in real life, and also to identify the conditions under which cooperation could come about. They provided a model which made it possible to make testable predictions over a wide range of species — all the way from bacteria to humans. Their basic reasoning was the following: In order for cooperation to work, individuals would either have to have disincentives to act selfishly, or incentives to act cooperatively. One possible condition would simply be not to be able to get away with acting selfishly. This would naturally happen if individuals could be counted on to meet again and be recognizable to one another. In other words, they would be involved in a *repeated or iterated Prisoner's Dilemma game*

Axelrod and Hamilton demonstrated how insights from an iterated Prisoner's Dilemma framework could illuminate the conditions under which cooperation between unrelated individuals could in principle evolve. What was needed was a high probability that individuals would meet (and „play") again. The basic insight was similar to Trivers' „reciprocal altruism", with the difference that game theoretical modeling made it possible to express that mathematically.

Biologically this principle could be realized in different ways. It could involve for instance maintaining continuous contact (e. g., inter-species mutualism), employing a fixed location (e. g., cleaner fish waiting for „customers"), territoriality (e. g., birds), ability to recognize faces (humans), or some kind of cues that indicated a promise of continued interaction. The interesting fact is that cooperation by reciprocity does not require a brain or memory — it is even applicable to bacteria! Bacteria are highly responsive to the chemical aspects of their environment, and can develop conditional strategies of behavior depending on what other organisms around them are doing. These strategies can be inherited. Higher intelligence organisms, of course, can play much richer games, since they are able to discriminate between individuals and can in this way reward co-operation and punish defection (Axelrod and Hamilton, 1981)

If the right conditions are present, cooperation can get started and be sustained even among antagonists (e. g., in politics or in wartime; for instance between the French and the Germans in World War I). Cooperation can develop in a population as long as there are small clusters of individuals who interact with each other and reciprocate. Such interaction clusters can be, and are in general, too, socially promoted through hierarchies, organizational structures, and spatial arrangements (see details in Axelrod, 1984).

To find out what is the most robust and desirable strategy, Axelrod famously used the method of computer tournaments between various strategies suggested by colleagues. The strategy that achieved the highest score was TIT FOR TAT. This strategy is very simple: *cooperate on the first move, and then do whatever the other player does. If the other player defects, retaliate, but then go back to cooperation.* In other words, TIT FOR TAT is „forgiving". It is also „nice" — it always starts by cooperating. Game theorists early on found that this strategy worked remarkably well and was widely applicable — be it to personal life, business or international politics. Later there have been updates: for instance a strategy called „generous TIT FOR TAT" is programmed to sometimes „forget" to retaliate to avoid chains of retaliation, and other measures may be needed to take care of defections that are in fact responses to errors or misunderstandings.

„TECHNOLOGY TRANSFER" TO HUMANS FROM INSECTS AND SLIME MOLDS

We can regard the process of evolution as a long trial-and-error search for sustainable social technologies. Scientists have started to tap into this enormous data base of accumulated information. Here are a couple of examples of what could be called „technology transfer" by mimicking living organisms.

It has long been believed that the secret behind teamwork can be found in the cooperative behavior of social insects. Recently this was investigated in a project involving biologists, computer scientists and engineers. First the biologists studied how ants solved various problems, for instance finding the shortest path to a food source, or determining when to dispatch workers to forage and bring back more food for the colony and bring it back. Then computer specialists simulated the situation with the help of agent-based modeling. These scientists were looking to find simple algorithms and simple rules behind the ant behavior that would later be usable for solving problems in real life, such as solving traffic congestion problems or moving objects up a slope. One of the important insights from this study was, incidentally, that rather than aiming for the best possible solution, just find a good one.

One of the things the researchers did was to mimic electronically the shortest path to a food source for a swarm of ants, indicated by the trail of pheromones left behind. When more ants use a particular trail the scent gets fortified; trails that are not used lose their scent. The artificial ants in the model deposited a digital equivalent of pheromone, proportionate to the shortness of the route. Just like real ants, also artificial ant agents learned to follow increasingly shorter routes (Peterson, 2000).

Living organisms can be amazing problem-solvers when it comes to calculating the shortest distance between two points. A slime mold (!) was able to beat serious experts on network analysis when it came to finding the shortest way through a maze or even planning a railway system. And this it did several years in a row (Gudrais, 2010, 44–50).

THE DARK SIDE OF COOPERATION RESEARCH

The evolution of large-scale cooperation was addressed already by Darwin in *The Descent of Man*. There he discussed the virtue of bravery and self-sacrifice and the general competitive advantage of groups with large numbers of altruistic individuals over groups with fewer. As a topic, however, this was not focal in evolutionary biology during the end of last century, because of a general emphasis on individual self-interest, competition and strategic calculation rather than spontaneous pro-sociality and cooperation as natural features for humans.

The challenge of dealing with unrelated strangers in large societies clearly required something beyond kin selection and reciprocity. As we saw, some researchers saw the solution in expanding the principle of reciprocity. Others, however, have taken a second look at *group selection* — a theory that has been out of favor for the last half century — or more properly termed, „*multi-level selection*", since humans typically form hierarchically organized larger entities. Note that many group level phenomena, including different forms of cooperation, can be explained as beneficial for the individual, so invoking the process of group selection may not be necessary. Group selection strictly speaking requires a situation with sufficient genetic variation between competing groups, where the less fit „go extinct". Applied to humans, it would mean that groups with a higher proportion of self-sacrificing individuals would tend to replace groups with fewer altruists.

Some leading biologists seem to take for granted that the „group extinction" required by group selection has most plausibly involved killing off the defeated group (e. g., Bowles 2006, Wilson, 2012). Boyd and Richerson (2009), however, suggest that members of the defeated group may rather get absorbed by the winner and learn their culture by resocialization, and bring in examples to support this view. Meanwhile there are different assessments about the level of killing in prehistory. It is, however, believed that genomic data will help improve our understanding of human evolution, including the timing of genetic changes and human population sizes and migration patterns.

I see the strong emphasis on ingroup-outgroup opposition of some researchers as the dark side of cooperation research. It is not clear what aim this serves, except to fortify the belief in the necessity of group conflict. We humans so easily commit the naturalistic fallacy, reading normative prescriptions into naturalistic statements — in this case thinking that what exists naturally is naturally „good" or „right". Now those who are prone to thinking this way will only be fortified in their belief by the matters proclamations by „guru" scientists writing for the public. It matters whether or not you believe that ingroup-outgroup opposition is inevitable, or that such a conflict is the best or only way to bring about the desired goal of cooperation! Especially if you are an important social decision. Fortunately there are also researchers at work studies investigating how people in fact construe „ingroups" and „outgroups" (e. g. Cikara and Van Bavel, 2014), as well the various conditions under which cooperation can develop independently of the threat from an outgroup.

CONCLUSION

Recently there has been an increased interest in explaining various aspects of human cooperation, with special focus on the origin of large scale cooperation of unrelated humans. This quest goes beyond such proposed extensions as „strong reciprocity" and „altruistic punishment". The question that is now challenging an multi-faceted community of researchers is: how did such large scale cooperation evolve in the ancestral human environment in the Pleistocene, which originally featured only small mobile groups of hunter-gatherers? Some see this question as intimately related to another big puzzle: the tripling of the human cranial capacity during the past 2 million years. These scientists are looking for explanations beyond the received view that this was due to some kind of mutation or „cognitive explosion", which has been a long-standing view. The result is a truly interdisciplinary project.

Nobody can go back to the Pleistocene, but plausible conditions can be modeled by comparison with existing small societies of hunter-gatherers and by considering available information about population movements, climate changes, and the like. Human evolution has typically involved cooperative and costly activities related to public goods, such as hunting big game, meat sharing, and warfare. This has brought in a new type of experimental economists, interested in working together with anthropologists and social scientific modelers, who together strive to explain how this evolution was possible. What made people participate in these costly cooperative activities, and how was this cooperation sustained? It seems increasingly clear that norms regarding this were developed originally in small scale societies and that the adherence to norms was closely monitored

An interesting alternative to the group extinction thesis is the suggestion that the human propensity for cooperation may well have arisen through *gene-culture co-evolution*, and here with *culture* as the driver. How can culture affect genetic evolution? Culture can in fact quickly create a new environment for adaptation and in this way put pressure on the genes — especially in times of rapid environmental or climatic change.

Also in another respect is culture given a larger role than before as a factor in human evolution. The „group extinction" required by group selection theory can in fact happen in the realm of culture. In other words, the variation that is needed between groups for there to be evolution (selection) at all can be of a purely cultural kind. Groups have naturally developed different social norms and ways of doing things. But the next step does not require inter-group competition or group extinction. It can happen by imitation of „better" approaches seen in neighboring groups. Or, as mentioned, after a conflict, members of the defeated group may simply get absorbed by the winner and learn their culture by resocialization (Boyd and Richerson, 2005, 2009). Alternatively, a selection pressure for „cooperative" genotypes might have been created by cultural rules alone (Bell, Richerson and McElreath, 2009).

These are exciting times for researchers interested in formulating a new encompassing theory of human nature and its probable origins, united by the wish to uncover and substantiate the until recently underrated role of cooperation as a factor in evolution. This could in fact be described as just going back to basics — that is, to the view of Darwin himself. At the same time, this effort can be seen as a current collective attempt to bring in a much needed paradigm in regard to human nature, one that both scientifically and morally rings more true than a paradigm based on human selfishness in the world today.

Acknowledgement: I wish to thank the Kone Foundation for financial support.

REFERENCES

[1] Alexander, R. D. (1987). *The Biology of Moral Systems*. New York: de Gruyter.
[2] Axelrod, R. and Hamilton, W. D. (1981). The evolution of cooperation. *Science* 211: 1390–1396.
[3] Axelrod, R. (1984). *The Evolution of Cooperation*. New York: Basic Books.
[4] Bell AV, Richerson PJ" and McElreath R (2009). Culture rather than genes provides greater scope for the evolution of large-scale human prosociality. *Proc Natl Acad Sci USA* 106: 17671–17674
[5] Bowles S (2006) Group competition, reproductive leveling and the evolution of human altruism. *Science* 314: 1569–1572
[6] Bowles, S and Gintis H (2004). The evolution of strong reciprocity: cooperation in heterogeneous populations. *Theor Pop Biol* 69, 17–28.
[7] Boyd R and Richerson PJ (2005) *Not by Genes Alone*. University of Chicago Press, Chicago
[8] Boyd R and Richerson PJ (2009) Culture and the evolution of human cooperation. *Philos Trans R Soc B* 364: 3281–3288
[9] Brown, D. E., (1991). *Human Universals*. McGraw-Hill, New York.
[10] Cikara, M. and Van Bavel, J (2014). The Neuroscience of Intergroup Relations: An Integrative Review. *Perspectives of Psychological Science*, Vol 9 (3), 245–274.
[11] Dawkins, R, (1976). *The Selfish Gene*. Oxford, Oxford University Press.
[12] DeWaal, F. (1996), *Good-Natured*. Harvard University Press, Cambridge, MA
[13] Fehr, E and Gachter, S (2002). Altruistic punishment in humans. *Nature* 415: 137–40.
[14] Ghiselin, M. (1974). *The Eonomy of Naure and the Evolution of Sex*. University of California Press.
[15] Gintis, H (2000). Strong reciprocity and human sociality. *J Theor Biol* 206: 169–179.
[16] Gudrais, E. (2010). Networked: Exploring the weblike structure that underlie everything from friendship to cellular behavior. *Harvard Magazine*, May-June 2010, pp. 44–50.
[17] Hamilton, W. D. (1964). The genetical theory of social behavior. I and II. *J. Theor. Biol.* 7: 1–16; 17–32.
[18] Hamilton, W. D., (1975). „Innate Social Aptitudes of Man: an Approach from Evolutionary Genetics." In R. Fox (ed.). *Biosocial Anthropology*, New York: John Wiley & Sons, pp. 133–157.
[19] Henrich, J and Boyd, R. (2001). Why people punish defectors. *Journal of Theoretical Biology* 208: 79–89.
[20] Lorenz, K. (1966). *On Aggression*. Methuen, London.
[21] Peterson, I. (2000). Calculating swarms: Ant teamwork suggests models for computing faster and organizing better. *Science News*, Vol. 158, pp. 314–316.
[22] Segerstrale, U. (2013). *Nature's Oracle: the Life and Work of W. D. Hamilton*. Oxford: Oxford University Press.
[23] Segerstrale, U. and Molnar, P. (Eds.) 1997, *Nonverbal Communication: Where Nature Meets Culture*. Lawrence Erlbaum, Mahwah, N. J.
[24] Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology* 46: 35–57.
[25] Volti, R. (2007). *Society and Technological Change*. New York: Worth Punlishers.
[26] Wilson, E. O. (1975). *Sociobiology: The New Synthesis*. Cambridge, Massachusetts: Harvard University Press.
[27] Wilson, E. O. 1978. *On Human Nature*. Cambridge, MA: Harvard University Press.
[28] Wilson, E. O. 2012. *The Social Conquest of Earth*. New York: W. W. Norton.