Interdisciplinary EUROCORES theme

The evolution of cooperation and trading: from microbes to man (TECT)

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Abstract

Few phenomena attract as much attention from as many different scientific disciplines as the study of cooperation – the fields of anthropology, biology, economics, political sciences, psychology and sociology all consider cooperation to be a central focus of inquiry. This fascination with cooperation – and its cousin, trading – rests on its puzzling nature: cooperation appears intrinsically unstable and theoretically problematic, yet it is ubiquitous throughout nature and human societies. Cooperating and trading agents may sometimes make a profit, but simultaneously risk suffering a loss; they must choose continually between small, but immediate, benefits and more substantial, but temporally distant, ones; more often than not the interests of partners are at odds. All of this implies that agents with very different natures, ranging from bacteria to multi-national alliances of humans, are equipped with similar evolved strategies designed to solve the same recurring dilemmas. While distantly related species probably use different mechanisms to implement these strategies, more closely related species are more likely to employ the same mechanisms when solving the same problems. We therefore propose a program in which these strategies and mechanisms form the focus of research, and where our main goal is to highlight the evolutionary *continuity* of cooperation, both genetic and cultural, and make it an object of study in its own right: What explains the evolution of different mechanisms and strategies? Can we trace the evolutionary history of mechanisms and does this explain the forms we observe today? Can 'bounded rationality' and the break-down of cooperation in modern human societies be explained by the activation of mechanisms that evolved in past environments? A second aim, essential to achieving the first, is to bring together experts from different disciplines in order to encourage, and enable, 'cross-fertilisation' of different traditions, terminologies and methods.

Keywords: anthropology; cognitive science, economic sociology; evolutionary ecology; evolutionary psychology; game theory, micro-economics; neuro-economics

Introduction

Cooperation and trade have essential elements in common: individuals or groups invest in order to increase their chances of obtaining a net benefit, while, at the same time, they run the risk of obtaining little or no return from their investment. It is therefore crucial for each participant in cooperation, and for each trader, to have a number of mechanisms at his/her disposal that help to ensure optimal profit. As trading and cooperation are not fully interchangeable concepts – there are forms of cooperation that lack the exchanges that typify trading (e.g., acceptance of mutual boundaries by territory holding animals) and there are automated forms of trading that have little to do with cooperation (e.g., internet stock-trading) – we propose to concentrate only on those areas in which the two phenomena overlap.

Evolutionary theory provides different explanations for cooperation between closely related individuals and for cooperation between unrelated or distantly related individuals. Investment in close relatives ("kin selection") yields a 'guaranteed return', because there is a high chance that the relative receiving the investment also shares the genetic information that gives rise to the investor's generous behaviour. While kin selection has its share of unresolved problems, the enigma posed by cooperation among unrelated agents presents a far greater challenge to evolutionary theory and is in need of much further study. The proposed program will therefore focus on cooperation in which kinship plays no role.

Evidence for cooperation and trade is apparent throughout the entire history of life on Earth, extending all the way back to our unicellular ancestors. Therefore, rather than studying cooperation and trading within the somewhat artificial confines of separate disciplines, we feel it is more valuable to study them as a single phenomenon, and draw on a wide array of methods and expertise from a variety of disciplines. The disciplines concerned include (in alphabetical order):
(1) **Anthropology** (biological, physical and social); (2) **Biology** (ethology, behavioural and evolutionary ecology, palaeontology); (3) **Cognitive science** (artificial intelligence, evolutionary robotics, embodiment, philosophy of mind) (4) **Economics** (micro-economics, neuro- & endocrino-economics, game theory); (5) **Mathematics** (game theory); (6) **Political sciences** (comparative politics, political theory); (7) **Psychology** (economic and evolutionary psychology); and
(8) **Sociology** (economic sociology).

Goals of the program

In order to obtain a deeper understanding of cooperation and trading, we need to improve our knowledge in the following six thematic areas:

1. Theoretical understanding of the phenomenon.

Which factors cause cooperative relationships to be unstable and which mechanisms can, in principle, overcome instability? Different forms of cooperation will require different kinds of theoretical models, but most fall into the following broad categories:

1.1. *Dyadic interactions*. Interactions may take place in a context of multiple individuals that can potentially interact (a 'market'), but the actual interactions are intrinsically dyadic (a bee visits a single plant; an individual customer buys goods in a single shop).

1.2. *Polyadic interactions.* Multiple individuals have to act together in order to obtain an outcome that is beneficial for some or all participants. Examples are the management of 'public goods' and the production of benefits through 'collective action' (villagers managing a common irrigation system; microbes forming a communal fruiting body).

1.3. *Cooperation between entities consisting of multiple individuals.* Recently, it has been shown that the evolution of specific forms of cooperation – and ones that seem to be exclusive to humans – can be attributed to a form of 'cultural' group selection (Richerson & Boyd, 2005). The importance of this process to humans can probably be linked to the evolution of language, which acts as a tool for synchronisation and policing (the announcement of sanctions, tarnishing the reputation of free-riders and so forth). Trading between companies can also be seen as cooperation between groups

rather than individuals, because the decisions at the company level are usually the result of the dynamic interaction between individuals involved in the decision-making process.
1.4. *Anonymous trading.* The above categories imply face-to-face interactions with the possibility of communication between agents. However, both human trading and natural forms of cooperation can entail completely anonymous interactions. For example on stock markets, at certain forms of auctions, and reproduction in which gametes are set free and meet randomly.

What needs to be done.
One of the major problems with past research on this issue has been the lack of integration between theory and empirical data. Theoretical models develop, multiply and are tested solely within the artificial world of computer simulations, rather than by real-world empirical observation and experimentation. A major goal of our program, therefore, is to generate a productive, collaborative dialogue between theoreticians and empirical researchers. A excellent example of this synergy can be seen in the work of Kummel (an ecologist) and Salant (an economist) on mycorrhiza (Kummel & Salant, 2005). Another goal is to develop normative models that more clearly distinguish between those behavioural strategies that are rational within the context of a particular interaction and those that represent deviations from such 'myopic rationality' and thus need further explication (e.g., considerations of phylogenetic inertia; reputation; long-lasting relationships; mechanistic constraints, bounded rationality)

2. The macro-evolution of cooperation and trading

In the above section we stressed the evolution of cooperation at the micro-level. In this section, we pose questions at a macro-evolutionarily time scale, namely: (1) What are the origins of the mechanisms used in present-day trading and cooperation? (2) Are these mechanisms inherited, and if so, by what means (genetic or learned)? (3) Can the evolution of cooperation be reproduced in the laboratory? Answering such questions will entail the further expansion of three scientific fields that have flourished only recently.
2.1. *The phylogeny of mechanisms of cooperation and trading.* In the field of evolutionary psychology it is often tacitly or explicitly assumed that the Pleistocene (1.8 – 0.01 mya) was the period in which most of 'typical' human behaviour evolved. However, as far as genetically inherited mechanisms are concerned, this is an odd assumption to make, considering that primate evolution alone stretches back over more than 80 million years. Many of the mechanisms involved in cooperation and trade are likely to be much older than either humans or the rest of the primates, and indeed much older than the vertebrates. Equally puzzling, given the speed of cultural evolution, is the assumption that any such mechanisms have remained essentially unchanged since Pleistocene. Thus, our aim here is to free phylogenetic considerations of human cooperative and trading behaviour from this ‘Pleistocentric’ approach.
2.2. *Heredity of mechanisms*. Tracing the phylogeny of a mechanism implicitly assumes that it can be inherited, either genetically or culturally (i.e, through learning). Recent developments in genetic methods in combination with careful observational and experimental work, should allow us to link individual behavioural variance to genetic variance and thereby pin-point genes that either influence cooperative behaviour per se, or are linked to particular learning mechanisms that are crucial for cooperation. Prior to this, it is necessary to establish whether the mechanisms involved are similar by analogy (i.e., independent, convergent evolution) or by homology (i.e. by common descent) using comparative phylogenetic methods. A further goal, which concerns mainly, but not exclusively, human behaviour is to disentangle cultural from genetic inheritance.
2.3. *Experimental evolution.* The evolution of some cooperative mechanisms can be tested in selection experiments using organisms with short generation times. An experimental approach may also enhance research in cultural evolution.

What needs to be done.
Phylogeny. After the key mechanisms have been identified (see below), we can attempt to reconstruct their phylogeny, both genetically and culturally. For behavioural strategies only, comparative methods using living organisms may be feasible but, for any form of cooperation

that leaves traces in the fossil record (e.g. seed transport mutualisms), a contribution from palaeontology may also be valuable. For further ideas on the construction of phylogenies on the basis of neurobiological methods, see below.

Heredity. One approach here is to correlate variation in cooperative behaviour with variation in the genome. Another is to concentrate on gene expression using biochip technology. This very recently developed technique is useful for establishing differences in gene expression among closely related organisms (e.g., differences in cooperative behaviour between members of clonal super-organisms and of eusocial insects) and in different sexes within the same species.

The mechanisms of cultural inheritance are likely to manifest themselves most clearly in fast-changing social environments. To give some examples of possible targets of research: (1) changes in reproductive cooperation in human societies which experience shifting sex ratios (see below), profound economic changes and/or changes in gender roles. (2) Changes in collective action rules in societies that are in transition from a system based on communal pastures and communal agriculture to individual land ownership (e.g. Mongolia; Eastern Europe).

Experimental evolution. Various micro-organisms offer ideal possibilities for artificial evolution (Rainey & Rainey, 2003; Velicer & Yu, 2003). Notably, these systems are excellent candidates for testing ideas about the evolution of 'collective action'. Inter-specific mutualisms between uni-cellular and multi-cellular partners (e.g. rhizobia – plants), or among multi-cellular organisms in which at least one party has short generation times (e.g. fungi & leafcutter ants) would be very well suited to test models in which partner choice (see below) plays a major role.

One way of experimentally inducing cultural evolution is by introducing cooperation 'memes', i.e. any form of culturally transferred cooperative strategy, into bounded societies. Internet-based social networks may be particularly well suited. Further possibilities include the passing on of strategies used in experimental games between 'generations' of players.

Experimental evolution can also be carried out with groups of robots that interact with each other in an environment under some selection pressure. In evolutionary robotics, the control systems, and even some physical properties of the robots, are described by 'genotypes'. Selection takes place because the reproductive fitness of the robots is coupled to their life-time performance (Nolfi & Floreano, 2001)..

3. Strategies of cooperation.

The mechanisms used in cooperation and trading can be examined at two different levels: (1) the actual strategies deployed and (2) the morphological, physiological and neurological mechanisms that are used to implement those strategies. The latter will be discussed under the next heading.

Strategies can be placed in the following broad, overlapping categories:

3.1. *Partner control*. These strategies are used in dyadic interactions to improve the net benefit received from the partner in the short or long run. They include refusals to cooperate, harassment and punishment. The most widely used theoretical paradigm is the Iterated Prisoner's Dilemma.

3.2. *Partner choice*. A variety of models consider the effects of partner choice. Partner control is but one goal that can be achieved by a (threat of) partner switching. Further effects include competition between potential partners and adjustments of exchange rates to shifts in the supply-demand ratio. The latter phenomena are described by the 'biological market' paradigm (Noë & Hammerstein, 1995).

3.3. *Honest (costly) signalling.* 'Costly' or 'honest' signalling during cooperative interactions and economic transactions has received considerable attention in biology and anthropology, as well as in economics.

3.4. *Reputation - standing*. One group of models specifically considers the influence of cooperative acts on uninvolved bystanders (Nowak & Sigmund, 1998; Leimar & Hammerstein, 2001). The fact that an act that is merely observed can influence the future behaviour of bystanders implies, in turn, that the threat of damage to the reputation of a partner can result in partner control.

3.5. *Fast and frugal heuristics*. Theoreticians working with the above classes of models deal mainly with functional fitness-based explanations, and do not consider the proximate cognitive and temporal demands of, and constraints on, such strategies. Other workers, however, specifically look

at which strategies are likely to be optimal given both the demands of the task and the constraints on time, cognitive abilities and memory (Gigerenzer & Todd, 2000).

3.6. *Mechanisms specific to collective action*. The problems surrounding 'collective action' and the management of 'public goods' have received ample attention within human society (Ostrom, 2001), but similar problems in non-human societies remain understudied.

What needs to be done.

For historical reasons, partner control has been considered as an isolated problem for far too long and has received a disproportionate amount of attention. This has resulted in a rather sterile edifice of theories that have only the most tenuous connection to empirical facts. Partner control remains an important theme, but needs to be integrated into models that encompass the full ranges of interactions. The most important development in the near future is the marriage between theory and empirical work on this front. Considerable progress can be expected when theoreticians and empiricists work together on a specific system (e.g. a cleaner symbiosis, mycorrhiza, cooperative hunting) and develop models through regular feedback. This, in turn, will enable the construction of more general models to generate hypotheses about forms of cooperation that have, to date, received little attention.

4. Mechanisms of cooperation.

Although we are far from identifying all the mechanisms relevant to cooperation and trading, enough is known to keep multiple projects busy. Two broad approaches can be taken:
(1) unravelling the neurological and endocrine basis of these mechanisms and (2) testing hypotheses about mechanisms by staging cooperation experiments.

4.1. *Neurological basis of cooperation.* "Neuroeconomics" is a fast growing field (Glimcher, 2003). One of the most exiting recent developments is the possibility to use recent technical developments (PET, fMRI) to monitor the brain activities of individuals involved in cooperation and trading.

4.1.1. Choice & preference. Choice and preference play a major role at different levels, notably through partner choice and the preference for different payoffs.

4.1.2. Emotions. Apart from 'wanting' and 'liking' several more emotions play a major role in cooperation, such as fear of deception, anger after being cheated, envy of a partner's payoff and jealousy of a partner's social relationships (Fessler & Haley, 2003).

4.2. *Hormonal basis of cooperation.* Some emotions, such as trust, have a hormonal as well as a neuronal basis (Zak et al., 2004). Hormone-driven emotions are more likely to play a role in long-lasting relationships and repeated interactions, while short and one-off interactions are more likely to be governed by neuronal processes.

4.3. *Cooperation experiments.* The above mentioned research into the mechanistic basis of cooperation implies placing individuals in experimentally controlled situations in which they have the option to cooperate while other functions are monitored simultaneously. In addition, cooperation experiments per se can contribute considerable insights into the mechanisms used. For example, one question of considerable theoretical importance is whether individuals communicate and whether they trust each others' signals (Noë, 2005a). Another is whether individuals placed in one-shot games really do act as though they will never interact with their partner again, given that, in daily life, their experiences are more akin to repeated games (Fehr & Henrich, 2003). Similarly, it is important to know whether individuals distinguish between anonymous partners and recognisable partners who are likely to keep their behaviour in memory, act upon this memory in the next interaction and/or spread word about their behaviour among other potential partners.

What needs to be done.

Neuroeconomics. This field can be developed further by encompassing the full spectrum of organisms that trade and cooperate, as long as they use neurons in the process. Comparative studies using fMRI and related techniques can be used to monitor the brain activity of members of different species involved in comparable cooperative tasks. This will allow tracing the phylogeny of neurological mechanisms (see also theme 2) and to increase our understanding of the effects of phylogenetic inertia on behaviour.

Endocrinoeconomics. This is one of the most underdeveloped fields in our program. One can imagine research into the hormonal basis of many more emotions that are relevant to cooperation than merely trust. Methodological improvements seem to be important in order to reduce the delay between the subject's actions and the measurements of hormone titres. Another option is to manipulate the hormone titres of subjects directly (Kosfeld et al., 2005).

Cooperation experiments. The great majority of experiments conducted to date do not include typical 'market' dynamics, such as a choice of partners, outbidding etc. The following activities would fit well in our program:

1. *Lab experiments with humans*. Micro-economics has gained important new insights thanks to relatively simple laboratory experiments (Fehr & Fischbacher, 2004). These experiments can be extended by introducing the above mentioned market dynamics.
2. *Field experiments with humans*. Carrying out the same simple experiments as above, but in different cultures and social settings, has been an important recent development in this area (Henrich et al., 2001). This comparative approach contributes to efforts to assess the relative impact of cultural and genetic evolution on these behaviours, and can be extended considerably to encompass many more aspects of cooperation and trading behaviour.
3. *Experiments with non-human vertebrates*. So far, cooperation experiments with non-human subjects have been limited to a small number of vertebrate species. In order to make a truly comparative approach a reality, more species need to be added. In addition, some non-vertebrate species may be included (e.g. octopus) to validate the generality of results.

5. Descriptive approaches.

Although methodological orthodoxy would prescribe a phase of observational and descriptive research before embarking on the development of theoretical models and the design of experiments, in practise these activities run in parallel, and sometimes in reverse: the relative ease with which models can be constructed and lab experiments can be organised, compared to time-consuming fieldwork, means that the simulation-based cart is often put before the empirical real-world horse. More effort to determine what happens in the real world is urgently needed, notably for comparative studies. We concentrate here on two topics that can be studied in both human and non-human societies: reproductive interactions and small markets.

5.1. *Interaction between reproductive and economic relationships.* Economic considerations obviously influence the formation of reproductive partnerships in many animal species, as well as in human societies, both traditional and modern. Many human reproductive relationships start with the transfer of dowry or bride wealth. 'Nuptial gifts' and 'courtship feeding' are also found throughout the animal kingdom. For human couples, the mixed reproductive-economic relationship continues after marriage (Grossbard-Shechtman, 1993), but the same is true for many animal species with bi-parental care.

Small markets and individual interactions. At present, one of the major discrepancies between economics on the one hand and the social sciences and biology on the other hand is the attention given to individual behaviour. Economists collect and analyse data at a very large scale, e.g. the economic output of nations, and mainly describe the behaviour of markets as a whole. The proposed program should therefore stimulate economic research in the direction of the observation, description and quantification of individual behaviour. This, in turn, would open up a large number of options to compare human and non-human behaviour, in the vein of biological market theory (Noë, 2001; Bshary & Noë, 2003), as well as a comparison of human economic behaviour in the different types of societies described above. A particularly intriguing topic in this respect is the evolution of social norms in different societies (Young, 2003) and the option to carry this question over to non-human societies as well.

What needs to be done.

Reproductive relationships. We suggest some topics that can be tackled in this area.

- *Criteria for partner choice*. In spite of a lot of work based on sexual selection theory in behavioural ecology and anthropology, one topic remains under-developed. The offering of nuptial gifts, *sensu lato,* implies that the partner's choice is influenced by the quantity or the

quality of the gift. This in turn means that the relationship between the size of the gift and the skew in the mating market can be quantified. An interesting question is what happens when the sex ratio between the partners ready to reproduce (know as Operational Sex Ratio or ORS) shifts considerably: do nuptial gifts shift in value with the market? Is there more inertia in systems with genetically inherited gift-giving strategies than in systems with culturally inherited strategies? This kind of approach is still rare, but has been shown to provide some intriguing and suggestive results (Pawlowski et al., 2000)

- *Revolutions.* A string of revolutions in recent human history make it necessary to study different groups of societies almost as if they belong to different species: before or after the agricultural revolution, before or after the industrial revolution, before or after widespread availability of contraception and so forth. One way of subdividing research into human mating markets is as follows.
  - *Historical populations.* Some have been so well documented (in church and tax registers, for example) that all the essential elements needed for an analysis of mating markets are available providing an opportunity to trace the evolution from the historical population (pre-industrial, pre-contraception) through to modern-day society. Have dowry and bride wealth norms changed and can this be explained in economic terms, evolutionary terms or both?
  - *Present day societies*. As well as 'vertical' comparisons of the same societies over time, one can also perform horizontal (cross-sectional) comparisons of present day societies ranging from hunter-gatherers to highly industrialised societies and sub-groups thereof.
  - *Shifting societies*. Some present day societies are in the process of rapid cultural change and provide what a biologist would call a 'natural experiment'. For example the 'one child' policy in China has caused a massive shift in the OSR due to a strong preference for sons.

Small markets and individual behaviour. We mention a number of possible forays one can make into the world of individual economic behaviour, with a preference for topics that provide opportunities for comparisons with non-human taxa (reviewed in (Noë, 2005b):

1. *Consumer behaviour.* Consumer behaviour is a prime candidate for a comparison between human and non-human agents. Insights into the strategies used in a natural context may provide insights into human choice behaviour and into strategies used under bounded rationality. Examples of natural equivalents abound (e.g. pollinators visiting flowers; ants 'milking' aphids).
2. *Employer – employee interactions.* Many elements of partner choice, be it in a reproductive or cooperative context, can be found in employer-employee interactions (aptly labelled 'mating markets' in economics). The comparison between this form of economic interaction on the one hand and reproductive and cooperative interactions among non-human individuals on the other hand represents an area ripe for a far-reaching comparative approach.
3. *Constrained rationality.* This is a very broad category that alludes to a relatively vague concept: the idea that present-day human economic behaviour is partially 'irrational' because it operates on the basis of strategies and mechanisms that were adapted to ancestral environments. The work on 'fast and frugal heuristics' (see above; (Gigerenzer & Todd, 2000) suggests that we should take a much closer look at whether such behaviour really is 'irrational'. After such a descriptive phase, we can then test for phylogenetic and cultural inertia if the behaviour in question continues to show signs of being irrational and potentially maladaptive in present day contexts (see section 2).

6. Biological model systems of human cooperation and trading

The last major goal of our program is to promote the development of biological systems that can be manipulated easily, either in the laboratory or in the field. These can then serve as model systems and alternatives to computer simulations. Working with agents that use strategies and mechanisms tested by natural selection reduces the risk that essential elements have been overlooked. A few specific attempts in this direction exist, notably tests of economic models (based on Ricardo's law) with plants and mycorrhizal fungi (Hoeksema & Bruna, 2000; Kummel & Salant, 2005).

What needs to be done.
This area needs to be developed almost from scratch, but we are fortunate in that we can rely on a considerable reservoir of knowledge of the candidate biological systems. The main challenge is to identify systems that share crucial elements with the markets for which they will serve as models (Bshary & Bronstein, 2005). We suggest a few options:

- Markets on which tangible goods are bartered or traded against common currencies can be compared to inter-specific mutualisms in which nutrients are traded against nutrients (e.g. mycorrhizal fungi and rhizobia trading with plants)
- Markets in which tangible goods are traded against services can be compared to biological systems in which nutrients are traded against protection (e.g. ants interacting with either plants or various other insect species) or against parasite removal (e.g. cleaning mutualisms).
- Collective action is probably best compared to the formation of fruit bodies in micro-organisms.

Coherence between the 6 themes

When dealing with phenomena as multifaceted and ubiquitous as cooperation and trading, it is inevitable that any attempt to demarcate and sub-divide areas of research will be somewhat arbitrary. In this respect, we may have stressed coherence within the themes represented by our programme at the expense of elucidating the links between them. We would therefore like to emphasise that we intend to build a highly integrated, web-like programme of research, in which the different disciplines interact in a synergistic manner, rather than a hierarchy of strictly subdivided activities. Limited space allows us to give only a few examples of the cross-connections between our major themes.

- *Cooperation by micro-organisms with fast generation times (bacteria, fungi etc.).* The development of such model systems can serve multiple purposes: (A) Testing of general theoretical models (theme 1) and the use of specific strategies (e.g. partner choice; theme 3) in a cooperation of theoreticians and empiricists; (B) Experimental evolution of novel forms of cooperation (theme 2); Developments of biological model systems for human markets (theme 6).
- *Reproductive behaviour as special form of dyadic cooperation.* Male-female couples that produce offspring together form an ideal example of dyadic cooperation in the context of a market (theme 1). The phylogeny of certain mechanisms; their genetic heredity (theme 2) and their neurological and hormonal basis (theme 4) can all be studied in the same species and human societies. Knowledge of the mechanisms underlying certain strategies used (e.g. partner choice; honest signalling; theme 3) can be used in a comparative study to separate analogies from homologies. Although data on reproduction and sexual selection are available for many species and many human societies, descriptive studies (theme 5) will still be necessary to provide additional data needed to complete the picture of investments and returns in reproductive relationships.
- *Collective action and the management of public goods.* Human subjects involved in collective action should have a strong inclination to reap short-term personal profit at a cost to the long-term collective interest. Nevertheless, laboratory experiments with humans show that they often do not do so, even in circumstances of anonymity, in which reputation plays no role, and in the absence of 'policing' (theme 3). The explication of such a phenomenon asks for a combined approach from many directions: neurobiological and endocrinological studies (theme 4) to elucidate underlying mechanisms, and comparative studies between human societies and between humans and non-human primates (theme 5) to separate effects of genetic and cultural selection (theme 2).

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Noë, R. 2001. Biological markets: partner choice as the driving force behind the evolution of cooperation. In: *In Noë, R.; van Hooff, J.A.R.A.M. & Hammerstein, P. (eds.) Economics in Nature. Social Dilemmas, Mate Choice and Biological Markets. Cambridge Univ. Press*.

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Pawlowski, B., Dunbar, R. I. M. & Lipowicz, A. 2000. Evolutionary fitness - Tall men have more reproductive success. *Nature*, **403,** 156.

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Richerson, P. J. & Boyd, R. 2005. *Not by Genes alone. How Culture Transformed Human Evolution.* Chicago: University of Chicago Press.

Velicer, G. J. & Yu, Y. N. 2003. Evolution of novel cooperative swarming in the bacterium Myxococcus xanthus. *Nature 425: 75-78*.

Young, H. P. 2003. The power of norms. In: *In: Hammerstein, P. (ed). Genetic and Cultural Evolution of Cooperation. MIT Press, Cambridge, Mass. pp. 389-399.*

Zak, P. J., Kurzban, R. & Matzner, W. T. 2004. The neurobiology of trust. In: *Biobehavioral Stress Response: Protective and Damaging Effects*, pp. 224-227.

Milestones

The bulk of the program will be executed by PhD candidates and post-doctoral researchers. Milestones to be reached for each individual project are therefore similar: publications for post-docs after 2 - 3 years and thesis, plus publications, after 4 years for PhD students. As a rule, recruitment and supervision of these young researchers will be shared by senior scientists belonging to at least two different disciplines. The cohesiveness of the network will also be guaranteed by:

(1) Two summer schools in which a number of senior scientists give lectures (recruited from the list of proposers, as well as people invited from inside and outside Europe). These will help newly recruited PhD-candidates to develop their projects. These summer schools should take place in the 1st and 3rd summer of the programme.

(2) Four conferences, one per year. At the first, heads of institutions should present their teams and their past work, as well as elaborate on their specific expertise to make others aware of options for collaboration and cooperation. The other 3 conferences will be used for the presentation of results of ongoing projects; the last of which will be geared towards the production of an edited volume.

Why this EUROCORES program?

A number of inter-disciplinary meetings have been organised over the last decade around themes related to those mentioned in this proposal. Such meetings certainly help to increase contacts between scientists and facilitate the formation of research collaborations: there are now several individual multi-disciplinary projects that are a testament to this organic development of research ideas. A dedicated EUROCORES-programme would boost this field enormously, however, because it would remove two barriers at once: (1) The barrier between disciplines. Inter-disciplinary grant proposals are often not well placed in competition with 'pure' grant applications in either discipline. (2) National barriers. Inter-disciplinary and inter-national often go hand in hand in this topic. It is not easy, however, to obtain grants simultaneously from two different national funding agencies. European science is certainly strong in some of the topics mentioned (e.g., experimental economics, work on bounded rationality), but is much less well represented in others (e.g., neuroeconomics and evolutionary anthropology). This can be partially corrected by a program that combines strong fields with less developed ones. Through our summer schools, conferences and by direct cooperation, we hope to secure the input from non-European frontrunners.

The program aims to focus on problems that manifest themselves in Europe on a daily basis: collective action and the management of public goods between states and between ethnic groups within states, marriage between individuals of different cultural background, cross-border economic cooperation by agents with different norms and cooperative strategies, and so forth. Europe not only offers the problems we wish to solve, but also many opportunities that will allow us to achieve this goal with our programme. Within the human populations of our continent there is an enormous genetic, but above all cultural diversity, which gives excellent opportunities for comparative studies.

Relationships with ongoing programs

Below we list a number of inter-disciplinary programmes in which some of the proposers are involved. However, none of these programs has the scope or comparative breadth of our proposed program of research.

- Robin Dunbar is a co-director of the British Academy Centenary Research project "Lucy to Language: Archaeology of the Social Brain" (2003–2010) http://www.liv.ac.uk/lucy2003/index.html.
- Noë & van Damme received a grant for the project "Economic behaviour in vervet monkeys" in the NWO programme for Interdisciplinary Research Projects "Evolution & Behaviour" (2003 – 2007). This very successful Dutch program, which will not be continued in this form, has been a model for the present proposal. http://www.nwo.nl/nwohome.nsf/pages/NWOP_5T8EXB
- Mace and Noë are both involved in multi-disciplinary grant proposals in the Cordis 6th Framework Programme (NEST – "What it means to be human"). If granted, these projects would have some areas of overlap with the present proposal.

Level of funding required

- We regard relatively small scale PhD and post-doctoral research projects as the backbone of this programme. We expect considerable movement of the candidates through our labs and institutions. This implies that travel and lodging costs will be higher than usual.
- A (4-year) PhD in many of our disciplines, which do not require expensive equipment or laboratory techniques, costs about € 200.000 in total (stipend plus basic support for research and travel). Three-year post-doctoral projects are estimated at € 240.000 on average.
- Some areas may require substantially more capital investment (e.g. fMRI; genetic analyses). In such cases we encourage cooperation with groups using those techniques and the application for additional grants, whereby the EUROCORES-grant can serve as a catalyst.
- We assume that the additional costs needed to run the network (congresses, summer schools, central administration) are carried by the ESF office in Strasbourg. The coordinating proposer can reach the ESF office on foot at no cost.
- On the basis of the above assumptions we estimate that a **funding volume of € 10 million** will allow us to start **40 research projects, each of which includes a stipend,** plus a number of

smaller grants to finance pilot studies, to allow the cooperation between existing projects in different countries and to bridge gaps in long-term projects.

Ethical and legal issues

We see no issues other than those routinely solved by the group of proposers in their ongoing research programs.

Appendices

(1) Present positions, research interests and publication list of proposers

(Contact details see proposer list)

Noë, Ronald *(coordinating proposer)* homepage MPG (English) - CEPE (français)

- Professor, Psychology, Université Louis Pasteur, Strasbourg, France.
- Research associate of the Centre d'Ecologie, Physiologie et Ethologie (CEPE-CNRS), Strasbourg.
- Senior lecturer, Faculty of Science, University of Basel, Switzerland.
- Fellow of the Applied Behavioural Ecology & Ecosystems Research Unit (ABEERU) of the Univerity of South-Africa, Pretoria.

Current research: Biological Markets: a theory of cooperation, mutualism and sexual selection. Social cognition and economic behaviour in non-human vertebrates. Behavioural ecology of primates.

1. **Noë, R.** (*2005 –in press)* Cooperation experiments: coordination through communication versus acting apart together. Animal Behaviour *(Invited review).*
2. **Noë, R.** The biological roots of trading. (*2005 – in press*) In: Kappeler, P. M. & van Schaik C. P. (eds.) Cooperation in Primates and Humans: Evolution and Mechanisms.
3. Bshary, R. & **Noë, R.**, 2003. Biological markets: the ubiquitous influence of partner choice on cooperation and mutualism. In: Hammerstein, P. (ed.) 'Genetic and Cultural Evolution of Cooperation, Berlin 23 – 28 juin 2002 Dahlem Konferenzen, Berlin – MIT Press pp. 167-184.
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5. **Noë, R.** & Bshary R., 1997, The formation of red colobus - diana monkey associations under predation pressure from chimpanzees. Proc. R. Soc. B. 264: 253-251.
6. **Noë, R**. & Hammerstein, P., 1995, Biological markets. Trends Ecol. Evol. 10: 336-339.
7. **Noë, R.** & Hammerstein, P., 1994, Biological markets: supply and demand determine the effect of partner choice in cooperation, mutualism and mating. Behav. Ecol. Sociobiol. 35: 1-11.
8. **Noë, R.**, 1992, Alliance formation among male baboons: shopping for profitable partners. In: Coalitions and alliances in humans and other animals., A. H. Harcourt and F. B. M. de Waal (eds), Oxford Univ. Press.
9. **Noë, R.**, van Schaik, C. P. & van Hooff, J. A. R. A. M., 1991, The market effect: an explanation for pay-off asymmetries among collaborating animals. Ethology 87: 97-118.
10. **Noë, R.**, 1990, A Veto game played by baboons: a challenge to the use of the Prisoner's Dilemma as a paradigm for reciprocity and cooperation., Anim. Behav. 39:78-90.

Barrett, Louise *(homepage) (De Hoop Baboon Project)*

- Senior Lecturer; School of Biological Sciences, University of Liverpool, UK
- Leverhulme Research Fellow (2004-2005)
- Fellow of the Applied Behavioural Ecology & Ecosystems Research Unit (ABEERU) of the Univerity of South-Africa, Pretoria.

Current research: Neurological bases of social interaction; cooperation and negotiation of interactions in bounded groups (dynamic biological markets); cognitive constraints and the evolution and development of social functioning.

1. **Barrett, L.** & Henzi, S.P. (in press) The social nature of primate cognition. *Proc. Roy. Soc. Lond. B.*
2. **Barrett, L.** & Henzi, S.P. (in press) Monkeys, markets and minds. In: P. Kappeler & van Schaik, C.P. (ed.) *Cooperation in Primates and Humans: Mechanisms and Evolution.* Springer-Verlag.

3. Henzi, S. P. **L. Barrett, D**. Gaynor, J. Greeff, T. Weingrill and R.A. Hill (2003). The effect of resource competition on the long-term allocation of grooming by female baboons: evaluating Seyfarth's model. *Anim. Behav*. 66: 931-938.
4. **Barrett, L.** Henzi, S.P. & Dunbar, R.I.M. (2003) Primate cognition: from 'what now?' to 'what if? *Trends in Cognitive Sciences* 7: 494-497.
5. Henzi, S. P. and **L. Barrett** (2002). Infants as a commodity in a baboon market. Anim. Behav. 63: 915-921.
6. **Barrett, L.**, Gaynor, D. & Henzi, S.P. (2002) A dynamic interaction between aggression and grooming among female chacma baboons. *Anim. Behav*. 63: 1047-1053.
7. **Barrett, L.**, R.I.M. Dunbar & J.E. Lycett (2001) *Human Evolutionary Psychology*, Princeton University Press, New Jersey.
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Bshary, Redouan *(homepage)* *(information en français)*

- Professor, Zoology, Université Neuchâtel, Switzerland
- Niko Tinbergen price of the Ethological Society (2002)

Current research: Cleaning mutualism between cleaner fish and clients. Theory of cooperation and mutualism.

1. **Bshary R** (2001) The cleaner fish market. *In: "Economics in Nature"* (Noë R, Van Hooff JARAM & Hammerstein P, *eds*), *pp*146-172. Cambridge: Cambridge University Press
2. **Bshary R** (2002) Biting cleaner fish use altruism to deceive image-scoring client reef fish. *Proceedings of the Royal Society of London Series B-Biological Sciences* **269**, 2087-2093.
3. **Bshary R** & Bronstein JL (2004) Game structures in mutualisms: what can the evidence tell us about the kinds of models we need? *Advances in the Study of Behavior* **34**, 59-104.
4. **Bshary R** & Grutter AS (2002a) Experimental evidence that partner choice is a driving force in the payoff distribution among cooperators or mutualists: the cleaner fish case. *Ecology Letters* 5, 130-136
5. **Bshary R** & Grutter AS (2002b) Asymmetric cheating opportunities and partner control in a cleaner fish mutualism. *Animal Behaviour* 63, 547-555
6. **Bshary R** & Noë R (2003) Biological markets - The ubiquitous influence of partner choice on the dynamics of cleaner fish - Client reef fish interactions. In: *Genetic and Cultural Evolution of Cooperation* (Ed. by P. Hammerstein), pp. 167-184. Cambridge; London, MIT Press.
7. **Bshary R** & Schäffer D (2002) Choosy reef fish select cleaner fish that provide high service quality. *Animal Behaviour* 63, 557-564
8. Grutter AS & **Bshary R** (2003) Cleaner wrasse prefer client mucus: support for partner control mechanisms in cleaning interactions. *Proceedings of the Royal Society of London Series B-Biological Sciences* **270**, 242-244.
9. Johnstone RA & **Bshary R** (2002) From parasitism to mutualism: partner control in asymmetric interactions. *Ecology Letters* **5**, 634-639.
10. Johnstone RA & **Bshary R** (2004) Evolution of spite through indirect reciprocity. *Proceedings of the Royal Society of London*, Series B **271**, 1917-1922

Clutton-Brock, Timothy H. *(homepage)*

- Professor of Animal Ecology, University of Cambridge, UK
- Fellow of the Royal Society
- Extraordinary Professor, Mammal Research Institute, University of Pretoria, South Africa
- Recent awards: Frink Medal, Zoological Society of London (1998), Marsh Award, British Ecological Society (1998), William Bate Hardy Prize of the Cambridge Philosophical Society (1999), Honorary Fellowship, Faculty of Science and Engineering, University of Edinburgh (2001)
- 'Highly cited' researcher according to the ISI 'Web-of-Science'

Current research: The evolution of vertebrate breeding systems. Population regulation and the control of population stability in large mammals. Natural and sexual selection in natural populations of mammals.

1. **Clutton-Brock, T.H.**, Brotherton, P.N.M., O'Riain, M.J., Griffin, A.S., Gaynor, D., Sharpe, L., Kansky, R., Manser, M. & McIlrath, G.M. 2000. Individual contributions to babysitting in a cooperative mongoose, Suricata suricatta. Proc. R. Soc. B. 267: 301-305.
2. **Clutton-Brock, T.H.**, Brotherton, P.N.M., Russell, A.F., O'Riain, M.J., Gaynor, D., Kansky, R., Griffin, A., Manser, M., Sharpe, L., McIlrath, G.M., Small, T., Moss, A. & Monfort, S. 2001b. Cooperation, conflict and concession in meerkat groups. Science 291: 478-481.
3. **Clutton-Brock, T.H.**, Russell, A.F., Brotherton, P.N.M., Sharpe, L., McIlrath, G.M., White, S. & Cameron, E.Z. 2001c. Effects of helpers on juvenile development and survival in meerkats. Science 293: 2446-2449.
4. **Clutton-Brock, T.H.**, Russell, A.F., Sharpe, L.L., Young, A.J., Balmforth, Z. and McIlrath, G.M. 2002. Evolution and development of sex differences in cooperative behavior in meerkats. Science 297: 253-256.
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6. **Clutton-Brock, T.H.**, Russell, A.F. & Sharpe, L.L. 2004. Behavioural tactics of breeders in cooperative meerkats. Animal Behaviour 68: 1029-1040.
7. Carlson, A.A., Young, A.J., Russell, A.F., Bennett, N.C., McNeilly, A.S. & **Clutton-Brock, T H.** 2004. Hormonal correlates of dominance in meerkats (Suricata suricatta). Hormones and Behavior 46: 141-150.
8. Stephens, P.A., Russell, A.F., Young, A.J., Sutherland, W.J. & **Clutton-Brock, T.H.** (2005) Dispersal, eviction and conflict in meerkats (Suricata suricatta): An evolutionarily stable strategy model. American Naturalist 165: 120-135.
9. Russell AF, Brotherton PNM, McIlrath GM, Sharpe LL, **Clutton-Brock TH** (2003) Breeding success in cooperative meerkats: effects of helper number and maternal state. Behavioral Ecology 14, 486-492
10. Russell AF, Sharpe LL, Brotherton PNM, **Clutton-Brock TH** (2003) Cost minimization by helpers in cooperative vertebrates. Proc. Nat. Acad. Sci. 100, 3333-3338.

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van Damme, Eric *(homepage)*

- Research professor of Economics, CentER for Economic Research, Tilburg University
- Director, TILEC (Tilburg Law and Economics Center), Tilburg University

Current research: Game Theory, Economic Theory, Competition Policy and Regulation, Experimental Economics, Bounded rationality, Bargaining, Auctions, Industrial Organization, Network Industries

1. Guth, W., Ritzberger, K. & **van Damme, E.** 2004. On the Nash Bargaining Solution with Noise. *European Economic Review*, **48,** 697-713.
2. **van Damme, E.** & Hurkens, S. 2004. Endogenous Price Leadership. *Games and Economic Behavior*, **47,** 404-20.
3. **van Damme, E.** & Weibull, J. W. 2002. Evolution in games with endogenous mistake probabilities. *J. Economic Theory*, **106,** 296-315.
4. Bhaskar, V. & **van Damme, E.** 2002. Moral hazard and private monitoring. *J. Economic Theory*, **102,** 16-39.
5. **van Damme, E.** 2002. Strategic Equilibrium. *Handbook of game theory with economic applications*, **3,** 1521-96.
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7. **van Damme, E.** 1999. Game Theory: The Next Stage. *Economics beyond the millennium***,** 184-214.
8. Guth, W. & **van Damme, E.** 1998. Information, strategic behavior, and fairness in ultimatum bargaining: An experimental study. *Journal of Mathematical Psychology*, **42,** 227-247.
9. **Van Damme, E.** & Hurkens, S. 1997. Games with imperfectly observable commitment. *Games and Econ. Behav.*, **21,** 282-308.
10. **van Damme, E.** 1997. Equilibrium Selection in Team Games. *Understanding strategic interaction: Essays in honor of Reinhard Selten***,** 100-110.

Dunbar, Robin *(homepage)*

- Professor of Evolutionary Psychology, School of Biological Sciences, University of Liverpool
- British Academy Research Professor (1993-1996); co-Director of the British Academy Centenary Research Project ("Lucy to Language: The Archaeology of the Social Brain")
- Fellow of the British Academy (elected 1998); Fellow of Royal Anthropological Institute (elected 1990); Academician of Academy of Social Sciences (elected 2002).

Current research: Evolution of group-living in primates and ungulates. Mate choice strategies in humans. Structure and dynamics of human social networks. Cognitive and neurobiological bases of cooperative and prosocial behaviour.

1. **Dunbar, R.** (1992). Neocortex size as a constraint on group size in primates. *J. human Evol*. 22: 469-493.
2. **Dunbar, R.** (1993). Coevolution of neocortex size, group size and language in humans. *Behav. Brain Sci*. 16: 681-735.
3. **Dunbar, R.** (1995). The mating system of Callitrichid primates. I. Conditions for the coevolution of pairbonding and twinning. *Anim. Behav.* 50, 1995, 1057-1070.

4. **Dunbar, R.** (1998). The social brain hypothesis. *Evol.Anthrop.* 6: 178-190.
5. Pawlowski, B. & **Dunbar, R.** (1999). Impact of market value on human mate choice decisions. *Proc. R.Soc., Lond.,* B, 266: 281-285.
6. Pawlowski, B., **Dunbar, R.** & Lipowicz, A. (2000). Tall men have more reproductive success. *Nature* 403: 156.
7. Kudo, H. & **Dunbar, R.** (2001). Neocortex size and social network size in primates. *Anim. Behav.* 62: 711-722.
8. Barrett, L., Henzi, P. & **Dunbar, R.** (2003). Primate cognition: from "what now?" to "what if?" *Trends Cogn. Sci*. 7: 494-497.
9. **Dunbar, R**. (2003). The social brain: mind, language and society in evolutionary perspective. *Ann. Rev. Anthrop.* 32: 163-181.
10. Zhou, W-X., Sornette, D., Hill, R.A. & **Dunbar, R.** (2005). Discrete hierarchical organization of social group sizes. *Proc. R. Soc. Lond.* 272B: 439-444.

Fehr, Ernst *(homepage)*

- Professor, Labour Economics and Social Policy, Faculty of Economics at the University of Zürich.
- Director of the Ludwig Boltzmann Institute for Research in Economic Growth, Vienna.
- Core Member of the Research Initiative of the MacArthur Foundation (Chicago) on "Evolution of Preferences and Social Norms".
- Awards: Honorary Doctorate from the University of St. Gallen (2004); Cogito Prize (2004).

Current research: Evolution of human cooperation and sociality; psychological foundations of incentives; fairness and reciprocity; behavioural labour economics; bounded rationality and strategic interaction; impatience and intertemporal choice

1. Kosfeld, M., Heinrichs, M., Zak, P. J., Fischbacher, U. & **Fehr, E.** 2005. Oxytocin increases trust in humans. Nature 435, 673-676.
2. **Fehr, E.** 2004. Don't lose your reputation. Nature 432: 449-450.
3. **Fehr, E.** & Fischbacher, U. 2004. Third-party punishment and social norms. Evolution and Human Behavior 25 (2): 63-87.
4. de Quervain, D. J.-F., Fischbacher, U. , Treyer, V., Melanie Schellhammer, M. , Schnyder, U., Buck, A. & **Fehr, E.** 2004. The neural basis of altruistic punishment. Science 305: 1254-1258.
5. Henrich, J.; Boyd, R.; Bowles, S.; Camerer, C.; **Fehr, E.**; Gintis, H. 2004. Foundations of Human Sociality. Economic Experiments and Ethnographic Evidence from Fifteen Small-Scale Societies. Oxford UP
6. **Fehr, E.** & Fischbacher, U. 2004. Social norms and human cooperation. TrendsCogn. Sci., 8, 185-190.
7. **Fehr, E.** & Rockenbach, B. 2003. Detrimental effects of sanctions on human altruism. Nature 422, 137 - 140.
8. **Fehr, E.** & Fischbacher, U. 2003. The nature of human altruism. Nature 425: 785-791.
9. **Fehr, E.** & Henrich, J. 2003. Is strong reciprocity a maladaptation? On the evolutionary foundations of human altruism. In: Hammerstein, P. (ed). Genetic and Cultural Evolution of Cooperation. MIT Press.
10. **Fehr, E.** & Gächer, S. 2002. Altruistic punishment in humans. Nature 415: 137 - 140.

Floreano, Dario *(homepage)*

- Professor, Intelligent Systems, Swiss Federal Institute of Technology, Lausanne (EPFL)
- Director of the Institute of Systems Engineering and of the Center for Electronic Circuits.
- Project "Swarmbots" listed as 'success story' of the European Commission (2005)

Current research: embodied cognitive science, evolutionary robotics, bio-mimetic electronics, neural computation, self-organizing systems, and biology reverse engineering.

1. **Floreano, D.**, Epars, Y., Zufferey, J.C. and Mattiussi, C. (2005) Evolution of Spiking Neural Circuits in Autonomous Mobile Robots. International Journal of Intelligent Systems. In press.
2. Suzuki, M., **Floreano, D.** and Di Paolo, E.A. (2005) The Contribution of Active Body Movement to Visual Development in Evolutionary Robots. Neural Networks. In press.
3. **Floreano, D.**, Suzuki, M. and Mattiussi, C. (2005) Active Vision and Receptive Field Development in Evolutionary Robots. Evolutionary Computation. In press.
4. **Floreano, D.**, Zufferey, J.C. and Nicoud, J.D. (2005) From Wheels to Wings with Evolutionary Spiking Neurons. Artificial Life, vol. 11(1-2), pp. 121-138.
5. Mattiussi, C., Waibel, M. and **Floreano, D.** (2004) Measures of Diversity for Populations and Distances Between Individuals with Highly Reorganizable Genomes. Evolutionary Computation 12 (4): 495-515.
6. Mondada, F., Gambardella, L.M., **Floreano, D.** and Dorigo, M. (2004) SWARM-BOTS: Physical Interactions in Collective Robotics. Robotics & Automation Magazine.
7. **Floreano, D.**, Kato, T., Marocco, D. and Sauser, E. (2004) Coevolution of active vision and feature selection. Biological Cybernetics, 90(3), 218-228.

8. Mondada, F., Pettinaro, G. C., Guignard, A., Kwee, I., **Floreano, D.**, Deneubourg, J.-L., Nolfi, S. and et al. (2004) SWARM-BOT: a New Distributed Robotic Concept. Autonomous Robots, 17 (2-3), 193 - 221.
9. Nolfi, S. and **Floreano, D.** (2002) Neural Synthesis of Artificial Organisms through Evolution. Trends in Cognitive Science, 6, 31-37.
10. Nolfi, S. and **Floreano, D.** (2000) Evolutionary Robotics. The Biology, Intelligence, and Technology of Self-organizing Machines. Cambridge, MA: MIT Press.

Hammerstein, Peter *(ITB) (Sonderforschungsbereich)*

- Professor, Institute for Theoretical Biology, Humboldt University, Berlin, Germany
- Chair of Berlin's Collaborative Research Center for Theoretical Biology *(Sonderforschungsbereich Theoretische Biologie)*
- Founding editor *Biological Theory* (MIT Press)

Current research: application of game theory in economics, evolutionary biology, genetics, immunology and human sociality; conflict and cooperation within and among organisms

1. **Hammerstein, P.** & Hagen, E.H. (2005). Evolutionary economics in biology: The second wave. *Trends Ecol. Evol.*
2. **Hammerstein, P.** (2005). Strategic analysis in evolutionary genetics and the theory of games. *J. Genetics*, 84, 7-12.
3. **Hammerstein, P.**, ed. (2003). *Genetic and Cultural Evolution of Cooperation*. Cambridge, MA: The MIT Press.
4. **Hammerstein, P.** & Leimar, O. (2002). Ants on a Turing trail. *Nature*, 418, 141-142.
5. Leimar, O. & **Hammerstein, P.** (2001). Evolution of cooperation through indirect reciprocity. *Proc. R. Soc. B.*, 268, 745-753.
6. Noë, R., van Hooff, J.A.R.A.M. & **Hammerstein, P.**, eds. (2001). *Economics in Nature*. Cambridge UP, 269 pp.
7. **Hammerstein, P.** (1996). Streetcar theory and long-term evolution. *Science*, 273, 1032.
8. **Hammerstein, P.** (1995). Evolutionary biology: A twofold tragedy unfolds. *Nature,* 377, 478.
9. Noë, R. & **Hammerstein, P.** (1995). Biological markets. *Trends in Ecology and Evolution*, 10, 336-339.
10. **Hammerstein, P.** & Selten, R. (1994). Game theory and evolutionary biology. In *Handbook of Game Theory with Economic Applications, Vol.2*, eds. R.J. Aumann & S. Hart, pp. 929-993. Amsterdam: Elsevier.

Henzi, Peter (Stephanus Petrus) *(homepage) (De Hoop Baboon Project)*

- Research Professor; Department of Psychology, University of Central Lancashire, Preston, UK
- Director De Hoop Baboon Project, South-Africa
- Fellow of the Applied Behavioural Ecology & Ecosystems Research Unit (ABEERU) of the Univerity of South-Africa, Pretoria.

Current research: Cooperation and negotiation of interactions in bounded groups (dynamic biological markets); cognitive constraints and the evolution and development of social functioning.

1. S.P. Henzi, J.E. Lycett and S. Piper (1997). Fission and troop size in a mountain baboon population. **Animal Behaviour** 53: 525-535.
2. S.P. Henzi, J.E. Lycett and A. Weingrill (1997). Cohort size and the allocation of social effort by female mountain baboons. **Animal Behaviour** 54: 1235-1243.
3. S.P. Henzi, J.E. Lycett and A. Weingrill (1998). Mate guarding and risk assessment by male mountain baboons during inter-troop encounters. **Animal Behaviour** 55:1421-1428.
4. S.P. Henzi, J.E. Lycett, A. Weingrill and S.E. Piper (2000). Social bonds and the coherence of mountain baboon troops. **Behaviour** 137: 663-681.
5. S.P. Henzi and L. Barrett (2002). Infants as a commodity in a baboon market. **Animal Behaviour** 63: 915-921.
6. H. Payne, M. Lawes and S.P. Henzi (2003). Competition and the exchange of grooming among female samango monkeys (*Cercopithecus mitis*). **Behaviour** 140: 453-471.
7. S.P. Henzi, L. Barrett, D. Gaynor, J. Greeff, T. Weingrill and R.A. Hill (2003). The effect of resource competition on the long-term allocation of grooming by female baboons: evaluating Seyfarth's model. **Animal Behaviour** 66: 931-938.
8. S.P. Henzi and L. Barrett (2003). Evolutionary ecology, sexual conflict and behavioral differentiation among baboon populations. **Evolutionary Anthropology** 12: 217-230.
9. Barrett, L. & **Henzi, S.P.** (in press) The social nature of primate cognition. *Proc. Royal Society, London, Series B*.
10. Barrett, L. & **Henzi, S.P.** (in press) Monkeys, markets and minds. In: P. Kappeler & van Schaik, C.P. (ed.) *Cooperation in Primates and Humans: Mechanisms and Evolution.* Springer-Verlag.

Keller, Laurent *(homepage)*

- Professor, Evolutionary Ecology, University of Lausanne, Switzerland
- Head of the Department of Ecology and Evolution, University of Lausanne

- Awards: E. O. Wilson Naturalist Award (2005); Ernest Dubois Prize (2005); National Latsis Prize (Swiss NSF; 2000)

Current research: Evolutionary genetics and ecology of social life: Ageing in social insects; Experimental tests of kin selection; Genetic, ecological and molecular bases for variation in social systems; Causes and consequences of genetic caste determination

1. Fournier, D., Estoup, A., Orivel, J., Foucaud, J., Jourdan, H., Le Breton, J. & **Keller, L.** In press. Clonal reproduction by males and females in the little fire ant. ***Nature***.
2. Langer, P., Hogendoorn, K. & **Keller, L.** 2004. Tug-of-war over reproduction in a social bee. ***Nature***, 428, 844-847.
3. Pearcy, M., Aron, S., Doums, C. & **Keller, L.** 2004. Conditional use of sex and parthenogenesis for workers and queen production in ants. ***Scienc***e, 306, 1780-1783.
4. Helms Cahan, S & **Keller, L.** 2003. Complex hybrid origin of genetic caste determination in harvester ants. ***Nature***, 424, 306-309.
5. Passera, L., Aron, S., Vargo, E. L. & **Keller, L.** 2001. Queen control of sex ratio in fire ants. ***Science***, 293, 1308-1310.
6. Krieger, M. J. B., Billeter, J.-B., **Keller, L.** 2000. Ant-like task allocation and recruitment in co-operative robots. ***Nature***, 406, 992-995.
7. **Keller, L.** & Ross, K. G. 1998. Selfish genes: a green beard in the red fire ant. ***Nature***, 394, 573-575.
8. **Keller, L.** & Genoud, M. 1997. Extraordinary lifespans in ants: a test of evolutionary theories of ageing. ***Nature***, 389, 958-960.
9. Passera, L., Roncin, E., Kaufmann, B. & **Keller, L.** 1996. Increased soldier production in ant colonies exposed to intraspecific competition. ***Nature***, 379, 630-631.
10. Sundström, L., Chapuisat, M. & **Keller, L.** 1996. Manipulation of sex ratios by ant workers: A test of kin selection theory. ***Science***, 274, 993-995.

Knorr Cetina, Karin *(homepage)*

- Professor of Sociology at the University of Constance (DE)
- Visiting Professor at the University of Chicago
- Member of the Institute for World-Society Studies, University of Bielefeld, Germany
- Member of the Institute for Advanced Study, Princeton, USA
- President of the International Society for Social Studies of Science

Current research: Trading and financial market cultures in the largest global markets (foreign exchange markets), trading of information, opportunism and trust in financial markets, trading and communication, social aspects of financial markets

1. **Knorr Cetina, K.**; Preda, Alex (Hrsg.): (2005): The Sociology of Financial Markets. Oxford: Oxford UP.
2. **Knorr Cetina, K.** (2005): Complex Global Microstructures: The New Terrorist Societies. Theory, Culture and Society, Special Issue on Complexity (John Urry, ed.), (in print).
3. **Knorr Cetina, K.** (2003): From Pipes to Scopes: The Flow Architecture of Financial Markets. Distinktion. Scandinavian Journal of Social Theory 7: 7-23.
4. **Knorr Cetina, K.**; Bruegger, Urs (2002a): Global Microstructures: The Virtual Societies of Financial Markets. American Journal of Sociology 107: 905-950.
5. **Knorr Cetina, K.**; Bruegger, Urs (2002b): Traders' Engagement with Markets: A Postsocial Relationship. Theory, Culture and Society 19:161-185.
6. **Knorr Cetina, K.**; Bruegger, Urs (2002c): Inhabiting Technology: Features of a Global Lifeform. Current Sociology 50: 389-405.
7. **Knorr Cetina, K.**; Bruegger, Urs (2001): Transparency Regimes and Management by Content in Global Organizations. The Case of Institutional Currency Trading. Journal of Knowledge Management 5:180-194.
8. **Knorr Cetina, K.**; Preda, Alex (2001): The Creation and Incorporation of Knowledge in Economic Activities. Current Sociology 49:27-44.
9. **Knorr Cetina, K.**; Bruegger, Urs (2000): The Market as an Object of Attachment: Exploring Postsocial Relations in Financial Markets." Canadian Journal of Sociology 25/2:141-168.
10. **Knorr Cetina, K.** (1999): Epistemic Cultures. How the Sciences Make Knowledge. Cambridge: Harvard University Press (3rd edition 2003).

Leimar, Olof *(homepage)*

- Professor, Zoology, Stockholm University, Sweden

Current research: Evolutionary game theory applied to phenotypic polymorphism, animal fighting behaviour, cooperation and mutualism. Adaptive dynamics theory. Life history theory. Population genetics. Experimental study of animal behaviour and life history.

1. **Leimar, O.** 2005. The evolution of phenotypic polymorphism: randomized strategies versus evolutionary branching. American Naturalist 165: 669-681.
2. **Leimar, O.** and Connor, R. C. 2003. By-product benefits, reciprocity and pseudoreciprocity in mutualism. In: P. Hammerstein (ed). Genetic and cultural evolution of cooperation, pp. 203-222. MIT Press.
3. **Leimar, O.** and Hammerstein, P. 2001. Evolution of cooperation through indirect reciprocity. Proceedings of the Royal Society of London B 268: 745-753.
4. Wiklund, C., Karlsson, B. and **Leimar, O.** 2001. Sexual conflict and cooperation in butterfly reproduction - a comparative study on polyandry and female fitness. Proceedings of the Royal Society of London B 268: 1661-1667.
5. **Leimar, O.** and Tuomi, J. 1998. Synergistic selection and graded traits. Evolutionary Ecology 12: 59-71.
6. **Leimar, O.** 1997. Reciprocity and communication of partner quality. Proceedings of the Royal Society of London B 264: 1209-1215.
7. **Leimar, O.** 1997. Repeated games: a state space approach. Journal of Theoretical Biology 184: 471-498.
8. Axén, A. H., **Leimar, O.** and Hoffman, V. 1996. Signalling in a mutualistic interaction. Animal Behaviour 52: 321-333.
9. **Leimar, O.** and Axén, A. H. 1993. Strategic behaviour in an interspecific mutualism: interactions between lycaenid larvae and ants. Animal Behaviour 46: 1177-1182.
10. Enquist, M. and **Leimar, O.** 1993. The evolution of cooperation in mobile organisms. Animal Behaviour 45: 747-757.

Mace, Ruth *(homepage)*

- Professor of Evolutionary Anthropology, University College London (since 2004)
- Reader, Lecturer and Royal Society Research Fellow, Anthropology, UCL (1994-2003)
- Founding member Centre for the Evolutionary Analysis of Cultural Behaviour, at UCL

Current research: Evolutionary ecology of human life history and reproductive behaviour, including marriage and fertility strategies; Phylogenetic approaches to cultural and bio-cultural evolution.

1. **Mace R**, Holden C. & S. Shennan. (Eds) (2005) The evolution of cultural diversity: a phylogenetic approach. UCL Press. 291pp
2. Pagel M. & **R. Mace** (2004) The cultural wealth of nations. New and Views Feature. Nature **428**:275-278
3. **Mace R.** & C. Holden (2005) A phylogenetic approach to cultural evolution. Trends Ecol. Evol.
4. Holden C & **R. Mace** (2003) Spread of cattle led to the loss of matrilineal descent in Africa: a co-evolutionary analysis. Proceedings of the Royal Society B. 270 (1532): 2425-2433
5. Gibson M & **R. Mace** (2002) The impact of a labor-saving technology on first birth intervals in rural Ethiopia. Human Biology **74**:111-128
6. Sear R, **Mace R.** & I.A.McGregor (2000) Maternal grandmothers improve nutritional status and survival among children in rural Gambia. Proc. Roy. Soc. B **267**:1641-1647
7. **Mace R.** (2000) Fair game. News & Views. Nature **406**:248-249
8. **Mace R**. (1998) The co-evolution of human fertility and wealth inheritance strategies. Phil. Trans. Roy. Soc. B. **353**:389-397
9. **Mace R.** & Pagel M. (1994) The comparative method in anthropology. Current Anthropology **35**:549-564
10. Fortunato, L., Holden C. & **R. Mace** (2005) On the origin of dowry: a phylogenetic approach. Human Nature.

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de Oliveira, Rui (Filipe Nunes Pais) *(institute's homepage)*

- Associate Professor ("Agregação"), Instituto Superior de Psicologia Aplicada (ISPA)

Current research: Physiological aspects of animal behaviour; endocrinology; animal welfare; comparative neurosciences

1. **R.F. Oliveira**, A.F.H. Ros & D.M. Gonçalves. Intra-sexual variation in reproduction in male teleost fish: a comparative approach. Horm. Behav., In Press.
2. K. Hirschenhauser & **R.F. Oliveira**. Social modulation of androgen levels in vertebrates: a meta-analysis. Anim. Behav., In Press.
3. **R.F. Oliveira**. (2005) hormones, social context and animal communication. In: P.K. Mcgregor (Ed), Animal Communication Networks, Pp. 481-520. Cambridge University Press.
4. **R.F. Oliveira**. (2004) Social modulation of androgens in vertebrates: mechanisms and function. In: P.J.B. Slater, J.S. Rosenblatt, C.T. Snowdon & T.J. Roper (Eds), Advances In The Study Of Behaviour - Vol. 34, Pp. 165-239. Academic Press, New York.

5. **R.F. Oliveira**, K. Hirschenhauser, A.V.M. Canario & M. Taborsky. (2003) Androgen levels of reproductive competitors in a cooperatively breeding cichlid. J. Fish Biology 63: 1615-1620.
6. K. Hirschenhauser, H. Winkler & **R.F. Oliveira**. (2003) Comparative analysis of male androgen responsiveness to social environment in birds: the effects of mating system and paternal incubation. Hormones And Behavior 43: 508-519.
7. **R.F. Oliveira**, K. Hirschenhauser, L.A. Carneiro, A.V.M. Canário. (2002) Social modulation of androgen levels in teleost fish. Comp. Biochem. Physiol. B 132: 203-215.
8. C. Doutrelant, P.K. Mcgregor & **R.F. Oliveira**. (2001) The sex of an audience affects intra-sexual male communication in fighting fish, Betta Splendens. Behav. Ecol. 12: 283-286.
9. **R.F. Oliveira**, L.A. Carneiro, A.V.M. Canário & M.S. Grober. (2001) Effects of androgens on social behaviour and morphology of alternative reproductive males of the azorean rock-pool blenny. Horm. Behav. 39: 157-166.
10. **R.F. Oliveira**, M. Lopes, L.A. Carneiro & A.V.M. Canário. (2001) Watching fights raises fish hormone levels. Nature 409: 475.

Pawlowski, Boguslaw *(homepage)*

- Professor; Department of Anthropology, University of Wroclaw, Wroclaw, Poland

Current research: Human mate market. Sexual dimorphism in size in humans and mate preferences. Steroid hormones and women preferences.

1. **Pawłowski B.** (2001) - The evolution of gluteal/femoral fat deposits and balance during pregnancy in bipedal Homo, Current Anthropology, 42: 572-574.
2. **Pawłowski B.**, Kozieł S. (2002) - The impact of traits offered in personal advertisements on response rates, Evol. Hum. Behav. 23:139-149.
3. **Pawłowski B**., Grabarczyk M. (2003) - Center of body mass and the evolution of female body shape, Am. J. Hum. Biol. 15:144-150.
4. **Pawłowski B.** (2003) - Variable preferences for sexual dimorphism in height as a strategy for increasing the pool of potential partners in humans, Proc. R. Soc. B., 270:709-712.
5. Kozieł S., **Pawłowski B.** (2003) - Comparison between primary and secondary mate markets: an analysis of data from lonely hearts columns. Personality and Individual Differences, 35:1849-1857.
6. **Pawłowski B.** (2004) - Prevalence of menstrual pain in relation to the reproductive life history of women from the Mayan rural community. Annals of Human Biology, 31:1-8
7. Rozmus-Wrzesińska M. & **Pawłowski B.** (2005) - Men's ratings of female attractiveness are influenced more by changes in female waist size compared with changes in hip size. Biological Psychology, 68(3): 299-308.
8. **Pawłowski B.** (2005) - Heat loss from the head during infancy as a cost of encephalization. Curr. Anthrop., 46(1): 136-141.
9. **Pawłowski B.**, Dunbar R.I.M - Waist:Hip Ratio versus BMI as Predictors of Fitness in Women, Human Nature - An Interdisciplinary Biosocial Perspective (in press)
10. **Pawłowski B.**, Jasieńska G. – Women's preferences for sexual dimorphism in height depend on menstrual cycle phase and expected duration of relationship. Biological Psychology (in press).

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van Schaik, Carel P. *(homepage)*

- Professor, Biological Anthropology, Universität Zürich, Switzerland
- Director, Anthropologisches Institut und Museum, Universität Zürich, Switzerland
- Adjunct Professor, Department of Biological Anthropology and Anatomy, Duke University

Current research: behavioural ecology in primates; culture and cultural evolution in the great apes; coalition formation in male primates; skill learning and life history

1. **van Schaik, C.P.** & Noordwijk, M.A. van (1989): The special role of male Cebus monkeys in predation avoidance, and its effect on group composition. Behav. Ecol. Sociobiol. 24: 265-276.
2. Aureli, F., **van Schaik, C.P.** & Hooff, J.A.R.A.M. van (1989): Functional aspects of reconciliation in captive Macaca fascicularis. Amer. J. Primatol. 19: 39-51.
3. Noë, R., **van Schaik, C.P.**, & Hooff, J.A.R.A.M. van (1991): The market effect: an explanation for pay-off asymmetries among collaborating animals. Ethology 87: 97-118.
4. Aureli, F. & **van Schaik, C.P.** (1991): Post-conflict behaviour in long-tailed macaques (Macaca fascicularis). I. The social events. Ethology 89: 89-100.
5. Hooff, J.A.R.A.M. van & **van Schaik, C.P.** (1992): Cooperation in competition: the ecology of primate bonds. In: A.H. Harcourt and F.B.M. de Waal (eds.) Coalitions and alliances in humans and other animals, pp.357-389. Oxford University Press.
6. **van Schaik, C.P.** & Paul, A. (1997) Male care in primates: does it ever reflect paternity? Evol. Anthro. 5: 152-156.
7. **van Schaik, C.P.**, Deaner, R.O. & Merrill, M. (1999) The conditions for tool use in primates: implications for the evolution of material culture. J. Hum. Evol. 36: 719-741.

8. Aureli, F.A., Cords, M. and **van Schaik, C.P.** (2002). Conflict resolution following aggression in gregarious animals: a predictive framework. Anim. Behav. 64: 325-343.
9. **van Schaik, C.P.**, Ancrenaz, M., Borgen, G., Galdikas, B., Knott, C.D., Singleton, I., Suzuki, A., Utami, S.S., & Merrill, M.Y. (2003). Orangutan cultures and the evolution of material culture. Science 299: 102-105.
10. **van Schaik, C.P.**, Pandit, S.A. & Vogel, E.R. (2004) A model for within-group coalitionary aggression among males. Behav. Ecol. Sociobiol. 57: 101-109.

Seabright, Paul *(homepage)*

- Professor of Economics, University of Toulouse, France
- Research fellow Institut d'Economie Industrielle (IDEI), Toulouse, France

Current research: economic history, environmental economics, evolutionary biology and economics, the economics of trust, the role of altruism in economic organizations

1. **Seabright, P.** (1993): "Managing Local Commons: theoretical issues in incentive design", *Journal of Economic Perspectives*.
2. **Seabright, P.** (1996): "Accountability and Decentralization in Government: an incomplete contracts model", *European Economic Review*.
3. Fingleton, J.; Fox, E.; Neven, D. & Paul **Seabright, P.** (1996): *Competition Policy and the Transformation of Central Europe*, London, Centre for Economic Policy Research.
4. **Seabright, P.** (1997): "Is Cooperation Habit-Forming?", in P. Dasgupta & K-G Mäler (eds): *The Environment and Emerging Development Issues*, Oxford, Clarendon Press.
5. **Seabright, P.** (1997): "Transferability of Collective Property Rights: does trade destroy trust?", in Roemer (ed): *Property Rights, Incentives and Welfare*, London, IEA/Macmillan.
6. **Seabright, P.**, editor (2000): *The Vanishing Rouble: barter networks and non-monetary transactions in post-Soviet societies*, Cambridge, Cambridge University Press.
7. Martens, B; Mummert, U.; Murrell, P. & **P. Seabright** (2001): *The Institutional Economics of Foreign Aid*, Cambridge University Press.
8. Carlin, W.; Schaffer, M. & **P. Seabright** (2004): "A Minimum of Rivalry: evidence from transition economies on the importance of competition for innovation and growth", *Contributions to Economic Analysis and Policy*, Berkeley Electronic Press.
9. **Seabright, P.** (2004): *The Company of Strangers: A Natural History of Economic Life*, Princeton University Press.
10. **Seabright, P.** (2005): "The Evolution of Fairness Norms", *Philosophy, Politics and Economics*, forthcoming.

Sigmund, Karl *(homepage)*

- Professor of Mathematics, University of Vienna
- Visiting scientist International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria
- Member of the Austrian Academy of Science
- Vice-president of the Austrian Science Fund FWF (2003-2005)

Current research: Game theory. Evolution of cooperation, from molecules to man. Experimental economics. Game dynamics (replicator dynamics, adaptive dynamics)

1. Brandt, H. & **Sigmund, K.** 2005. Indirect reciprocity, image scoring, and moral hazard. *PNAS*, **102,** 2666-2670.
2. Nowak, M. A. & **Sigmund, K.** 2004. Evolutionary dynamics of biological games. *Science*, **303,** 793-799.
3. Nowak, M. & **Sigmund, K.** 2004. Evolutionary dynamics of biological games. *Science*, **303,** 793-799.
4. Hofbauer, J. & **Sigmund, K.** 2003. Evolutionary game dynamics. Bulletin AMS **49**, 479-519.
5. Hauert, C., De Monte, S., Hofbauer, J. & **Sigmund, K.** 2002. Volunteering as Red Queen mechanism for cooperation in public goods games. *Science*, **296,** 1129-1132.
6. **Sigmund, K**., Hauert, C. & Nowak, M. A. 2001. Reward and punishment. *PNAS*, **98,** 10757-10762.
7. Nowak, M. A., Page, K. M. & **Sigmund, K.** 2000. Fairness versus reason in the Ultimatum Game. *Science*, **289,** 1773-1775.
8. Nowak, M. A. & **Sigmund, K.** 1998. Evolution of indirect reciprocity by image scoring. *Nature*, **393,** 573-577.
9. Nowak, M. & **Sigmund, K.** 1993. A strategy of win-stay, lose-shift that outperforms tit-for-tat in the Prisoner's Dilemma. *Nature*, **364,** 56-58.
10. Nowak, M. A. & **Sigmund, K.** 1992. Tit-for-Tat in Heterogeneous Populations. *Nature*, **355,** 250-253.

Stopka, Pavel *(homepage)*

- Senior Lecturer; Department of Zoology, Charles University, Prague, Czech Republic
- Head of Biodiversity Research Group, Charles University, Prague, Czech Republic

Current research: Genomic and proteomic study of communication and cooperation in mice, theoretical study of cooperation; sperm cell cooperation and competition

1. **Stopka P**. & Macdonald D.W. 1998: Signal interchange during mating in the wood mouse (*Apodemus sylvaticus*): the concept of active and passive signalling. *Behaviour*, 135: 231-249.
2. **Stopka P.** & Macdonald D.W., 1999: The market effect in the wood mouse, *Apodemus sylvaticus*: selling information on reproductive status. *Ethology*, 105: 969-982.
3. **Stopka P.** & Graciasová, R. 2001: Conditional allo-grooming in the Herb-field mouse. *Behav.. Ecol.*, 12: 584-589.
4. Polechová J. & **Stopka P.** 2002: Geometry of social relationships in the Old World wood mouse, *Apodemus sylvaticus*. *Canad J Zoology*, 80: 1383-1388.
5. Bryja J. & **Stopka, P.** 2005: Facultative promiscuity in a presumably monogamous mouse (*Apodemus microps*). *Acta theriologica*, 50 (2): 189-196.
6. Buesching C.D., **Stopka P.** & Macdonald D.W. 2003: The social function of allo-marking in the European badger (*Meles meles*). *Behaviour*, 140: 965-980.
7. Johnson D.D.P., **Stopka P.** & Bell, J. 2002. Individual variation evades the Prisoner's Dilemma. *BMC Evolutionary Biology* 2:15 (pp. 8)
8. Johnson D.D.P., **Stopka P.** & Knights, S. 2003. Punishment and human cooperation. *Nature*, 421: 911-912.
9. Johnson D.D.P., **Stopka P.** & Macdonald D.W. 2004: Ideal Flea Constraints on Group Living: Unwanted Public Goods and the Emergence of Cooperation. *Behavioral Ecology*, 15: 181-186.
10. Macdonald D.W., Stewart P.D., **Stopka P.** & Yamaguchi N. 2000: Measuring the dynamics of mammalian societies: an ecologist's guide to ethological methods. Pages 332-388 In: L.Boitani and T.K. Fuller, eds. Research techniques in animal ecology: controversies and consequences. Columbia UP, New York.

Szathmáry, Eörs *(homepage)*

- Professor of biology, Dept of Plant Taxonomy and Ecology, Eötvös University,
- Permanent fellow, Collegium Budapest (Institute for Advanced Study)
- Awards: Member of Academia Europaea (2001); Prize of the Academy, Hungarian Academy of Science, Budapest (1999); New Europe Prize for Higher Education and Research, Stanford (1996)

Current research: Theoretical evolutionary biology. Common principles of the major steps in evolution: origin of life; emergence of cells; origin of animal societies; origin of human language.

1. Maynard Smith, J. & **Szathmáry, E.** (1995) *The Major Transitions in Evolution.* Freeman & Co., Oxford.
2. **Szathmáry, E.** & Maynard Smith, J. (1995) The major evolutionary transitions. *Nature* **374,** 227-232.
3. Maynard Smith, J. & **Szathmáry, E.** (1999) *The Origins of Life.* Oxford Univ. Press.
4. **Szathmáry, E.** (2000) The evolution of replicators. *Phil. Trans. R. Soc. Lond.* B. **355,** 1669-1676.
5. Szabó, P., Scheuring, I., Czárán, T. & **Szathmáry, E.** (2002) *In silico* simulations reveal that replicators with limited dispersal evolve towards higher efficiency and fidelity. *Nature* **420,** 360-363.
6. **Szathmáry, E.** (2002) Cultural processes: the latest major transition in evolution. In: L. Nadel (ed.) *Encyclopedia of Cognitive Science* Nature Publishing Group, Macmillan, London. Pp. …….
7. **Szathmáry, E.** & Wolpert, L. (2003) The evolution of multicellularity. In: Hammerstein, P. (ed.) *Genetic and Social Mechanisms of Cooperation.* pp. 271-290. MIT Press, Cambridge, MA.
8. Santos, M,. Zintzaras, E. & **Szathmáry, E.** (2004) Recombination in primeval genomes: a step forward but still a long leap from maintaining a sizeable genome. *J. Mol. Evol.* **59,** 507-519.
9. Lenton, T.M., Schellnhuber, H. J. & **Szathmáry, E.** (2004) Climbing the co-evolution ladder. *Nature* **431,** 913.
10. Fernando, C., Santos, M. & **Szathmáry, E.** (2005) Models of protocells (minimal life). *Top. Curr. Chem.*

Velicer, Gregory *(homepage)*

- Group Leader, Max-Planck Institute for Developmental Biology, Tübingen Germany
- Adjunct Professor, Center for Microbial Ecology, Michigan State University

Current research: Experimental evolution of social behaviours in the cooperative bacterium *Myxococcus xanthus*. Comparative studies of natural behavioural and genetic variation in *M. xanthus.*

1. **Velicer, G. J.** 2005. The benefits of ridesharing. Heredity, *in press.*
2. **Velicer, G. J.** 2005. Evolution of cooperation: Does selfishness restraint lie within? Current Biology 15, R173-R175.
3. Hillesland, K. L. and Velicer, G. J.. 2005. Resource level affects relative performance of the two Myxococcus xanthus motility systems. Microbial Ecology, in press.
4. Travisano, M. and **Velicer, G. J.**. 2004. Strategies of microbial cheater control. *Trends in Microbiology,* **12**, 72-78.
5. **Velicer, G. J.** and Y. N. Yu. 2003. Evolution of novel cooperative swarming in the bacterium *Myxococcus xanthus.* *Nature* **425**, 75-78.

6. Fiegna, F. and **Velicer, G. J.**. 2003. Competitive fates of bacterial social parasites: persistence and self-induced extinction of *Myxococcus* cheaters. *Proceedings of the Royal Society, London* B **270**, 1527-1534.
7. **Velicer, G. J.** 2003. Social strife in the microbial world. *Trends in Microbiology* **11**, 330-37.
8. **Velicer, G. J.**, R. E. Lenski, and L. Kroos. 2002. Rescue of social motility lost during evolution of *Myxococcus xanthus* in an asocial environment. *Journal of Bacteriology* **184**, 2719-2727.
9. **Velicer, G. J.**, L. Kroos, and R. E. Lenski. 2000. Developmental cheating in the social bacterium *Myxococcus xanthus.* *Nature* **404,** 598-601.
10. Lenski, R. E. and **Velicer, G. J.**. 2000. Games microbes play. *Selection* **1**, 51-57.

Visalberghi, Elisabetta *(homepage)*

- Research director, ISTC-CNR (Unit of Cognitive Primatology & Primate Center), Rome, Italy
- Secretary General of the International Primatological Society
- President of the Italian Ethological Society (Società Italiana di Etologia)

Current research: cognition and learning in primates, notably capuchin monkeys; comparative psychology

1. Fragaszy, D., Fedigan, L., **Visalberghi, E.** (2004) The Complete Capuchin. The Biology of the Genus Cebus. Cambridge: Cambridge University Press. pp. 339
2. Padoa-Schioppa, C., Jandolo, L., **Visalberghi, E.** (in press) Multi-stage mental process for economic choice in capuchins. Cognition
3. Fragaszy, D., Izar P., **Visalberghi, E.**, Ottoni, E., Gomes de Oliveira, M. (2004) Wild capuchin monkeys (Cebus libidinousus) use anvils and stone pounding tools. Am. J. Primatol., 64, 359-366
4. **Visalberghi, E.** & Addessi, E. (2003) Food for thought: social learning and the feeding behavior in capuchin monkeys. Insights from the laboratory. In: Fragaszy, D. & Perry, S. (eds), Traditions in nonhuman animals: models and evidence (pp. 187-212) Cambridge: Cambridge University Press
5. **Visalberghi, E.** & Limongelli, L. (1996) Acting and understanding: Tool use revisited through the minds of capuchin monkeys. In: Russon, A., Bard, K. & Parker, S. (eds) Reaching into thought. The minds of the great apes, pp 57-79. Cambridge: Cambridge University Press
6. Paukner, A., Anderson, J.R., **Visalberghi, E.**, Borelli, E. & Ferrari, P.F. (2005) Macaques (Macaca nemestrina) recognise when they are being imitated. Proc. R. Soc. B: Biology Letters (online).
7. **Visalberghi, E.**, Fragaszy, D., Izar, P., Ottoni, E.B. (2005) Terrestriality and tool use. Science, 308, 951.
8. **Visalberghi, E.**, Pellegrini Quarantotti, B. & Tranchida, F. (2000). Solving a cooperation task without taking into account the partner's behavior. The case of capuchin monkeys (Cebus apella). J. Comp. Psy., 114: 297-301.
9. Hare, B., Addessi., E., Call, J., Tomasello, M., & **Visalberghi, E.** (2003) Do capuchin monkeys (Cebus apella), know what conspecifics do and do not see? Animal Behaviour, 65, 131-142.
10. **Visalberghi, E.** & Tomasello, M. (1998). Primate causal understanding in the physical and in the social domains. Behavioral Processes, 42, 189-203.

Weissing, Franz J. *(homepage)*

- Professor of Theoretical Biology, Univ. Groningen (NL).
- Scientific director, Dutch research school Functional Ecology.
- Coordinator, international Top Master's programme Evolutionary Biology, Univ. Groningen
- Speaker of the National Advisory Panel Ecology and Evolution

Current research: Evolutionary game models on conflict and cooperation; evolution of animal personalities; selection at different levels; kin selection and kin competition; sexual selection and sexual conflict; ecological and sexual selection models of sympatric speciation; resource and interference competition; host-pathogen coevolution.

1. Van Doorn, G.S. & **Weissing, F.J.**, 2004, The evolution of female preferences for multiple indicators of quality. Amer. Nat. 164: 173-186.
2. Van Boven, M. & **Weissing, F.J.**, 2004, The evolutionary economics of immunity. Amer. Nat. 163: 277-294.
3. Henrich, J., **Weissing, F.J.**, et al., 2003, The cultural and genetic evolution of human cooperation. In: Hammerstein P (ed.): Genetic and Cultural Evolution of Cooperation. MIT Press, pp. 445-468.
4. Van Doorn, G.S., Hengeveld, G.M. & **Weissing, F.J.**, 2003, The evolution of social dominance. Behaviour 140: 1305-1322 (part I), 1333-1358 (part II).
5. **Weissing, F.J.** & Van Boven, M., 2001, Selection and segregation distortion in a sex-differentiated population. Theor. Pop. Biol. 60: 327-341.
6. Pen, I.R. & **Weissing, F.J.**, 2000, Towards a unified theory of cooperative breeding: the role of ecology and life history re-examined. Proc. Roy. Soc. Lond. B 267: 2411-2418.
7. Pen, I. & **Weissing, F.J.**, 2000, Optimal floating and queuing strategies: the logic of territory choice. Amer. Nat. 155: 512-526.

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9. **Weissing, F.J.** & Ostrom E., 2000: Rule enforcement on government- and farmer-managed irrigation systems. In: M.D. McGinnis (ed.): Polycentric Games and Institutions. Michigan UP, pp 366-398.
10. **Weissing, F.J.**, 1996, Genetic versus phenotypic models of selection: can genetics be neglected in a long-term perspective? J. Math. Biol. 34: 533-555.

(2) List of the 15 most important scientists and institutes in the field

In such a widely ranging field it is virtually impossible to compare the contributions of institutions and individual researchers. The following list reflects the choice of the coordinating proposer in consultation with several other proposers that are not themselves listed. (Sorted according to location and discipline; the order has no meaning.)

Europe:

1. Center for Adaptive Behavior and Cognition (Director G. Gigerenzer), Max-Planck Institute for Human Development, Berlin, Germany
2. Institute for Empirical Research in Economics (directed by E. Fehr), Faculty of Business Administration, University of Zurch, Zürich, Switzerland
3. International Institute for Applied Systems Analysis (IIASA) (K. Sigmund among others), A-2361 Laxenburg, Austria
4. Institute for Theoretical Biology (directed by P. Hammerstein among others), Humboldt University, Berlin
5. Large Mammal Research Group (directed by T. Clutton-Brock), Department of Zoology, Cambridge University, Cambridge, UK.
6. Biological Anthropology (L. Aiello, R. Mace, V. Sommer among others), Department of Anthropology, University College London, London, UK.
7. Department of Evolutionary Ecology (directed by M. Milinski), Max-Planck Institute for Limnology, Plön, Germany.
8. Department of Ecology and Evolution (L. Keller among others), University of Lausanne, Switzerland.

USA:

9. Program for Evolutionary Dynamics (Directed by M. Nowak), Harvard University, Cambridge, Massachusetts, USA
10. Department of Neurology (A. R. Damasio, A. Adolphs among others), University of Iowa, Iowa City, Iowa, USA.
11. Department of Sociology (chair M. Granovetter), Stanford University, Stanford, California, USA.
12. Department of Economics (H. Peyton Young among others), John Hopkins University, Baltimore, Maryland, USA.
13. Computer Science and Artificial Intelligence Laboratory (directed by R. Brooks), Massachusetts Institute of Technology (MIT), Cambridge Massachusetts, USA.
14. Living Links Center (directed by F. de Waal), Yerkes Primate Center and Emory University, Atlanta, Georgia, USA.

USA & Europe:

15. The MacArthur Foundation Norms and Preferences Network (S. Bowles, R. Boyd, E. Fehr, H. Gintis, , among others), http://www.umass.edu/preferen/. (With strong links to the Santa Fé Insitute, Santa Fé, New Mexico, USA)

(3) List of potentially interested scientists and institutes in Europe

We abandoned our attempt to make this list. Interesting grant proposals can be expected from all departments that cover the disciplines mentioned in this proposal. Listing part of these would be rather arbitrary. We expect a high number of grant applications in the framework of this program. To give an idea: a comparable call in The Netherlands (NWO-programme Evolution and Behaviour) yielded 75 proposals, many of which were of high quality.