The Evolution of Cooperation & Trading

from microbes to man

Cooperation is omnipresent in nature
... and presents itself in many different forms

Cooperative hunting
**Inter-specific cooperation**

- Trading nectar against transport of pollen

**Symbiosis**

- Trading nutrients
- Protection against dehydration

**Cooperation among humans shows similarities ..**

- Trading transport for money in Calcutta
- Cooperative hunting by !San men

**.. but can also take a very different dimension: collective action**

- Amish barn raising
Warfare: collective action with and against conspecifics

Trading and cooperation have much in common

Common characteristics of cooperation and trading

- investment in other agents
- risk of no returns

Considerable effort has been put in the study of control mechanisms

game theoretical models based on the Prisoner’s Dilemma and related paradigms
**The iterated Prisoner’s Dilemma**

More interaction between theoreticians and empiricists would be desirable, not only to study partner control, but also …

- partner choice
- division of payoffs
- indirect reciprocity
- reputation
- power asymmetries
- punishment & harassment
- and more ….

**Collective action and the management of public goods**

Participation in cooperation among large numbers of unrelated individuals could be used to define ‘being human’

Large scale cooperation among unrelated individuals became stable only after control mechanisms evolved

- policing
- religion
Bacteria are capable of collective action too, but only when closely related.

Interdisciplinary research 1

neuro-economics

neuronal basis of:
- preference for certain items
- choice of certain partners
- detection of cheating
- altruistic punishment
- moral behaviour

Economic decisions and the brain

fMRI research in reward anticipation (‘wanting’) and reward outcome (‘liking’)

Knutson et al. (2001). NeuroReport 12 (17): 3683-3687 (Fig. 1)
Interdisciplinary research 2

**Biological markets**
- Influence of supply & demand ratio on exchange rates
- Partner choice as mechanism of selection
- Exchanges without contracts

Mycorrhiza markets

Kummel & Salant *(Ecology in press)*

- Low light
- High light

Carbon – nitrogen trade: when to trade with which fungus?

Interdisciplinary research 3

- Political sciences
- Evolutionary anthropology
- Micro-economics

The role of power asymmetries

Mycorrhiza markets

2 plants under different light conditions in interaction with 2 fungus species

Kummel & Salant *(Ecology in press)*
Paying for cuddling

Female baboons have to groom the mother before getting access to the infant

The baboon baby market

- higher ranking mother ➤ higher price
- fewer infants ➤ higher price

Barrett & Henzi 2005 (in Kappeler & van Schaik ed)

Interdisciplinary research 4

bounded rationality

fast & frugal heuristics in decision making

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The origin of life is understood as complex molecular cooperation.

**Interdisciplinary research 5**

- Molecular cooperation
- Microeconomics
- Replicator chemistry
- Behavioural ecology

The major transitions

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
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<tbody>
<tr>
<td>Replicating molecules</td>
<td>Populations of molecules in protocells</td>
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<td>Independently replicating genes</td>
<td>Chromosomes</td>
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<td>RNA as gene and enzyme</td>
<td>DNA genes, protein enzymes</td>
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<tr>
<td>Bacterial cells (prokaryotes)</td>
<td>Cells with nuclei and organelles (eukaryotes)</td>
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<td>Asexual clonal</td>
<td>Sexual populations</td>
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<tr>
<td>Single-celled organisms</td>
<td>Animals, plants and fungi</td>
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<td>Solitary individuals</td>
<td>Colonies with non-reproductive castes</td>
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<tr>
<td>Prelinguistic societies</td>
<td>Human societies with language</td>
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*These transitions are regarded as ‘difficult’*

Table 1. The major transitions in evolution

Termites: fraternal transition

- Kinship is the most important factor
- Reproductive (and other division of labour) readily arises
- Niche construction: „the wisdom of the hive”

Egalitarian and fraternal major transitions

<table>
<thead>
<tr>
<th>Table 2. Egalitarian and fraternal major transitions</th>
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<tbody>
<tr>
<td>Egalitarian</td>
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<td>Examples</td>
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<tr>
<td>Units</td>
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<tr>
<td>Reproductive division of labor</td>
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<td>Control of conflicts</td>
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<td>Initial advantage</td>
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<td>Means of increase in complexity</td>
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<td>Greatest hurdle</td>
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Eukaryotic cells: egalitarian transition

- Reproductive division of labour is impossible
- Compartments with different genetic origin must be centrally regulated for reproduction

Different bacterial lineages have contributed to the origin of eukaryotic cells.

Simple ideas about molecular cooperation break down

- Autocatalysis
- Parasite
- Heterocatalytic aid
- Short circuit

Cooperation on the surface allows the increase in complexity

- Molecules interact with their neighbours
- Have limited diffusion on the surface

Life is the “symbiosis” of genes, metabolism and membrane

- Metabolism
- Template copying
- Membrane growth

Systems chemistry aims at synthesizing systems of molecular cooperation.
Group selection of early replicators

- A bag of genes: genes sitting in the same boat
- How fast can complexity increase?
- When did chromosomes arise?

Interdisciplinary research 6

The role of communication
coevolution of language and complex forms of cooperation?

Understanding language evolution is difficult

The explanatory power of theories for the origin of language
(1) selective advantage (2) honesty (3) grounded in reality
(4) power of generalisations (5) cognitive abilities (6) uniqueness

<table>
<thead>
<tr>
<th>Theories/Questions</th>
<th>1</th>
<th>2</th>
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<tbody>
<tr>
<td>Language as a mental tool (Jerison, 1991; Burling, 1993)</td>
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<td>Grooming hypothesis (Dunbar, 1998)</td>
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<td>Gossip (Power, 1998)</td>
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<td>Tool making (Greenfield, 1991)</td>
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<td>Mating contract (Deacon, 1997)</td>
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<td>Sexual selection (Miller, 2000)</td>
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<td>Status for information (Dessalles, 2000)</td>
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<td>Song hypothesis (Vanechoute &amp; Skoyles, 1998)</td>
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<td>Group bonding/ritual (Knight, 1998)</td>
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<td>Gestural theory (Newes, 1973)</td>
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<td>Hunting theories (Washburn &amp; Lanchester, 1988)</td>
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An educated guess

The evolution of human language had something to do with the following activities:

- Mental representations/mental models
- Tool making
- Gesturing
- Co-operative hunting (planning)
- Individual recognition
- Population structure (fission/fusion society)

The ultimate goal is to re-enact this transition in simulated and embodied agents.

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&

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Are humans a special case?

- Vast behavioral differences among groups
- Kinds and scope of cooperation
- Trade among millions of anonymous individuals
- Other-regarding preferences

What distinctively human characteristics explain the differences in the extent and types of cooperation and trade? Possibilities include:

- Long lives, large cognitive capacity and language
- Can formulate, communicate and enforce moral rules
- Evolved meat-intensive diet
- Docility/socialization: internalization of norms
- Heightened in-group out-group distinctions
- Projectile weapons: lethal warfare, low cost punishment of defectors
- Social institutions as a form of niche construction
Is human cooperation and trading supported entirely by self-regarding motives, or are other-regarding motives (social preferences) involved?

If self-regarding motives are the main support for cooperation did they evolve by reciprocal altruism? Indirect reciprocity? Can these models explain the adherence to norms of cooperation in large groups with noisy or private information?

Is kin altruism the template for more extensive forms of cooperation, and how important is it in explaining cooperation?

If other-regarding motives are involved, are they best described by inequality aversion, resistance to domination, altruistic punishment, strong reciprocity?
Puzzles

- How could altruistic behaviours emerge and proliferate among humans? Kin selection, group selection, other forms of positive assortment?
- Is it empirically plausible that a genetic predisposition to cooperate could have evolved by group selection?

Social institutions are an example of human niche construction that support cooperation: what is the role of suppression of within-group competition and phenotypic variance reduction (i.e., reproductive and other forms of levelling)?

Conflicts over the division of the gains to cooperation may preclude cooperative solutions: when does this occur and how can it be avoided?

Example: What can econs and other social sci.s learn from biologists?

- Variance reduction as a force propelling evolution
- Speciation as a model of the emergence of new social institutions
- Quorum sensing (e.g., in bacteria) and neutral mutations as a prototype for political action against the status quo (applications to the fall of Communism etc)
- Multilevel selection as a model of interactions of firms, firms, regions, and nations
The question: in an experimentally controlled interaction with real material stakes and identical incentives, how do 15 small-scale societies with differing cultures cooperate (or fail to do so) and police defectors?

The research team: decision scientists, game theorists, ethnographers, evolutionary modelers

Funding: The MacArthur Foundation

Results: cultural diversity, purely self interested subjects a small minority, strong impact of economic structure

Self interested subjects who believe others to be self interested would offer the least possible amount. Few did.

Henrich, Boyd, Bowles, et al, BBS, 2005

Payoffs to trans-disciplinary research in the cross cultural experiments project

- Many peer reviewed and other papers (American Economic Review, Behavior and Brain Science, etc etc) and books
- An active learning process among the 17 participants; many of the anthropologists have since taken up both game theory and experimental methods; some economists have become serious students of anthropology.
- Imitations, spin offs in other disciplines, and a well funded second round
Cooperation is omnipresent, .. but not that easy