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Simulating Norms, Social Inequality, and Functional Change in Artificial Societies

***Journal of Artificial Societies and Social Simulation* vol. 2, no. 1,**
<http://jasss.soc.surrey.ac.uk/2/1/2.html>

To cite articles published in the *Journal of Artificial Societies and Social Simulation,* please reference the above information and include paragraph numbers if necessary

Received: 25-Nov-98 Accepted: 20-Dec-99 Published: 31-Jan-99

Abstract

In this paper, we compare the computational and sociological study of norms, and resimulate previous simulations (Conte and Castelfranchi 1995a, Castelfranchi, Conte and Paolucci 1998) under slightly different conditions. First, we analyze the relation between norms, social inequality and functional change more closely. Due to our results, the hypothesis stating that the "finder-keeper" norm while controlling aggression efficaciously reduces social inequality holds only in quite egalitarian societies. Throughout a variety of inegalitarian societies, it instead increases social inequality. This argument which can be traced back to Marx is being investigated by use of computer simulations of artificial societies. Second, we remodel normative behaviour from a sociological point of view by implementing Haferkamp's theory of action approach to deviant behaviour. Following the game theoretic models, the computational study of norms has up to now ignored the importance of power in explaining how norms affect social behaviour, how norms emerge, become established and internalized, and change. By simulating Haferkamp and repeating the Conte and Castelfranchi experiments, we demonstrate that it is possible to integrate power into computational models of norms.

Keywords:
Simulation of norms, Social inequality, Functions of norms

Introduction

1.1

In recent years, the computational study of norms through simulation has grown in importance (Shoham and Tenneholtz 1992a, Shoham and Tenneholtz 1992b, Conte and Castelfranchi 1995a, Conte and Castelfranchi 1995b, Walker and Wooldridge 1995, Castelfranchi, Conte and Paolucci 1998). Most interestingly, the theoretical input to this field of research seems to originate in game theory, but not in sociology itself, although the sociological study of norms has a tradition going back more than a hundred years. In this paper we claim that the computational study of norms could gain from a wider sociological perspective on norms.

1.2

In the next section we compare the computational and the sociological study of norms and make some suggestions to the further development of the computational study of norms. In the third section we present and discuss the Conte and Castelfranchi model from a wider sociological perspective. In the fourth section we present two resimulations of the Conte and Castelfranchi model under slightly different conditions. First, we analyze the relation between norms, social inequality, and the functions of norms more closely. Our results suggest that the hypothesis stating that the 'finder-keeper' norm while controlling aggression efficaciously reduces social inequality holds only in egalitarian predator-collector societies. In the majority of inegalitarian societies, it instead increases social inequality. Second, we remodel normative behaviour from a sociological point of view and repeat the Conte and Castelfranchi experiments. Finally, some conclusions will be drawn, and suggestions for further studies will be discussed.

The Computational vs the Sociological Study of Norms

2.1

Social norms are a classical topic of research in sociology. The sociological study of norms aims at the appropriate definition of norms, the explanation of how norms affect social behaviour, and the explanation how norms emerge, become established and internalized and change. Like game theory, the computational study of norms is a formal approach to theory building in the field of norms. It is hoped that the computational study of norms will advance our knowledge about the interrelation between cognitive and social processes. Both can be modeled with the help of intelligent agent technology.

The Computational Study Of Norms

2.2

In the Artificial Intelligence literature a norm is operationalized as a behavioural constraint on agents which interact with each other in a multi-agent society. Previous studies have taken the theoretical input from game theory.

Conceptualization Of Norms

2.3

Within game theory three different conceptualizations of norms have been developed (Ullman-Margalit 1977):

1. Norms as solutions to problems of co-ordination: Here, norms are seen essentially as conventions, behavioural conformities that do not presuppose explicit agreements among agents. They emerge from the individual interests of the agents (Schelling 1960, Lewis 1969), but do not presuppose explicit agreements among them. Lewis' example is that of two persons unexpectedly cut off in a telephone conversation. Each has to choose whether to call back or wait. Norms of coordination emerge gradually from interactional practice. There is no conflict of utility because both participants want to resume their conversation.
2. Norms as solutions to conflicts of utility: In case of social dilemmas the conflict structure calls for norms whenever the agents' choices tend to produce a state of affairs that is both individually and socially undesirable.
3. Norms as solutions to problems of inequality: In this case norms aim at maintaining a state of affairs in which one party is favoured or privileged at the expense of another.

2.4

Following Ullman-Margalit (1977), Conte and Castelfranchi (1995b: 77) refer to the moral philosopher Hart (1961) who defines norms as 'a prescribed guide for conduct or action which is generally complied with by the members of a society'. Three features are characteristic of norms: their prescriptive force, their expected necessity for social life (this concept has been criticized by Conte and Castelfranchi as vague; Hart himself states 'The rules supported by this serious pressure are thought important because they are believed to be necessary to the maintenance of social life or some highly prized feature of it' (Hart 1961: 85)), and expected clashes between norms, on one hand, and interests and desires of the agents who owe the duty, on the other. Conte and Castelfranchi (1995b: 80) claim that game theory has not 'produced a general theory of norms as prescriptions, that includes norms of co-ordination, i.e. conventions, as well as other types of norms.' Game theory is not able to grasp the complementarity of people in society. Society is seen as a bunch of self-sufficient beings. But some of the goals and interests of the agents cannot be achieved in isolation. Instead, they call for the skills of other agents. The agents are complementary. Because of this shortcoming, game theory cannot account for collective rationality. It cannot give a full explanation of norms which do not always produce distributive advantages, but often only collective ones.

2.5

Conte and Castelfranchi (1993, 1995a, 1995b) and Castelfranchi, Conte and Paolucci (1998) account for norms as prescriptions represented in the minds of self-interested agents. They propose a model in which norms are seen as both macro- and micro-objects, social objects and mental constructs. Two concepts of normative behaviour are introduced: Norm-abiding behaviour, which appears to correspond to some norms, and norm-governed ('fully normative', Conte and Castelfranchi 1995b: 90) behaviour, which results from cognitive processing of norms and implies a mental representation of norms. They discuss the relative advantages of three different architectures of norm-abiding behaviour: norms as built-in constraints, goals, or obligations. These differ in reliability, learning, novelty, faculty to change and repair, and social control, and make the representation of norms increasingly demanding, leading up to norm-governed behaviour (see table 1).

Table 1: Alternative representations of norms inside the agents' architectures (norm-abiding systems)

Norms as	**built-in constraints:** norms are seen as constraints on the agents' action repertoires (behavioural notion); no truly normative choice	**build-in ends (goals):** cognitive agents are allowed to choose among competing goals (instead of simply applying procedures and routines) but they treat norms like any other of their goals	**built-in obligations:** explicit and specific mental object; differs from a constraint since it does not automatically reduce the set of actions available to the agents; and from a goal since it is not immediately transformed into a goal
reliability	high reliability: the constraints will always be executed	low reliability: goals may be abandoned when they clash with competing, more urgent needs	average reliability: agents may give up normative goals, but this will cost them more than abondoning ordinary goals

learning	no learning: new constraints are implemented when the system is off-line	average learning: build-in ends should be added when the system is off-line;	normative goals are autonomously produced on the grounds of normative beliefs, and in principle beliefs may be acquired when the system is on-line
novelty	no novelty: constraints reduce available actions; only proscriptions, that is, prohibitions ('Don't ...'), can be represented, but not prescriptions ('Do...')	build-in ends may correspond to prescriptions and not only to prohibitions; but since learning is not granted, there ought to be a one-to-one correspondence between social norms and internal goals with a consequent high computational complexity	normative beliefs may be formulated as prescriptions, and not as mere prohibitions
repair	no repair: agents are not endowed with the capacity for modifying unsuccessful constraints	goal-oriented systems ought to be able to try out several solutions and choose those that achieve their goals to the highest degree, before giving up their goals	as with any other kind of goal, plans for normative goals are subject to change and repair
social control	no need	no social control: agents may have preferences corresponding to norms or not; they may cling to these or abandon them as a function of circumstances	since normative goals are a special type of goals, and normative actions have specific costs, agents can be shown to be interested in some monitoring of norms

2.6

The advantages of norm-governed systems are avoiding useless, stupid, and self-destructive behaviour favoured by the rigid execution of routines, as well as the spreading of errors and deviations produced by pure imitation. Therefore, it is promising to construct autonomous artificial agents with a capacity for applying norms. Conte and Castelfranchi put forward the thesis that norm-governed systems are more useful than norm-abiding systems. It has to be tested to see which of norm-governed or norm-abiding systems perform better. They state that 'all these hypotheses should be tested computationally. Unfortunately, we are far from being able to execute such a test' (Conte and Castelfranchi 1995b: 92).

2.7

Conte and Castelfranchi (1995b: 85) describe four roles which agents may adopt in relation to norms: sovereign, addressee, defender, and external observer, and give a formal description of the beliefs about norms that must be represented in an addressee's and a sovereign's mind.

2.8

As far as implemented models are concerned, the agents in Conte and Castelfranchi's study are the most advanced ones (Castelfranchi, Conte and Paolucci 1998: 5.1-5.9; for details see later). They investigate the costs of complying with norms, as norm-governed systems not only have advantages, but also disadvantages. Under certain circumstances the normative agents alone bear the cost of norms while other agents benefit from their presence. Castelfranchi, Conte and Paolucci introduce communication and normative reputation into their agents' design. As a result, the spreading of agents' reputation via communication allows normative agents to co-operate without deliberation at the expense of non-normative agents, thereby redistributing the costs of normative strategies. The design of the agents is not yet consistent with their theoretical suggestions. There is no division of roles such as the sovereign, the addressee, the defender, or the external observer of a norm. From the computational point of view, the model represents norm-abiding behaviour with norms as built-in constraints.

The Functions Of Norms

2.9

Implemented computational studies of norms have explored two different functions of norms: to permit or improve co-ordination among agents (Shoham and Tenneholtz 1992a, Shoham and Tenneholtz 1992b), and to control aggression between them (Conte and Castelfranchi 1995a, Castelfranchi, Conte and Paolucci 1998, Walker and Wooldridge 1995). There is also a third function which could have been made explicit.

2.10

Conte and Castelfranchi state that 'this type of norm [the finder-keeper norm], while controlling aggression efficaciously, also reduces the variance of strength among the agents; that is, their inequality' (Conte and Castelfranchi 1995a: 264). They point out that this norm is not truly a norm of property, since the possessions are not ascribed exclusively on the grounds of the 'right of birth', but may be acquired over the course of each agent's life. They investigate distributive rationality (which leads, in the long run, to the best possible outcome, or the least possible harm, for all agents) and collective rationality (which leads, in the long run, to the best possible outcome for a collective entity even though it does not imply the best outcomes for all its subcomponents, see Conte and Castelfranchi 1995b: 114f). Referring to those norms that control aggression they state: 'Norms seem to play an equalizing role' (Conte and Castelfranchi 1995b: 115). On the same page, we find as one of three possible relations between norms and the interests of agents, 'partial tutoriality':

> actions prescribed are in the interests of a subset of the MAS at the expense of the rest; these are either the norms aimed to restore equity, protecting the interests of underprevileged categories, or, conversely, norms which favour inequality, protecting the interests of the privileged party (e.g. norms defending private property); (Conte and Castelfranchi 1995b: 115f).

The concept of partial tutoriality seems to be derived from Ullman-Margalit's 'norms of partiality'. It is complemented by distributive tutoriality (actions prescribed are in the interests of all members of the system) and collective tutoriality (actions prescribed are in the interest of the MAS as a collective, but independent of and outside the interest of its members). Do norms have a function in relation to (in)equality? Remember Ullman-Margalit's third argument: Norms are solutions to problems of inequality.

The Sociological Study Of Norms

Conceptualization Of Norms

2.11

The sociological study of norms has developed four different conceptualizations of norms (Nonner-Winkler 1984), including even an overall suspension of the concept of norms itself:

1. The statistical conceptualization of norms originates in behaviourism. A behavioural pattern becomes a norm if the majority of actors in fact behave due to this pattern. Thus, norms are objectively observeable and measureable. From this perspective any regular behaviour becomes a norm. One cannot distinguish between regular and rule-obeying behaviour, or conditioned and rule-obeying behaviour, or sanction-avoiding and rule-obeying behaviour. Examples of this approach are the theories of the formation of social norms by Sherif (1967) and Geiger (1962).
2. The theories of action of Durkheim, Weber, and Parsons represent the 'sociological' conceptualization of norms. According to Durkheim norms are social facts which can be identified through the mere existence of certain sanctions (1965: 112). The sanction does not constitute the norm, it is the symbol of it 'and as this symbol has the great advantage of being objective, accessible to observation and even to measurement, it is a good method to prefer it to the thing it represents' (Durkheim 1966: 426). Durkheim does not deny the reality of a subjective perspective on norms, but he promotes the methodological principle that scientists should choose the perspective of an objective observer. It was Weber (1960) who made explicit the difference between objectively observed behaviour and subjectively intended action. There are behavioural regularities which are based on practice (customs or tradition), on similar interest (market behaviour), and on notions of legitimate order. It is constitutive of normative action that the actor perceives behavioural rules as obliging or representative (1960: 26). In Parson's theory (1964) norms represent institutionalized role expectations. The objective character of norms is guaranteed by the integration of role expectations into the cultural system, its subjective character by internalization.
3. Ethnomethodologists deny the overall relevance of the sociological conceptualization of norms. According to Garfinkel (1967) there is not such a thing as a general norm which is independent of concrete context conditions. There are only situation specific expectations of concrete interaction partners which are actively negotiated by both sides. It is then the question how individuals constitute a common world. Ethnomethodologists have discovered several basic rules which have a pseudo-normative character. They are seen as obliging, and deviations are sanctioned. But they are not equivalent to sociological norms: they are far more deeply rooted in sociality, and are not amenable to reflection. Deviation from these basic rules is judged in clinical, not moral categories. Furthermore, 'a society's members know the moral order as perceivedly normal courses of action' (Garfinkel 1967: 35), i.e., in concrete interactions actors resort to the statistical conceptualization of norms.
4. Finally, developmental psychologists have put forward an ethical conceptualization of norms. Piaget and Kohlberg (1969, 1971) reconstruct the development of the moral consciousness of man. At any time, a subject is actively structuring and reflecting his/her social environment. Throughout his/her moral development three main stages can be distinguished: at the first stage of preconventional morality a child conforms to norms in order to avoid punishment - this corresponds to behaviourism; at the second stage of conventional morality a subject conforms to norms because he/she has internalized the norms of his family, peer group, or society - this corresponds to Parson's view; at the third, and final stage of postconventional morality a subject conforms to norms because of insight into abstract principles that allow for the foundation and justification of norms - this corresponds to the ethical conceptualization of norms. At this stage the subject is able to distinguish between statistical norms, 'sociological' norms, and ethical norms.

The Functions Of Norms

2.12

Functional analysis asks for the objective effect that one element of a social system produces for the system as a whole. There is not necessarily common knowledge about the objective effect of a social element. Functional analysis in general does not concentrate on where the causal relation lies. Cause effect-relations are a special case of functional relations. Different causes are functionally equivalent if they produce the same effect.

2.13

From the beginning, the functions of norms in society as a whole have been a central field of research in sociology. There are two positions in this debate. First, norms have been analysed as solutions to social problems (Marx, Durkheim, Parsons). According to Marx (1936) norms are dependent on the economic foundations of society. Hence, the functions of norms follow the interests of the ruling class. Following Durkheim 'Society cannot exist if its parts are not solidary', 'morality consists in being solidary' (Durkheim 1966: 399). In Parsons's L-I-G-A or A-G-I-L scheme norms fulfil the I-(integration) function of social systems. Solidarity is produced primarily at the level of values, which are shared by more or less everyone in society. Children are socialized by their parents so that the basic values and norms of society are 'internalized' as parts of their personalities. As a result, individuals need and want to do what society demands of them. Second, norms have been analysed as generating social problems themselves: Dahrendorf states that wherever behaviour is regulated by and measured in terms of established norms, and wherever these norms are backed by sanctions, a rank order of social status is bound to emerge (Dahrendorf 1962: 102).

Comparison And Suggestions

Conceptualization Of Norms

2.14

Comparing the computational (Shoham and Tenneholtz 1992a, Shoham and Tenneholtz 1992b, Conte and Castelfranchi 1995a, Conte and Castelfranchi 1995b, Walker and Wooldridge 1995, Castelfranchi, Conte and Paolucci 1998) and the sociological study of norms, we find that the computational development of concepts advances from the statistical to the 'sociological' conceptualization of norms (especially Conte and Castelfranchi 1995b). It is the intention of these authors increasingly to differentiate between regular and rule-obeying, or conditioned and rule-obeying, or sanction-avoiding and rule-obeying behaviour. Modelling norms as both macro- and micro-objects, social objects and mental constructs, they advance towards Weber's position, making explicit the difference between objectively observed behaviour and subjectively intended action . By modelling knowledge of others and communication with others their model will soon be able to include expectations.

2.15

As far as implemented models are concerned, the agents in the Castelfranchi, Conte and Paolucci's (1998: 5.1-5.9) study are the most advanced. In order to put forward our theoretical argument here, we sketch the critical characteristics of their model without going into details. In their model of normative action, agents move and try to eat food items that are distributed randomly to the world. Food can be possessed and may be stolen. There is a norm, the finder-keeper norm, that prescribes 'attack an eater unless the food item being eaten is marked as 'owned' by that agent'. The multi-agent system is composed out of two different sub-populations: agents either respect the finder-keeper precept (the Respectful) or not (the Cheaters). Either through experience, or through communications the agents learn whether another agent is a Respectful or a Cheater. From the sociological point of view, the division into normative (Respectful) and non-normative agents (Cheaters) is not yet fully convincing. The 'normative' algorithm of the Respectful is modified so that they respect the norm only with agents known to be Respectful. This looks like a sanction towards the Cheaters, but as the finder-keeper precept does not hold for any Cheater - it is in fact not prescribed for them - they cannot violate it, and therefore they cannot be sanctioned.

2.16

Following Hart (1961), Conte and Castelfranchi (1995b: 82) have stressed that norms are imposed obligations. In their model, the finder-keeper precept is not imposed on the Cheaters. The Cheaters are defined as non-normative, i.e. self-interested agents. Only if norms have been imposed on agents they can violate them. In this respect, in the Castelfranchi, Conte and Paolucci model, it is the Respectful who violate the finder-keeper norm if they do not respect the Cheaters! It is rational that the Respectful only respect themselves, but how do we know, that decisions about the respect or disrespect of norms are the result of a rational calculus? Is it rational that the Cheaters always disrespect the finder-keeper norm? Under the title of deviant behaviour, there is a long research tradition in sociology that investigates the reasons for a lack of respect of norms which could advance theory construction here.

2.17

We suggest two modifications to advance the computational concepts of the development of norms:

- In order to model normative behaviour more sociologically we suggest imposing norms on all agents of a MAS, introducing a mechanism that decides whether they respect the norms, and introducing a mechanism that decides about the defence of norms.
- In order to model the conditions of norm violations more sociologically we suggest consulting sociological theories of deviant behaviour.

The Functions Of Norms

2.18

Whereas the computational study of norms has concentrated on distinct functions of norms, from the sociological point of view, we have in mind that the functions of norms are relative. They depend on time and space, like so many other social facts. It would not be surprising to find that certain norms may also impede co-ordination, or increase aggression. The same holds for norms and inequality. A certain norm may increase inequality, but under different conditions the same norm may decrease inequality. We suggest that to advance the computational study of norm functions it would be desirable to implement functional change in simulation models, in order to investingate the relative time and space-dependent functions of norms.

The Conte and Castelfranchi Model

3.1

The following design decisions are made by Conte and Castelfranchi (1995a) and Castelfranchi, Conte and Paolucci (1998): 50 agents are placed randomly into a two-dimensional world that consists of a 10 * 10 grid with connected edges (a torus). The initial strength of each agent is 40. Twenty-five food items of nutritional value 20 are distributed randomly on the grid. Each food item is replenished at a randomly selected location on the grid after it has been consumed. At the beginning of a match, agents are randomly allocated to locations and are assigned those food items which happen to fall into their own territories (their von-Neumann neighbourhood). Food possessed is flagged and each agent knows to whom it belongs. Several types of action that cost resources are available to each agent in order to find and eat food (see table 2).

Table 2: Types of actions in the Conte and Castelfranchi model

Action type	Order of preference among these actions	Cost of action (in food items)
EAT	1	0
MOVE-TO-FOOD-SEEN	2	1
MOVE-TO-FOOD-SMELLED	3	1
ATTACK	4	4
MOVE-RANDOM	5	1
STAY	6	0

3.2

Actions are supposed to be simultaneous. It may be that an agent does not get to perform its action because the conditions for performing the action are no longer fulfilled (e.g., two agents planning to move to the same position cannot both achieve their goal). Depending on built-in routines and knowledge, agents may decide to attack one another. Three routines are available: blind aggression ('attack an eater to get its food, unless free food is available at a lower cost'), strategic aggression ('attack an eater whenever you perceive it as no stronger than you, unless free food is available at a lower cost'), and normative aggression ('attack an eater unless the food item being eaten is marked as 'owned' by that agent', i.e. the finder-keeper norm).

3.3

An experiment consists of 100 matches, each of which includes 2000 games. During each game each agent performs one action. For each experiment, the number of attacks, the average strength, and the standard deviation of individual strength is recorded, and the significance of the differences tested. In the standalone simulation (homogeneous population) the agents using the normative routine do best at controlling aggression, promoting average strength, and keeping inequality low. In mixed populations (two subpopulations containing agents each of which behaves according to one of two routines, ratio 50:50) the normative strategy becomes the worst.

Resimulating Norms

4.1

We have resimulated the Conte and Castelfranchi model in three series of experiments:

1. replication
2. resimulating the relation between norms, social inequality, and the functions of norms
3. remodeling normative behaviour from a sociological point of view

Replication

4.2

First, we have reimplemented the Conte and Castelfranchi model in JAVA according to the model descriptions in Conte and Castelfranchi (1995a) and Castelfranchi, Conte and Paolucci (1998). We have resimulated their original model in order to guarantee that we can reproduce their results qualitatively. There are only small differences between our reimplementation and the original model: Actions are not executed simultaneously, but in sequence. This alteration is motivated by theoretical considerations: if the agents plan their actions and act simultaneously there are many conflicts between contradicting actions (like moving to the same position, or attacking the same victim). Planning and acting in sequence decreases the number of conflicts and the results of the simulation are less dependant on random resolutions of conflicting actions. Also, multiple aggressions do not take place. An agent is attacked consecutively by other agents, whereas it could be attacked simultaneously by several others in the original model. Simultaneous attacks result in higher losses than consecutive ones because an agent can be attacked as long as it is in possession of its food item. After the food item has been robbed it cannot be attacked any longer. As can be seen from table 4 our replication results reproduce the original results (table 3, reproduced from Castelfranchi, Conte and Paolucci 1998: 4.5) qualitatively.

Table 3: The results of the Castelfranci and Conte model

Strategy	Str	st.dev.	St.Dev	st.dev.	Agg	st.dev
Blind Aggression	4287	204	1443	58	9235	661
Strategic	4727	135	1775	59	4634	248
Normative	5585	27	604	41	3018	76

Source: from JASSS Volume 1, Issue 3, http://jasss.soc.surrey.ac.uk/1/3/3.html

Table 4: Replication results

Strategy	Str	st.dev.	St.Dev	st.dev.	Agg	st.dev
Blind Aggression	4848	38	1690	40	14134	139
Strategic	5962	24	1967	36	5798	63
Normative	7405	24	404	33	1809	61

Key to tables 3 and 4:
The results are gathered from sets of 100 matches for each Strategy. The values shown are from left to right: The average of the agent's strength (Str) at the end of the match, the standard deviation of Str, the average of the standard deviation (St. Dev) of the agents' strength values at the end of the match, the standard deviation of St. Dev, the average number of aggressions (Agg) occuring during one match, and the standard deviation of Agg.

The Relation Between Norms, Social Inequality, And The Functions Of Norms

4.3

Second, we reanalyze the relation between norms, social inequality, and functional change. Following our suggestions above we have two goals:

1. We want to demonstrate that the thesis that the 'finder-keeper' norm reduces social inequality while controlling aggression efficaciously holds only in egalitarian predator-collector societies. Throughout the majority of inegalitarian societies, it instead increases social inequality. This argument, which can be traced back to Marx, is investigated by use of computer simulations of artificial societies.
2. We want to demonstrate that societal evolution leads to functional change of norms: More concretely, we show that the finder-keeper precept while controlling conflict and establishing an equal distribution of resources in egalitarian predator-collector societies turns to stabilizing and promoting inequality if we allow private property and heritage, or private property, heritage and unequal renewal of resources.

First Experiment: Private Property And Heritage

4.4

To examine the effect of private property and heritage upon inequality in an agent-society we extended the Conte and Castelfranchi model: agents may reproduce and the offspring inherit the sum of the strength of their parents. To keep things simple and the number of agents constant we decided that one in 100 time steps each agent would have the chance to produce offspring. Then, the agent chooses another agent who is next to it within its von Neumann-neighbourhood. They unite their strength, produce two children, divide their total strength and forward it to the children. The parents die immediately and the children take their places in the grid. The whole reproduction process is completed in one time step. We varied the share the children inherit from their parents ($alpha_i = alpha_j = 0.5$ in experiment 1a, $alpha_i = 0.9$, $alpha_j = 0.1$ in experiment 1b). The results are given in tables 5 and 6.

Table 5: Private property and equal heritage ($alpha_i = alpha_j = 0.5$)

Strategy	Str	st.dev.	St.Dev	st.dev.	Agg	st.dev
Blind Aggression	4832	37	202	31	14153	125
Strategic	5935	29	244	32	5844	76
Normative	7387	27	77	10	1835	67

Table 6: Private property and unequal heritage ($alpha_i = 0.9$, $alpha_j = 0.1$)

Strategy	Str	st.dev.	St.Dev	st.dev.	Agg	st.dev
Blind Aggression	4852	34	7662	836	14059	130
Strategic	5958	32	9304	1074	5790	67
Normative	7404	29	11392	1227	1808	67

Key to tables 5 and 6:
The results are gathered from sets of 100 matches for each Strategy. The values shown are from left to right: The average of the agent's strength (Str) at the end of the match, the standard deviation of Str, the average of the standard deviation (St. Dev) of the agents' strength values at the end of the match, the standard deviation of St. Dev, the average number of aggressions (Agg) occuring during one match, and the standard deviation of Agg. Alpha i (j) represents the share that child i (j) inherits from the total strength of its parents.

4.5

As can be seen from table 5, neither the average strength of the agents, nor the number of aggressions change qualitatively. With variance, or inequality, however, the pattern varies. Private property and equal heritage prove to be extremely equalizing. The redistribution of strength due to the equal heritage reduces the inequality among the agents dramatically. This effect has no feedback on the number of aggressions or the average strength of the agents. The normative strategy is found to do best at increasing the average strength of the agents, reducing inequality among them, and reducing aggression.

4.6

As can be seen from table 6, when there is unequal heritage neither the average strength of the agents, nor the amount of aggressions change qualitatively. With variance, or inequality, however, the pattern varies. Private property and unequal heritage lead to extreme inequality. The redistribution of strength due to the unequal heritage increases the inequality among the agents dramatically. This effect has no feedback on the aggressions or the average strength of the agents. The normative strategy is found to do best at increasing the average strength of the agents, and reducing aggression, but now, it proves to be worst in producing inequality. Most interestingly, blind aggression now leads to the highest degree of equality!

Second Experiment: Unequal Renewal Of Resources

4.7

To examine the effect of unequal renewal of resources upon inequality in an agent-society we extended the Conte and Castelfranchi model. In human societies, the unequal renewal of resources is a social fact. Merton has called this phenomenon the Matthew effect (Merton 1968), whereas Zuckerman (1993) used but did not introduce the term cumulative advantage to describe the same phenomenon. According to the Matthew effect (derived from the New Testament according to St. Matthew 25,29) those who already own a portion of something shall be given more.

4.8

In our model, the nutritional value of food is no longer constant. When a food item is replenished and happens to fall at the same location as an agent, the nutritional value is set to depend on the strength (s) of the agent. The higher the strength of the agent during the previous time step the larger is the nutritional value (v) of the replenishing food item:

$$v_t = 20 + \text{beta}\,(s_{t-1} - 40) \qquad (1)$$

To avoid hopelessly deprived agents the minimum nutritional value of a food item is set to 20. Food landing on an empty position has the nutritional value of 20.

4.9

With this model, the nutritional value of food items may become very large. The nutritional value increases with time, as the agents' strength increases with time. For example, a food item landing on the cell already occupied by an agent of strength 5,000 would have a nutritional value 49,620 (with beta = 10.0). In order to avoid the dramatic increase of the average strength of the agents (the results would hardly be comparable to the results of previous experiments with constant nutritional value of 20 units) we introduce a time restriction. An agent cannot consume food items of more than 20 nutritional units at once. Instead, it eats away a portion of 20 in two rounds. Each food item is split into *n* portions of size 20, and to consume the portions the agent will need *n* * 2 time steps. For instance, it will need 6 rounds to consume a food item of 42 (42 is split into 2 portions of 20 units and one of 2 units). What we have in mind as the social equivalent in a primitive human society which respects the finder-keeper norm is a hunter having found a very big resource, e.g. a mammoth. The hunter and his family will be satiated very soon, but most of the mammoth will remain. The hunter and his family will need some weeks to consume the whole mammoth before hunting again. We tried to implement this logic in our model. In the experiments we varied the extent of the Matthew effect (parameter beta: beta = 0.2 in experiment 2a; beta = 10.0 in experiment 2b, and beta = 0.0375, removed time restriction in experiment 2c). The results are given in tables 7, 8, and 9.

Table 7: Unequal renewal of resources (beta = 0.2)

Strategy	Str	st.dev.	St.Dev	st.dev.	Agg	st.dev
Blind Aggression	5368	80	4832	116	18338	494
Strategic	7755	40	6070	88	2333	75
Normative	8569	20	2275	193	336	35

Table 8: Unequal renewal of resources (beta = 10.0)

Strategy	Str	st.dev.	St.Dev	st.dev.	Agg	st.dev
Blind Aggression	6655	322	7651	216	9228	1104
Strategic	8844	160	8453	176	241	31
Normative	9096	189	7879	341	42	12

Table 9: Unequal renewal of resources (beta = 0.0375), time restriction removed

Strategy	Str	st.dev.	St.Dev	st.dev.	Agg	st.dev
Blind Aggression	246394	3585	192707	22045	14114	141
Strategic	280354	3986	224561	27327	5798	74
Normative	842996	4552	331122	73152	1806	65

Key to tables 7 to 9:
The results are gathered from sets of 100 matches for each Strategy. The values shown are from left to right: The average of the agent's strength (Str) at the end of the match, the standard deviation of Str, the average of the standard deviation (St. Dev) of the agents' strength values at the end of the match, the standard deviation of St. Dev, the average number of aggressions (Agg) occuring during one match, and the standard deviation of Agg. Beta represents the extent of the Matthew effect.

4.10

As can be seen from tables 7, 8 and 9, the average strength of the agents is slightly greater. The normative MAS has the highest average strength and the lowest degree of aggression. Compared to the original model (see Table 1), inequality is much more pronounced. Aggression among the blind agents has increased because agents who sit on big food items can be attacked much more frequently. Aggression among the strategic agents is reduced because strong agents who sit on big food items are not attacked. Also, strong agents restrain more often from attacking others because they need longer to eat their bigger food items. In societies with highly unequal renewal of resources (beta = 10.0; beta = 0.0375 with removed time restriction) blind aggression proves to lead to the lowest degree of inequality! The equalizing function of the normative strategy has vanished. In experiment 2c the normative strategy becomes the worst with respect to equality. However, because of the extraordinary high values in average strength and inequality this interpretation should be treated with caution. In sum, in homogeneous societies, the finder-keeper norm

- minimizes aggression in all of our experiments,
- maximizes the average strength of the agents in all of our experiments,
- but its function with respect to equality depends very much on the initial conditions and the redistribution of strength. In MAS with private property and equal heritage the finder-keeper precept has an equalizing function. In MAS with private property and unequal heritage, and in MAS with highly unequal renewal of resources it increases inequality. If a society changes its structure from comparatively equal (e.g. a predator-collector society) to comparatively unequal there is a threshold that leads to a functional change of the finder-keeper precept with respect to equality (at present, we cannot specify this threshold value).

Remodeling Normative Behaviour From A Sociological Point Of View

4.11

Next, we will model normative behaviour from a more sociological point of view. Following our earlier suggestions we impose norms on all agents of a MAS, introduce a mechanism that decides about the respect or disrespect of norms, and introduce a mechanism that decides about the defence of norms. We consult sociological theories on deviant behaviour to specify the theoretical model.

Theory

4.12

We have decided to implement Haferkamp's theory of action approach to deviant behaviour. In his theory of deviant behaviour Haferkamp (1972, 1976, 1980, 1984, 1987) brings together the normative (Parsons, Durkheim) and the interpretative (Berger and Luckmann) paradigms, he combines the theory of action and system theory, and he integrates power and rule as conflict theoretical elements. Conformity and deviance are seen as two opposed kinds of social action which follow the same structural principles. His starting point is a multi-group society, not a fictional primitive society. It is not his intention to describe the original process of the production of deviant behaviour. Instead, he is interested in the social processes that lead within already existing social institutions to social behaviour which is labeled as deviant.

4.13

Haferkamp defines norms as conceptions which are internalized by the majority of members of a social situation. The conception implies the correct (re)actions to defined situations and the certitude that deviance will be sanctioned (Haferkamp 1980: 31). The concept of norms is central to the sociology of deviant behaviour. In his theory of action, norms are relevant as internalized rules of behaviour, behavioural expectations by others, and labels of deviance. As far as sanctions are concerned, it is the subjective probability to be sanctioned which directs behaviour. Power and rule are related to deviant behaviour in two ways. Those individuals who are most powerful rule and therefore decide about the definition and institutionalization of norms, and about the definition and sanctioning of deviant behaviour. Power and rule, as well as economic resources are distributed unequally.

4.14

According to Haferkamp (1980), norms are negotiated on the macro level. The negotiation process is structured into production, definition, integration, and identification. Societal groups differ in their abiliy to articulate their interests and the resources they can offer to other groups. This asymmetry is used by the groups which are more resourceful. They transfer some of their resources to the poorer groups in exchange for the institutionalization of norms which represent the interests of the resourceful. Thus, the negotiation of norms becomes the prescription of norms. In the end, it is the scarcity of resources and the efforts to overcome this scarcity that decide about the prescription of norms (Haferkamp 1980: 51). The resourceful and the non-resourceful internalize the norm. The resourceful are able and allowed to sanction deviant behaviour. This stabilizes the norm, and the stabilization of norms increases the power of the resourceful. In more complex societies, the resourceful delegate sanctioning and social control to new functional groups and pay them for their support (e.g. the police). In a multi-group society there is no balance of power between the groups. Instead, inclusive groups ('in-groups') recognize out-groups which produces a feeling of solidarity between the members of the in-group. In-group and out-group represent conformity and deviance from the point of view of the in-group (Haferkamp 1976: 100). According to Haferkamp, the out-groups, although exhibiting deviant behaviour from the point of view of the in-groups, may no longer be defined as anomic: They follow their own norms. As a consequence, in one and the same social situation, members of different groups expect different behaviours from their members. Following the distribution of power, only the deviation from the in-group's norms is defined as deviant behaviour and sanctioned.

The Model

4.15

In our model we implement Haferkamp's approach. We start from the Castelfranchi, Conte and Paoluccis later study with mixed populations (1998: 5.1-5.3). The modeling of the agents is extended as follows:

- **The agents live in a two-group society**, in-group g_1 and out-group g_2. Members of the in-group are more resourceful and have more power than members of the out-group.
- **Those individuals who are most powerful rule and therefore decide about the institutionalization of norms in society as a whole.** Each time step members of the in-group transfer some of their resources to a redistribution agent on the macro level in exchange for the institutionalization of norm n_1 in situation s_1 on the society level. Institutionalization on the society level means that norm n_1 is saved in the knowledge base of the redistribution agent. The redistribution agent redistributes the resources uniformly to all agents (Here, we deviate from Haferkamp who redistributes these resources only to members of the out-group. The problem is, that the redistribution agent in Haferkamp's theory would have to be omniscient about the membership of each agent with respect to in-group and out-group. This seems unrealistic to us). Each agent has internalized that on the level of the society norm n1 holds in situation s_1.
- **The agents are able to identify and define social situations.** If certain conditions are given agent a_1 (a_2) who is a member of the in-group (out-group) will identify and define situation s_1 as situation s_1. All agents know that situation s_1 implies norm n_1. Whereas agents of the in-group comply with norm n_1 and show behaviour b_1, the members of the out-group transgress the norm and show behavior b_2. Deviant behaviour is sanctioned by members of the in-group. Agent a_1 will sanction agent a_2 if it observes it reacting by behaviour b_2 to situation s_1. Whenever an agent of the in-group sanctions an agent of the out-group this will increase its power and decrease its resources.

4.16

The model was implemented using the finder-keeper norm. Situation s_1 is a situation in which an agent a perceives another agent b who has a claim to the food items which are placed in b's von Neumann-neighbourhood (the food is 'flagged' for b). Each agent has internalized that on the level of the society the finder-keeper norm holds in situation s_1. The members of the in-group (out-group) comply (not) with the finder-keeper norm and show behavior respect-the-finder (attack-any-weaker-finder, or attack-any-finder). These behaviours are the redefined agent's normative, strategic, or blind aggression strategies introduced by Conte and Castelfranchi (1995a). The agents live in a two-group society. The probability to be a member of the in-group (out-group) is 50 percent (This initialization was maintained in order to be able to compare our results to those of the original model by Conte, Casterfranchi and Paolucci. From a sociological point of view, smaller out-groups are much more interesting). Members of the in-group (out-group) have an initial strength of 40 (20) and an initial power of 20 (10) items. Each time step each agent of the in-group transfers 1 unit of its resources to the redistribution agent who is assumed to be located on the macro level (it has no location on the grid, it has no defined neighbourhood, it does not act due to the action types specified in table 2; in sum, it is very different from all other agents). The redistribution agent redistributes the resources uniformly to all agents. In-group agent a_1 will sanction any out-group agent a_2 if it observes it within its territory (von-Neumann neighbourhood) attacking any other agent a_3. Sanctioning increases a_1's power (+1), decreases its resources (-4), and decreases a_2's resources (-6). Most important, we have changed the mechanism of unequal renewal of resources. Food is no longer replenished depending on the individual strength of an agent. Instead, the nutritional value of food now depends on an agent's power (p):

$$v_t = 20 + p_{t-1} \tag{2}$$

4.17

The results are given in tables 10 and 11. (The experiment blind *vs* strategic is not of interest here because our argument concentrates on the normative strategy. We have changed the algorithm of the normative strategy. This strategy is not used in the experiment blind *vs* strategic. If we simulate blind *vs* strategic we would need two subcases, one in which the strategic are the in-group and one with the blind as the in-group. Furthermore, we would have to introduce sanctioning into the blind as well as the strategic algorithm in case this strategy represents the in-group. The results would not be comparable to the Castelfranchi, Conte and Paolucci experiment.)

Results

4.18

As can be seen from tables 10 and 11, in the mixed population case, the normative strategy no longer beomes the worst (as it was in the Castelfranchi, Conte and Paolucci experiments). The normative strategy is now better than the blind one (table 10). The average strength of the normative is moderately higher, the degree of inequality and the aggressions are lower. The transfer payments weaken the normative. Also, they have to pay for sanctioning the deviant behaviour of the out-group agents. These effects are almost compensated by the unequal renewal of resources that depends on the power of the agents. Here, the in-group members are privileged. Their power increases slowly but continuously by sanctioning the deviant behaviour of the out-group agents. As in the Castelfranchi, Conte and Paolucci experiments, the strategic agents are stronger than the normative, and the degree of inequality among the normative is lower than among the strategic (table 11). Most interestingly, the finder-keeper norm no longer controls aggression the most effectively. Aggression is moderately lower among the strategic: because of the sanctions, the power of the in-group agents increases. This increases their food items. The strategic now rob bigger and bigger food items from the normative. They need more and more time to eat the big food items they have robbed. They do not attack other agents while eating. Therefore, the attacks by the out-group agents decrease below those of the in-group. Eating big food items takes time. During that time, the food is not replenished. Therefore, there is a lack of uncontrolled food. The attacks of the in-group agents increase because they try to recover the big food items they possessed.

Table 10: Normative behavior from a sociological point of view; two sub-populations: Blind vs Normative (50:50)

Strategy	Str	st.dev.	St.Dev	st.dev.	Agg	st.dev	Pow	st.dev
Society	3647	111	2261	122	10352	1395		
Out-Group: Blind	3437	561	3038	174	7775	1164	10	0
In-Group: Normative	3717	635	759	129	2757	415	209	20

Table 11: Normative behavior from a sociological point of view; two sub-populations: Strategic vs Normative (50:50)

Strategy	Str	st.dev.	St.Dev	st.dev.	Agg	st.dev	Pow	st.dev

Society	4116	61	2236	252	7651	416		
Out-Group: Strategic	6195	93	1149	172	3793	428	10	0
In-Group: Normative	2086	461	584	129	3858	232	118	8

Key to tables 10 and 11:
The results are gathered from sets of 100 matches for each Strategy. The values shown are from left to right: The average of the agent's strength (Str) at the end of the match, the standard deviation of Str, the average of the standard deviation (St. Dev) of the agents' strength values at the end of the match, the standard deviation of St. Dev, the average number of aggressions (Agg) occuring during one match, the standard deviation of Agg, the average value of power (Pow) and the standard deviation of Pow.

4.19

However, this model has a serious problem. It is incomplete with respect to the power variable. The power of the in-group agents increases continuously, whereas the power of the out-group agents remains constant. Power is not consumed. The problem can be traced back to Haferkamp who has not presented a closed theory of power within his theory of deviant behaviour. We have to work on this problem and include a theory of power in order to be a convincing functional equivalent to Castelfranchi, Conte and Paolucci's later study with mixed populations and communication.

4.20

Nevertheless, we are convinced that it is a promising approach to include power in the computational study of norms. Following the game theoretic models, the computational study of norms has up to now ignored the importance of power in explaining how norms affect social behaviour, how norms emerge, become established and internalized, and change. In our model, we have introduced power as an important variable that decides about the institutionalization of norms and the distribution of wealth. At present, as the model has to be systematically tested with respect to the robustness of its results, we would like to stress the advance in theory adequacy that our model represents. The numerical results are also important, but only a sensitivity analysis will reveal systematically the critical values of parameters within the parameter space that lead to a functional change of the finder-keeper precept with respect to equality and aggression.

Conclusion and Future Work

5.1

In our experiments we have demonstrated that simulating artificial societies advances our knowledge about social norms, inequality, and functional change, and that the computational study of norms gains from a wider sociological perspective on norms that includes power.

5.2

We have given an example of the functional change of norms. The function of the finder-keeper norm with respect to equality depends very much on the initial conditions and the redistribution of strength. In a homogeneous MAS with private property and equal heritage the finder-keeper precept has an equalizing function. In a MAS with private property and unequal heritage, and in a MAS with highly unequal renewal of resources it increases inequality. We suggest it is necessary to investigate systematically the functional change of norms. We encourage all interested readers to consult Java applets of our simulation models.

5.3

Following the game theoretic models, the computational study of norms had so far ignored the importance of power in explaining how norms affect social behaviour, how norms emerge, become established and internalized, and change. By simulating Haferkamp's theory of action approach to deviant behaviour, we have demonstrated that it is possible to integrate power into computational models of norms. To improve our model, we will have to (1) include a theory of power, and to (2) make the model dynamic. At present, our implementation of Haferkamp's conception is static.

5.4

In the following, we will concentrate on the second question. There are two promising approaches to building a dynamic model:

1. Haferkamp's dynamic conception is that groups compete with each other and try to expand their norms to further groups. His explanation is on the macro level and he argues that on different levels of generality there exist different in-groups and out-groups. The in-groups try to extend their norms to levels of higher generality. On levels of higher generality personal contact between the members of the in-group becomes more difficult which leads to the formation of new in-groups on levels of lower generality.
2. Sutherland has given a dynamic explanation of deviant behaviour on the micro level (Sutherland 1983, Sutherland and Cressey 1966, Cohen, Lindesmith and Schuessler 1956). In his theory of differential learning he points out that criminal behaviour is learned behaviour. Criminal behaviour is learned in interactions with persons who show criminal behaviour. But the contact with these persons is not the crucial point. It is the contact with the deviant behaviour itself, the observation of the techniques and the motives that leads people to learn deviant behaviour from others. Sutherland assumes that a majority of contacts with deviant behaviour leads a person to learn and finally show deviant behaviour (this is a very simple assumption which was operationalized by Opp (1974: 165)).

5.5

First experiments have shown that there is a serious problem that has to be overcome before the dynamic model will succed. In contrast to the cellular worlds of Hegselmann and Flache (1998) and Nowak and Lewenstein (1996), in the Conte and Castelfranchi model grid positions not only represent social locations, but also geographical ones. The clustering which has proved to be a precondition for the survival of minority groups is not possible in a world with randomly distributed food. Thus, learning almost always results in equilibrium states where one group has been extinguished. This problem has to be solved before dynamic MAS will be as successful as game theoretic models in simulating normative and deviant behaviour of different subpopulatons (Vila and Cohen 1993).

5.6

Finally, we would like to encourage further experiments into norm-governed and norm-abiding agents. From the computational point of view, the advantages of norm-governed systems are avoiding useless, stupid, and self-destructive behaviour as favoured by the rigid execution of routines, as well as the spreading of errors and deviations produced by pure imitation. Therefore, it is promising to construct autonomous artificial agents with a capacity of applying norms. Like Castelfranchi, Conte and Paolucci, we have investigated the costs of complying with norms, as norm-governed systems not only have advantages, but also costs. From the computational point of view, like the Conte and Castelfranchi model, even our model represents norm-abiding behaviour using norms as built-in constraints. We should advance to more intelligent representations of normative behaviour, with norms as built-in ends, or built-in obligations.

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