Formal aspects of the emergence of institutions

Juergen Jost*†

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Abstract

We argue that social institutions emerge on the basis of the human cognitive ability to integrate an evaluation of the behavior and performances of other group members over long time periods. The results of those evaluations are condensed into the social status of an individual, and that status is the link between short time achievements and long term success within the group. Altruistic behavior on a short time scale can be advantageous for an individual on a longer time scale as it contributes to her or his status. Conversely, building mating decisions not on events that may be quite random on a short time scale, but on long term accumulations is an evolutionarily rational behavior because it reduces stochastic fluctuations by averaging. Our proposal does not need any group selection scheme. It calls some approaches to computer simulations of social dynamics into question. It is based on considerations from system theory, in particular, concerning the integration of different temporal scales. It utilizes a new concept of emergence as opposed to self-organization through non-linear interactions of simple elements. It requires further studies from the social sciences to understand that scale shift as encoded in social status.

Humans live in groups, and the life of a group is regulated by institutions that stabilize the social interactions between its members. Thus, the patterns of interaction become more durable and predictable for the individuals. These institutions are implemented through rules that can range from mere conventions and informal codes of behavior to formal laws in advanced societies. The individual members obey these rules and contribute to them often at a personal

*Max Planck Institute for Mathematics in the Sciences, Inselstr.22-26, 04103 Leipzig, Germany, jost@mis.mpg.de

†Santa Fe Institute, 1399 Hyde Park Road, Santa Fe, NM 87501, USA, jost@santafe.edu

cost. From the presently prevailing evolutionary perspective, this poses a puzzle because such a behavior seems to decrease the individual fitness and should therefore not be evolutionarily stable. The obvious solution seems to be that those institutions benefit the group as a whole and therefore also enhance the reproductive success of its members in comparison with members of less strictly regulated groups. This, however, in turn poses the problem that within such a group, always those individuals are at an advantage that exploit the institutions for their own benefit without contributing to their maintenance or enforcement, and so, those selfish individuals should evolve to dominate the group which then destabilizes because its institutions fall apart. For this reason, the concept of group selection has fallen somewhat into disreputation in evolutionary theory. One research strategy in this situation is to develop formal models that depend on certain additional factors, like a mechanism of increased competition between groups (e.g. [4]) or additional options for the individual behavior than simply cooperation or defection. In any case, the starting point of these considerations is usually that the members of a group benefit from mutual adherence to social norms, see e.g. [5]. These models are then tested in computer simulations, and sometimes predict the emergence of cooperative behavior, for example in the form of some kind of reciprocity in the interactions within the group. A good survey of such models and their comparison with empirical findings is given in [9].

In this essay, a more complex perspective on this issue is proposed. This will depend on certain system theoretic considerations developed by the author, see e.g. [11, 12].

The present study is not a historical one tracing the actual development of social institutions on the basis of archaeological records or historical documents. We rather try to understand certain social phenomena within a conceptual context. In doing so, we unsystematically mix examples from primitive societies or early stages of evolution with patterns from complex advanced societies. This is not meant to imply that we attempt to understand the patterns of behavior observed in contemporary advanced societies in terms adaptations developed in a more primitive hunter-gatherer stage of human evolution. We rather wish to capture essential features of the process of social history. A historically systematic analysis therefore remains a desideratum.

1 Formal approaches

In this section, we briefly discuss the merits and shortcomings of various theories that in some way or another address the issue of institutions. Economic theory, as exemplified here by its neoclassical version (see [18] as the classical textbook) primarily deals with market societies that employ money as the medium of exchange and can thereby easily quantify its concepts. In that theory, it is assumed that agents make rational choices to maximize their internally consistent utility functions. Institutions provide the framework in which agents can operate efficiently, and their emergence and maintenance is usually not included

in the theory, but rather considered as externally provided. A globally efficient equilibrium between supply and demand emerges, at least in an idealized situation, as the unintended result of the actions of the agents that pursue their individual advantages. The underlying mathematical theory describes aggregate quantities. So far, it has essentially been developed as an equilibrium theory (a classical text being [6]), and it remains a challenge to construct a mathematical framework for understanding non-equilibrium states and the resulting dynamical processes. While this is conceivable, a serious limitation of the theory is that innovations do not readily fit into the picture.

While, as mentioned, neoclassical economic theory is a theory of aggregates, the competitive interactions between individual agents have been formalized in game theory as created by von Neumann and Morgenstern. Such games possess stable equilibria where no player can increase his pay-off because any attempt to do so will provoke a counter-reaction from his opponent(s) that leaves him worse off than before. Rational players then will settle at such an equilibrium. Rationality implies here that each player knows the pay-offs of all players for any combination of strategies, and that the goal of each player is to maximize his pay-off at the expense of the other players (unless in a pure cooperation situation). In particular, each player is able to anticipate the reactions of the others to any move of his own and can then select his own move accordingly.

Game theory constitutes a link between economic and evolutionary theory. In the latter, one investigates population games where each agent plays repeated games against randomly drawn members of his own or some other population. Here, agents discover inheritable strategies by chance mutations and differentially reproduce according to their cumulated fitness, the score in the evolutionary game. Institutions in the sense of stable patterns of interactions or implicit conventions obeyed by the actors emerge as unintended consequences of individual actions at the group level. (We should note, however, that the meaning of institutions in this context is different from the one presented in the introduction, insofar as it only refers to those interactions that are formalized in the game considered.) The problem then is that the pursuit of individual advantage may destabilize group beneficial institutions, or even prevent their emergence. While agents can discover new strategies in the evolutionary process, in practice, that is, in simulations of a formal model, the limitations of the available strategy space usually prevent the appearance of more than rudimentary innovations. An important point is that the rationality criterion in evolutionary game theory has changed to the reproductive success of inherited strategies. In fact, what I see as a fundamental problem of the application of game theory to evolutionary dynamics is that it is assumed that the, perhaps accumulated, success in the game as a measure of fitness directly translates into evolutionary success. In other words, an extrinsic measure of fitness, namely the score in a predefined game, is often uncritically identified with an intrinsic measure of fitness, namely the reproductive success. Game theory can explain evolutionary dynamics only as far as the extrinsic measure is chosen well enough that it is strongly correlated with the intrinsic one. This issue is usually not addressed. It seems, however, that for understanding the emergence of institutions in soci-

eties, we need to understand how the score in a repeated game translates into the production of offspring. We need to identify the missing link, and anticipating the reasoning below, this should be provided by some form of social recognition, status, prestige. In particular, this link is indirect, and we shall identify that as a source for the emergence of institutions. This link will be different from the role of reputation arising in evolutionary game theory. Namely, it is an important insight from game theory, see e.g. [8], that in repeated games whose outcome for the individual players can be improved by mutual trust, players can build up a positive reputation of being trustworthy and thereby enhance their long term gains.[1] Our mechanism will be rather different; namely, the reward will be decoupled from the outcomes of the individual games. This will then necessarily lead to a shift of strategies. In a certain sense, we shall change the rules of the game rather then the strategy space, however. This is a point that cannot be analyzed within standard game theory. Of course, one may think of extensions like meta-games, but even that should have difficulties in capturing the issues of emergence and scale shift emphasized below. The problem is that a new meta-level needs to be defined a priori and cannot emerge a posteriori in the formal setting of game theory.

We also need to return to the rationality issue. The rationality assumption in neoclassical economic theory has been criticized on the ground that humans do not always behave fully rationally in the sense of economic theory, and it has been proposed to replace it by some version of bounded or limited rationality. On the other hand, evolutionary game theory also falls short of the reality of human societies when it stipulates that optimal strategies can only be acquired via selectively stabilized mutations of genetically encoded strategies represented in the population. In other words, given the intellectual capabilities of advanced primates and proto-humans, one should rather expect that the ability of a rational individual strategy selection, including the ability to choose one's strategy on the basis of the anticipation of the reactions of other group members, should be acquired in the course of the evolutionary process. But this expected result is neither completely compatible with the experimental findings (see the experiments of Fehr and Gächter [7]), nor does it offer an explanation for the emergence of institutions in human societies. Humans are intrinsically clever, and if they rationally pursue their own advantage – as every agent in an evolutionary game is supposed to do –, they should exploit the group solidarity recklessly and contribute to the group structure only when they are rewarded. Altruism is evolutionarily stupid (except in cases of kin selection). Punishing defectors is risky and costly. How can then schemes of indirect or delayed reci-

[1] In this regard, there is also the approach of [10] who analyze the concept of prestige as freely conferred deference by other group members as the means of identification of those group members who can serve as useful role models in processes of social learning. The idea there is that learning by imitation of others that have particular valued skills is evolutionarily advantageous as it is often more efficient than individual learning. Trasnferred to a game theoretic setting that would simply mean to copy the strategies of successful conspecifics. The additional point in social anthropology is that those copied individuals also gain something from being desirable targets of imitation, namely prestige. That prestige then confers other advantages in social interactions.

procity be established and maintained? Why do people insist on fairness and contribute to group institutions? Selection between groups as an explanation is also doubtful because selection tends to eliminate the differences between groups.

2 Reduction of external complexity through scale shifts; robustness

Since any system depends for maintaining its internal operations on regularities provided by its environment, it constantly needs to reduce external complexity in internal models, that is, transform external data into internal meaning, and this in turn can then be the basis for supporting more complex internal processes. This is often efficiently achieved by a shift of complexity to a different scale. A simple example is food sharing. When the food sources are unpredictable at some smaller time scale, in the sense that they fluctuate a lot around their average values, then it is a good strategy for a group to dampen these fluctuations by food sharing. In abstract terms, this is simply an application of the law of large numbers. When one averages over many independent, identically distributed random variables, the result comes closer to the expectation value because the independent fluctuations balance and cancel each other. When individual hunting success depends on chance encounters of prey, the result for every individual becomes much more predictable when everybody shares his captures with the rest of the group. Of course, this leads to the problem of free riders, that is, group members that do not contribute to the effort of catching prey, but still take their share of the results distributed by their fellows. This issue will be taken up below. More advanced social systems make use of such scale shifts in a sophisticated manner. We find an interplay of differentiation and integration, of tight and loose coupling on different, interacting, but partly autonomous temporal and spatial scales. In particular, complexity can be shifted between scales. As already explained, fluctuations and randomness at one scale can average out to produce regular patterns at some higher scale. This is well known and often applied in physics, but it also seems to be a fruitful principle in the social sciences. Conversely, rigid regularities at a lower scale can lead to uncontrolled fluctuations at a higher scale because the system may loose some of its flexibility. This has been explored in a profound manner by van der Leeuw and his group [19]. In general, robustness – which in any case is a meaningful concept only relative to some internal process – at one scale is achieved through flexibility at another scale.

Even in game theoretic simulations, one can sometimes see the importance of a second, longer time scale. In [13], a complementarity game with many equilibria was simulated in a population setting. Which equilibrium is attained depends on the population history, and an individual player entering the game performs best when acting in agreement with that equilibrium that she has to accept as given. On one hand, this constrains the possible options promising a decent

outcome, but on the other hand, it also simplifies the setting for the individual agents. In fact, those simulations also show that agents with smaller strategy spaces, that is, fewer options available, typically perform better in such games in an evolutionary setting because they can find a good solution more easily. Conversely, populations containing some erratically acting, and therefore less successful, individuals are at an advantage when playing against the more predictable members of other populations because they can drive the population equilibrium in their favor. So, once more we find that some small scale flexibility can convey an advantage at a larger scale.

The flexibility at one scale can even go so far as to abandon the identity of the constitutive elements at that scale. Recent advances in general system theory, like the theory of autopoietic systems of Maturana [17] and Varela, constructivism as a theoretical framework for understanding cognition, or Luhmann's theory of social systems [16], have put the emphasis on the continuation of a process rather than the reproduction of a structure. This makes the constituting elements exchangeable, and the system can become very flexible at the level of those elements. Those elements can not only get replaced continuously, but their structure can also undergo profound changes, thereby making the encompassing process more resilient against external variations or systematic trends. Taking this insight seriously can call the relevance of agent based modeling for understanding complex systems into question. Of course, such a conceptual approach seems to be necessary for a theory of cultural evolution that can conceive institutions as primary elements, instead of as derived structures of a genetic evolution of human traits.

We have discussed that a system can convert external fluctuations into more regular patterns through shifts of scales. In contrast to this, it can also be beneficial for the system to produce internal fluctuations. Internal fluctuations of a system can on one hand enable it to maintain a (partial) independence from its environment by making it less predictable from the outside and shielding it from direct external control, and on the other hand generate the necessary variations for alternative internal options.

The mechanism of increasing robustness through shifts of complexity between scales is an important one, but we still need to explain in a concrete situation how it emerges and is maintained. We need one more conceptual consideration before addressing that issue in the case of social institutions.

3 Emergence

It seems that the presently dominant research paradigm in formal approaches to complex systems is built around the concept of self-organization. This is usually understood in the sense that complex behavior arises from local non-linear interactions of simple elements. Sometimes, these elements are only capable of the most rudimentary alternative, namely a binary choice. The complex behavior of the system arises because the choice performed by an element influences the choices of selected others according to some fixed (or, sometimes, evolving)

rule, and in turn that element is influenced by certain other ones. If institutions can be understood as the result of such self-organization processes from local interactions according to specified rules or rule classes from extremely simplified elements, then it is not clear why other animals did not produce complex social organizations. Human individuals are themselves very complex, and guided by that, we propose a concept of emergence as an alternative to the outlined one of self-organization. That means that the coordination of intrinsically complex elements reduces the individual degrees of freedom, but can lead to emergent behavior at some higher level that the individual elements are not capable of. This coordination can be achieved by a central commander, but, more interestingly, also from local interactions. Perhaps the simplest coordination mechanism is synchronization. This can also be studied in formal models. Kaneko [14] discovered that when chaotic oscillators are coupled, they can synchronize their chaotic behavior. This, however, represents only the first step of our emergence scheme, as only the degrees of freedom are reduced because the oscillators are no longer capable of independent behavior. Atay and Jost [1] then found that in the presence of transmission delays in the local interactions, the coupling of chaotic oscillators can generate a new type of regular collective behavior on a longer time scale. While the details of this effect remain to be further explored, this represents a formal exemplification of our abstract concept of emergence, still, of course, in a rather simple setting.
Some aspects of emergence are also well illustrated by Leroi-Gourhan's analysis [15] of the evolution of human techniques as externalizations of physical actions. First, the actions of the hands and the mouth get externalized as hitting or cutting tools, then the physical action of the arm is transferred to a thrown object, next the mechanical force itself is externalized into a harnessed animal or a man-made machine, and then even the control itself is shifted to electronic devices. Incidentally, this view of technical evolution also clearly shows that the concept of innovation as usually employed in economic theories as technical improvement or invention of new products or production methods is too flat to capture the essence of those transformations.

4 Social status as transformation of scores to a different scale

Individual members of human groups or societies are never completely equal. Besides differences of their physical or cognitive abilities, they are usually distinguished by their position in the network of social interactions. Social rank, expressed and enforced by power, is a more formal such distinction, but the informal one of social status that is based on respect received instead of power exerted may often be even more powerful. Social status reflects the standing of an individual within a group, leads to some unsymmetries in the interactions with other individuals of different status, and may regulate the access to scarce

items or services by group consense.[2]
On the basis of the preceding abstract considerations, we propose here social status as a mechanism that decouples success from immediate reward, but rather integrates it over some period of time. Founding the selection of a mating partner upon time averaged success rather than upon the randomness of temporary one is a rational strategy in the evolutionary sense.
We now explain how that can lead to an understanding of social institutions. The key point is that group beneficial behavior at one scale can become advantageous for the individual itself at a longer scale. This, in fact, is also a fundamental aspect of religion. The traditional catholic dogma essentially says that one should perform acts of charity towards one's fellows in order to be rewarded in afterlife. Thus, again, the most altruistic deeds will eventually turn into individual reward. The protestant doctrine of election and predestination circumvents this issue. It is resolved only in the concept of a bodhisattva in Mahayana Buddhism. In any case, because altruism on the short time scale can turn into benefit on a longer one, we do not need any group selection scheme. This scale shift is made possible by the evolution of the human cognitive capabilities, in particular by an ability to memorize and integrate individual behavior of group members over a longer time scale and a restructuring of the mating system on the basis of those results. We have explained above how a system can reduce external randomness and uncertainty by averaging over longer time scales. When we apply this insight to the strategy for selecting a mating partner, this means that the partner should not be chosen because of short term achievements, but rather on the basis of his or her performance over a longer period of time, in order to select that partner that can be expected to contribute most to the success of the offspring. Some animal species have developed sophisticated courtship schemes for testing possible candidates. Humans, in contrast, are able to draw upon a much more powerful memory. In particular, they are able to identify individual group members consistently over any span of time while most animals can only form fleeting relationships with buddies and at most identify their own mate they have already bonded to over longer periods, but are unable to keep track of various group members and compare their records over such longer periods. Primates and perhaps some other mammals can apparently maintain individual distinctions between group members, but they are still not capable of incorporating long time performances into their mating decisions. While the channeling of the sexual energies of their members is an important aspect of all human cultures, still humans obviously do not decide about their matings in a fully conscious and rational manner. More precisely, the individual mating partners may rather follow subconscious patterns of sexual attraction. In most advanced cultures, however, mating choices are not made by the individuals concerned themselves, but rather by their families. This provides better opportunities for implementing appropriate criteria. Even

[2]The terminology here does not seem to be generally agreed upon. [10] contrast dominance as status achieved by agonistic means and prestige as status based on admiration of others for superior skills. The spirit of that distinction is similar to ours, a difference being that they emphasize the more domain specific aspects of prestige.

in simpler societies, control over daughters by their families leads to strict selection criteria for their husbands, and these typically not only include individual abilities, but also group beneficial behavior and strict adherence to social rules. Some of this is easy to understand in terms of advantages to the in-laws, in particular in matrilinear societies. But these are probably later developments, and for understanding the emergence of institutions, we need a mechanism that transforms short term success and achievement into a long term pattern of mate attraction. Evolutionary theory tells us that the participating individuals need not be consciously aware of that scheme, even though it may heavily draw upon their cognitive abilities. In the case of human societies, this mechanism is provided by social status. Here, we want to distinguish the concept of status from the one of reputation as employed in evolutionary game theory. There, one can build up a reputation of being a fair or cooperative player and can thus improve one's chances of also being treated fairly by others. This refers strictly to the individual interactions defining the game under consideration. Social status rather is the standing of an individual in the society that is gradually accumulated over longer periods of time as the result of many individual actions and interactions, like reputation, but in contrast to the latter need not convey a direct advantage in those interactions. It will rather show its advantage on a larger temporal scale or in other types of interactions.

Since social status is not the result of conscious computations, it will stabilize itself evolutionarily through the most efficient implementation scheme. As the story of sexual selection in biological evolution tells us this need not necessarily lead to the individually most beneficial result. Concretely, for a successful hunter, the best way to increase his social status might be to share his prey with the other group members in an ostentative manner so that his success and his generosity will be deeply remembered over a long time and his mating success consequently enhanced by making him attractive to the best females in the group. Conversely, a female that makes some innovation in developing a new food source should share that innovation with the rest of the group instead of keeping it for herself in order to enhance her own status or that of her offspring. So, instead of seeking the short term gain by consuming the newly discovered food herself and becoming attractive by being fatter, she rather lets others participate and becomes attractive as an inventive person that can discover new sources and guide others. Again, this scheme does not need to invoke any conscious decisions. In the same way that sexual attractivity in humans seems to be little controlled by conscious factors, then also those mechanisms that increase one's prestige within a group seem to be quite rigidly wired into humans, either through genetic inheritance or through socialization processes. This improves their performance and reduces the risk for an individual of social failure. In fact, as Bateson [2] argued, genetic hard-wiring of adaptive behavior decreases the load on individual adaptation and increases the flexibility of an individual towards less predictable external fluctuations.

Of course, there are also competitive mechanisms within the group at work, like envy. Namely, it is in the interest of the other group members to prevent a

successful status increase and resulting mating advantages of one member. [3] If status were solely based on food accumulation, then gangs of envious other group members could easily deprive any successful individual of his gains. Distributing acquisitions generously within the group then is a mechanism to deflect that envy and still acquire social prestige. So, seemingly altruistic behavior like food sharing becomes a good strategy for avoiding conflicts with rivals and at the same time gaining social reputation as the basis for finding good mating partners. The precise details of the process of the acquisition of social status can well be shaped and determined by the contingencies of sexual selection and the like. It only needs to be self-enforcing and reasonably stable against perturbations. Self-enforcement is easy in principle; namely, in a group where a particular feature contributes to social status and thereby indirectly to reproductive success, all group members will strive towards that feature, and its link to reproductive success will become tighter because it strengthens its role as a mate selection criterion.[4]
So far, we have addressed only rather simple institutions, like the conventions or patterns of food sharing within a group. The mechanism, however, is general. Whenever the contribution to durable and group beneficial patterns of interaction gets linked with social status, which in turn conveys long term benefits, it will be stabilized.

5 Concluding remarks

Our explanation scheme for the emergence and stability of social institutions has several consequences:

1. It points to the importance of the interplay between different scales for an understanding of complex systems.

2. It is not easily accessible to agent based computer simulations. In fact, such simulations so far are not even able to reproduce the presumably simpler effects of run-away sexual selection. A basic reason for these difficulties is that in all evolutionary or genetic optimization schemes, the fitness criteria are externally provided and fixed. It is precisely the purpose of these optimization schemes to find a strategy that yields a high score on some given fitness function, and the methods work because that score translates directly into reproductive success. In contrast, in the scenario developed here, that translation of some score into reproductive success is intrinsically developing within the system. Whatever counts for real biological entities is not any score on some external fitness function, but

[3] Such egalitarian tendencies and aversions to dominance hierarchies have been widely documented in the ethnological literature and comprehensively analyzed in [3].

[4] The relationship between social status and reproductive success can also work in the other direction. In many societies, having many sons increases the prestige of a father. In other cases, people strive to have many children not because they want to reproduce in future generations, but rather becasue having many children guarantees a comfortable old age.

only reproductive success itself, achieved by whatever means, perhaps by bypassing external constraints imposed instead of satisfying them. This seems to be a fundamental challenge for any artificial life project. In an evolved social system, reproductive success occurs both at the level of individual agents and at the level of social norms or institutions, and this obviously compounds the difficulties.

3. It focusses not on competition between groups, although that unquestionably also plays an important role, but rather on group intrinsic mechanisms based on higher cognitive abilities and individual long term memories. It therefore is not readily amenable to simple formalizations as in game theory.

4. It predicts that at some stage, there has been a positive correlation between social status and reproductive success. It does not imply, however, that such a correlation always exists, for the reason that social institutions can utilize mechanisms of cultural evolution to counteract pressures from biological evolution.

5. It is not possible to explain the details of social institutions without a basic contribution from the social sciences. The issue here is the structure and function of social status as the link between short time achievements and long term reproductive success, and this is at the heart of social theory. In fact, this requires a deeper level of social studies than simple tests about the behavior of individuals in artificially isolated laboratory situations. We need an understanding of social processes including the self-reinforcement of socialization schemes in the context of a culture, and of the various ways of display as means for social status increase and their long time effects on the success of an individual within her or his society.

Our scheme also leads to various questions for social science research:

1. We need to understand better to what extent in a given society novel types of individual behavior can positively or negatively affect social status. What kinds of fashion can a society tolerate and perhaps even reward for their innovative aspects, and which kinds of display will get rejected as deviant?

2. The status acquisition scheme within a society can perpetually change. What types of invariances are required here within or between cultures?

3. What is the relationship between social status and power? This is relevant because power is a scheme for establishing long term structures of social control that might compete with status.

4. Can our scheme guide a historical study of the emergence of social institutions? As already explained in the introduction, the present study neglects the historical dimension, and incorporating the latter is desirable.

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