Chaos and Annealing in Social Networks

Faris Shafee

Department of Physics
Princeton University
Princeton, NJ 08540
USA.

In this work we compare social clusters with spin clusters and compare different properties. We also try to compare phase changes in market and labor stratification with phase changes of spin clusters. Then we compare the requisites for redrawing the boundaries of social clusters with respect to energy minimization and efficiency. We finally do a simulation experiment and show that by choosing suitable link matrices for agents and attributes of the same and of different agents it is possible to have at the same time behavior similar to chaos or punctuated equilibrium in some attributes or fairly regular oscillations of preferences for other attributes, using greatest utility or efficiency as a criterion for change in conflicting social networks with different agents having different preferences with respect to the attributes in the agent himself or with similar attributes in other agents.

PACS numbers: 89.65-s, 89.65 Ef, 89.65 Gh, 89.75 Fb
Keywords: social dynamics, phase transitions, social evolution

I. INTRODUCTION

In economics, every agent behaves rationally to maximize his or her utility curves. However, in an imperfect world, not all the people we know look rational. Phenomena like war and spite look very contrary to what a rational person would do to maximize his or her material needs.

The reason human interactions are possible, and it is also possible to have a coherent system of trade and negotiation is explained by the idea that a common set of needs and understanding are shared by the majority of people. Classical economics deals with this set of needs and formulates equations for every possible deal. However, it fails to account for the so called irrational human behaviors. If a set of scientific data observed by most and possible to be experimentally verified by the majority did not exist, social networks would perish. However, together with the existence of a network with a common set of knowledge, exist phenomena like revolutions, hatred, riots, and many basic instincts not explainable by a concrete set of knowledge. Attempts have been made to justify irrational behaviors as weak, inconsistent or culturally inferior and evolution-wise unfit. However, in this paper, we try to understand the fine structure of human perceptions and needs to model possible chaotic and annealing behaviors of social lattices from a spin glass point of view without any a priori bias towards a certain logic system successful in adapting with nature at a certain time point.

Previously, we have tried explaining the non quantifiable human needs and the variations in utility curves by taking Gödel's incompleteness theorem into account. In discrete math only the states 0 and 1 exist for switching. In the real world, of course, there can be many states in between corresponding to a continuum. However, one can also consider only extreme conflicting cases that are opposites in a simplified picture. We have argued that although strategies to maximize needs might be rational, the needs themselves might not be a "common rational" set of constants. As any logic system is based on a set of axioms that are by themselves not provable within the logic system itself, and the axioms or sets of information are acquired by each agent individually by interacting with its environment and other agents, not all agents necessarily need to share the same set of axioms or needs that they tend to optimize. Some needs, however, might be very common and "material" whereas some other needs are quite hard to quantify. We try to explain the branchings of these spin clusters to chaos and annealing by taking this unprovability theorem into account. We argue that although majority of the people must agree on a majority of utilities and perceptions, fine structures in variables that define agents and their perceptions or utilities connected with other variables in a lattice may cause chaotic behavior or annealing when placed in an interacting lattice.

In our simplified model, we describe each agent as an n tuple of qualities and needs. We call each of these entries in an "array" possessed by the agent as a variable. We start with a set of basic quantifiable needs that an agent tends to maximize in this paper. We also define a set of
variables that an agent possesses that he/she can use in order to maximize the needs. The second set will include skills that the agent can trade and calculating efficiency to interpret the other agents’ needs as subsets. The third set will define a set of easily discernible variables that other agents can use to mark or tag an agent. We can then describe each agent as a multivariable spin state, and investigate how it interacts in a social cluster and with nature.

II. THE DEFINITION OF "SELF"

We define an agent’s "self" as an array of variables possessed by the agent. In our model, the idea of self, instead of being an object contained within a body, will be rather a slowly weakening concept of the self similar variables. We use the term slowly weakening because the idea of "self" decreases as another array contains fewer variables in common and also the strength of the "bonds" as a function of physical or need wise distance. By need-wise distance we mean the placement of a variable in a position where it can be influenced by the agent or from where it can influence the agent. This distance is not necessarily solely a geographic distance. As a result, our model of "self" is a fractal like model with a basic array of variables forming the shortest unit. As we include more and more self similar variables from other agents placed in a cluster but also containing dissimilar variables, the idea of self weakens.

The "existence" axiom is related to a concept of "self". But in this paper, we propose making the definition fuzzy. Networks arise because people associate with others who are similar to themselves in some respect. In our model, each agent can be defined as finitely or infinitely many variables in an n-tuple or an array. An agent will identify the array with the definition of self. However, the variables are connected to the concept of "self" with certain weight factors which may be modifiable. An agent chooses to maximize the utility curves for him"self". He may choose to perpetuate different variables related to "self" with more energy invested. This preference, again, is complex, and may not be definable by simple functions. However, the other agents in the cluster also possess an array of variables and may or may not have the same value as the first agent in each of the variable slot. We can say that an agent will "identify" with other agents who possess similar values for the variables. This extended fuzzy idea of "self" may create some loosely or strongly defined clusters where the agents relate with self-similar structures in specific variables. The affinity with agents may also be a function of time, as which variables an agent would tend to find more important may be a dynamic function of time. When an agent invests in perpetuating "self", we thus add a correction term to the self that includes other agents possessing similar variables. However, granted that no two agents are similar in every possible variable, any investment in perpetuating other agents with similar variables also comes with the cost of perpetuating some dissimilar variables.

These affinity clusters may be modeled as follows: We can describe an agent as an array of variables. The variables may have discrete 0 or 1 values or continuous values within a range. Within the social lattice, we can say that each of these spin type variables is coupled to the similar variable slot of other agents. The coupling will depend on a coupling strength, which might be a function of time, and also on the values of the variables in the two agents. What is interesting here is that the agents may or may not have knowledge of the proper values for the variables. So each variable in an agent has an actual value and also a value perceived by the other agent/s. The individual utility curve can get distorted because of this "affinity factor" as the corrected utility would be the utility of the individual corrected by a weighted utility of the affinity group. The affinity factor will reflect an agent’s perception of other agents’ variable values. A miscalculation or bluffing on other agents’ parts will cause the agent to invest energy in perpetuating dissimilar or contradictory variables. However, each member within a known affinity group will have the individual affinity and the corrected group affinity both playing a role in the utility curve. Moreover, the group utility is a factor that is shared by all members of the group, and each individual will tend to utilize the other agent’s affinity points to gain an increase in utility at no or little expense of ones own cost of entropy. As a result, it might be profitable to "net utility" to invest in increasing other agents’ affinity utility factor. Again, investments made in maximizing group affinity utilities from others will result in an expenditure within a closed subdomain. If the total amount of investment, or energy to be spent is kept constant, an increased investment within the subdomain will reduce investments in games with other subdomains and with nature. As a result, agents in a subdomain playing against each other with a large weight factor to increase each others group affinity factor will have less to invest in games outside the subdomain. Again, bluffing about ones variables might be a strategy an agent uses to gain group affinity points from agents with dissimilar variables with no expenditure of group affinity from the agent’s own side. We can check out by simulation cases where agents who are indeed sharing affinity variables are put together in a cluster, and clusters where some concealing agents are mixed.

The other interesting property of this notion of "self" is that the variables in the unit array are dynamic. As a result, the idea of self will change with time as external variables change. However, as the basic array gets modified, so does a person’s perception of “self” and the affinity clusters that appear as weaker versions of "self" also redraw their boundaries.
III. VARIABLES AND THEIR EVOLUTION

A. Knowledge, Preferences

Knowledge is a set of information that an agent obtains by interacting with nature and other agents. Knowledge is obtained by symmetry breaking and provides an agent with a rule or a measurement that is in a collapsed state and can be used in the future to play against nature. A knowledge or piece of information can be used to satisfy the agent’s preferences of what should be done in the future. Although knowledge can be shared among agents, so that agents can decide on a possible set of largely overlapping common knowledge, the preferences about how these knowledge pieces should be used to interact with nature is not necessarily a common set of knowns. Preferences or utilities, may vary in importance or weight from agent to agent. Some of the utilities are fixed, and some are not. Pieces of knowledge are combined with resources that can be explained as specific sites of interactions with nature can be used to change nature. Given a finite amount of resources, with many possibilities of investment in future games, the “choice” of the optimum investment remains unfixed. Agents use the set of knowledge they possess to interact with nature using the resources to change nature to accommodate their preferences. In appendix A, we discuss a theoretical model for a group of agents possessing a largely overlapping knowledge and preferences.

B. Skill and Aptitude Variables

The interactions of the agents with nature in order to modify nature depend on both skill and aptitude. An agent can modify his ability to interact with nature by repeatedly interacting with nature. It is a mechanism of adaptation by which the agent learns to optimize his efforts to interact in a certain way. However, the innate ability of an agent to interact in a certain way or perform a certain deed can be contributed as talent or aptitude. An agent with no aptitude will need to invest a higher amount of time and energy to master a certain task. We can model aptitude as follows: We can assume that each agent is born with a group of preference curves that are slightly different from other agents’ preference curves. The curves can be modified by interacting with nature, and can be brought to roughly resemble another person’s preference curve distribution. However, adaptation and learning will create an exact match with another distribution very rarely with the increase in number of variables and steps in learning process involved with a certain distribution. A certain distribution, gain, can be optimized to interact with nature in specific ways and produce specific results. A certain agent’s aptitude for a certain job may also be interrelated with his or her aptitude for other specific jobs as performing a certain group task optimally may require sharing one or more preference variables. However, these fine tunings are very rarely going to match an exact optimized result need, and can be taken as a random function of chance over all agents.

C. Self and Mutability with respect to Fitness

An agent will try to perpetuate himself and in order to do so, he will play against nature and against other agents. We tried formulating this game in our first paper. However, while playing against nature, a certain set of variables will be fitter at a certain time space point than other. An agent will try to dynamically change the idea of “self” to make himself fittest to perpetuate. On other words, an agent will either change variables to be placed at an optimal condition with respect to nature, or change nature to fit himself best. As a second strategy, an agent will try to include other agents with optimal variables in the cluster of “extended self”. This can be done so by mating with an agent with the coveted variable to include the variable in the agent’s own array.

D. Optimized variables and Bluffing

The agents use their set of variables to play against nature and also against the other agents competing for a finite resource offered by nature. So although an agent may be interested in utilizing another agent’s more optimized variable, they are also playing against each other to maximize the perpetuation of their own variables. At a certain time point, an agent may not have a set of variables that are all optimal with respect to nature. Agents can at that point form a network where more optimized variables of one agent are used by another agent in return for the other more optimized variables of the second agent. However, the possession of more optimized variables puts an agent in a position with higher bargaining power. The game at this point can very easily be modeled in the same fashion as several agents with cards with higher or lower values. An agent may show the value of the card before placing a bid in the game or bluff. In a pioneering theory on game theory, the authors argue how bluffing is an essential strategy of any such game. Similarly, in the game of social lattice, equilibrium points are achieved by bluffing and trying to interpret the correct optimizations of the variables possessed by other agents. The inclusion of an optimized variable in an agent’s array by mating with an agent possessing that variable, also includes variables previously not in that array and not optimized with respect to nature in the array of the agent. This new array will for a new definition of self and will thus isolate the agent from its older cluster defining self if the newly introduced variables are dissimilar enough with the first set of variables. As a result, an agent not wishing to break his former ”self” cluster might as well find strategies to make use of the other agent’s optimized
variable without making the second agent part of him "self".

E. Correlated and Uncorrelated Variables and Their Interpretations

Variables may be obtained by genetic inheritance or by interactions with nature and with other agents. Again, the variables an agent possesses may or may not be correlated. Moreover, they may appear to be correlated if they are placed in a certain environment for a certain time period and then become uncorrelated when the agent is removed from the environment. For example, if placed in a certain environment that requires optimization of two variables for survival, an agent may develop specializations in two factors. However, if the agent is removed from the environment, it is possible for one of the variables to become randomized while the other remains fixed. Again, some variables may be dominant and others recessive. As a result, mating among specialized agents and non-specialized agents may produce off-springs that are specialized in one variable but not specialized in the other.

F. Interpretation of Variables

Some variables may be easy to understand whereas others may require a heavier investment of time and energy for interpretation. We can say that some of the variables are easily visible but others are not. However, if two variables are "assumed" to be correlated, interpreting the more easily visible one saves time and energy that otherwise would have been spent in interpreting the second one. This process may be efficient as long as the two variables are in reality very closely correlated, and the risk of the variables becoming uncorrelated is very small.

G. Difference with a Parochial Cluster

Networks arise partly because agents choose to associate with others who are similar to themselves in some great respect [4]. In Persistent Parochialism: Trust and Exclusion in Ethnic Networks [4], the viability of ethnic clusters and parochialism is described in detail. We propose a model similar in some aspects with the parochial model here, but also in terms of the spin glass model. Variables that are easy to fake and variables that are difficult to fake are also taken into account. However, the main dissimilarity between the Bowles model and our model is that instead of taking parochial networks as networks where the fixed variables act as markers for shared beliefs and information only, we define an agent as an array of variables where all the entries add up to the definition of "self" and the agent finds strong or weak affinity with other agents depending on the weight of the variable in the agent’s definition of "self". As a result, the agents do not form a network based on more easily identifiable ethnic qualities because of the expectation of shared information to enhance cooperation only. The agents will form positive, negative or neutral bonds with all other agents depending on the value of the variable at each variable slot. However, the bonds will be weighted by the agent’s definition of self. In order to be successful, a parochial network must be very small so that the information structure is efficient [5]. However, in order to play in the entire pool of agents and with nature, a stratification of skills in the cluster is required if the cluster is to be self sufficient. However, the skill depends on both innate ability and training. We will be discussing the idea of aptitude and skill with respect to our model later. Although training might be imposed on agents by a small parochial cluster, a wide distribution of innate skill aptitudes is statistically less and less probable in smaller and smaller clusters. The other point to be taken into account is that as agents from different clusters come into contacts, beliefs and utility curves tend to get modified and the fixed ethnic tag and the easily flippable beliefs can get less correlated and the tag can be used to fake beliefs. The other point that might cause the agents to desert the cluster is mating, which can make the markers uncorrelated. The choice of mates is not the same as the choice of business partners where long term commitments are always necessary. Also, mating can offer a deserting agent security in the new cluster so that his self similar variables can get a guarantee to perpetuate there. Because of all these reasons, we propose clustering where all variables including beliefs and utility curves act as possible reasons for bonding, and one agent can be loosely affiliate with more than one clusters. The affinity clusters are dynamic, and hence so are an agent’s utility curves. The other main difference with the parochial model that takes into account only the ease and cost effectiveness of the information system of a parochial cluster is that, although there are bonds that take into account similarity in beliefs that account for ease in exchanging information, our model also takes into account similarities in genotypical properties, something that accounts for unconditional love for children and close ties with siblings even they grow up physically isolated and share totally different views.

H. Optimization of Energy

Each agent in the network tries to attain the maximum utility at the expense of minimum energy invested. We can define a variable similar to free energy to define this term. The agent will tend to cause minimum change of entropy of his own environment for the maximum possible gain of utility. The cost in this game is entropy. We can define this situation by a mathematical optimization equation with a constraint to minimize entropy. This can
be achieved if we can find a variable $v$ such that utility is directly or positively correlated with $v$ whereas entropy is negatively correlated with $v$ and then we find the maximum of utility - entropy by varying on $v$. Let us call this quantity (utility - entropy) to be net utility. As each of the agents maximize their net utility, the social cluster reaches an equilibrium as no agent can gain more net utility by shifting from that position. This situation is similar to reaching a Nash equilibrium in game theory. The situation is also similar to a spin lattice reaching one of its stable phases.

I. Flipping of Variables: Critical net utility and Correlation among variables

The variables can be modeled similar to an array of spins coupled to one another with weight factors. These weight factors can be updated as more information is fed from the environment and other agents. An agent will tend to maximize the net utility on each variable by taking the weight factor into account. When the net utility in one variable is lower than a threshold, there may be a flip in the preference. A flip in one of the variables again affects the other variables depending on the coupling. This might be described as follows. As an agent’s preference shifts, the agent may need to modify his/her skill set to maximize the new preference. Also, if the flipped preference creates a conflict with other preferences, flipping may continue until a stable state with no contradictions or a minimal contradiction is achieved. As a result, the cost of flipping a variable will be the cost of flipping all the variables that are strongly coupled to it. The threshold for flipping can be explained as follows. In order to flip a variable, a certain amount of energy needs to be spent. This energy includes the effect of decoupling from any affinity cluster that was based on the value of the variable, energy spent in loss of credibility etc. Loss of credibility can be explained as the fluctuations in the interactions with other spins because of an unstable state of the spin. Agents in an affinity cluster will contribute there share of affinity utilities to the agent only when his variable value is credible. Once an agent flips his variable and joins another cluster, the agents of the new cluster will need to calculate whether the flipped variable is true or bluffed, or whether it is a temporary fluctuation, since a temporary fluctuation will not make the agent incur the cost of flipping all the coupled variables. The other part of the flipping cost is the physical cost incurred to flip a variable: the time and energy spent. Also, flipping a variable would mean that an agent will be placed in a pool with other agents with a new similar variable and agents possessing contradictory variables, if the variable is an axiom, will be acting against it. Flipping in one variable might also be economically efficient if flipping in one variable optimizes the utility in some other variables in the agents array substantially, so that the flipping cost is expected to be compensated for by future increase in utilities in other variables. As an agent’s variable flips, agents coupled strongly with the flipped agents on other variables may flip the certain variable. This will depend on if the flip weakens the total coupling of the flip agent from the affinity cluster, and if the decoupling results in a loss of the affinity utility which is larger than the flipping threshold. Again, an agent with a flipped variable may bluff in order not to lose the affinity utility share. The spin-spin interaction energy among agents can be modeled as $\sum_i J_{ijk}s_is_j$, where $J_{ijk}$ is the coupling constant between spin $k$ of agent $i$ and that of agent $j$. Flipping the spin will change the sign of the interaction energy. However, a new term will be added with the flip, which will be the energy spent in making the spin flip look credible. Also, the internal energy spent will be the sum of the flipping energy all flipped spins coupled to the agent. If the internal spins are coupled with, weight factors, then it might be sufficient to flip only leading term spins. How many internal spins will be flipped can be decided by the following equation: We model the flipping energies as follows. The variables are coupled to similar variables with other agents or the variables may also be coupled with nature. If the variables are coupled with other variables in nature, the total energy in flipping will depend on the number of agents coupled together in a network, and also the weight placed on the variable. Also, the energy required to flip a variable will depend on the internal couplings. Let us assume that the external flipping energies are the product of three variables:

1. a coupling weight $J_{ij}$, that takes into account the weight given to the certain variable by agent $i$. $J_{ij}$ is the same for all $j$ for a specific $i$, as the weight would depend specifically on agent $i$'s valuation,

2. the number of agents in the network, or the total number of nodes in the cluster carrying the same variable,

3. a distance factor that explains whether agent $j$’s variable have effect on gent $i$’s variable and a constant flipping energy $E_{flip}$. If, on the other hand, the variables are coupled to nature, the situation is a little different. In the cluster with other agents, all agents are assumed to have the capability of influencing other agents. However, when a certain variable is coupled with nature, the flipping energy can be very high. Nature, here, compared to a large heat bath with which the cluster is held in contact, and the thermodynamic fluctuations of the clusters will depend on the spin-spin interactions with the other agents, whereas, the equilibria in some other variables will be predetermined by the external environment, determined by nature. This huge "average" behavior of the large bath will determine the unflippable variables or utilities that an agent cannot do away with. Examples are eating and shelter. However, variations on what to eat and what to use as shelter are not globally fixed, but depend on local variables and agent to agent interactions, and these variables can be flipped.
J. The "difficult to flip" variables and mating

The variables that are difficult to flip can also get reshuffled from one generation to another by mating. A network that tends to optimize efficiency by heavily relying on fixed variables to deduce inherent values and faith is also prone to get deceived by "fake markers" carried by progeny of agents belonging to the network. In a one-generation game where deserters can easily be tagged by their markers and punished, the fixed markers can be an efficient choice to enforce homogeneity of values within the cluster. However, as the markers diffuse and values get uncorrelated, the forced belief in the correlation can produce disastrous results.

Let us imagine a cluster where several sub-clusters marked by some fixed variables operate within the system. Let us also assume that bargaining powers of the agents are based on his/her placement in the labor market, and also that the labor market is strictly controlled by the fixed variables, so that a certain job is done only by an agent carrying a certain variable. This situation can put certain sub-clusters to a more advantageous position as they receive a high bargaining power, and they are assured of their variables remaining in a high bargaining power situation over generations if diffusion of markers is rendered unacceptable. The situation will create quite a few inefficiencies:

1. An agent's aptitude variables may not get propagated in the same way as the fixed variables. A guarantee of a placement in the labor market based on an external marker will also at as a lack of incentive for individual agents to invest in acquiring the skill. As a result, total competence in the skill will go down for the cluster.

2. The lack of incentive for the agents placed in lower bargaining power categories to be efficient.

3. Dynamic nature of the important skill as the game with nature and other cluster evolves. Labor reorganization might be required to adapt to a dynamic game. However, a cluster that heavily relies on fixed variables to assign labor preferences will find it costly to reorganize quickly, as all systems taking the fixed variables into account to account for labor must be updated.

4. Two dissimilar variables even kept in the strictest social rules but in a physically connected space will diffuse. We elaborate diffusion in a later section.

The other aspect to be taken into account is inter-cluster games, where because of mating, it might be possible to fake one or more fixed variables.

The other interesting property of a cluster composed of more than one sub-clusters held together, even if there is no strict fixed variable labor stratification is the following:

The subcomponents of the cluster will depend on one another, but will also need to be held together by a sufficient number of similar variables that are highly weighted and also have a high flipping cost. However, if the sub-clusters differ in one or more highly weighted variables, they will also compete against one another when resources become scarce, as each sub-cluster will prefer perpetuating members of the own clusters that are similar in more variables. However, if labor assignments are made within the entire cluster itself and if all members are allowed to come into close contacts, the members of different sub-clusters will have their fixed variables diffuse with generations. However, any subgroup possessing a variable that can be initially associated with a higher bargaining power will be reluctant to give up the bargaining power unless the other fixed variables from agents from other sub-clusters also hold a bargaining power with an equal degree. However, with diffusion, the fixed and skill variables will get disjoint and unless the variable interpretation system is totally reorganized, the wrong agent will be affiliated with the wrong skills. Now, let us assume that the sub-clusters are held together for a long enough time without the cohesive variable being disturbed, and the agents' fixed variables diffuse to create a cluster where no fixed variables can separate one agent from another. What does remain interesting at this part is the evolution of the set of preferences held by the different sub-domains. Each of the subgroups are assumed to hold a set of common axioms in the beginning that lead to a set of cohesive decision preferences. Now each of the sub-domains must have at least some axioms that are contradictory to the axioms of the agents in the other sub-domains. Although genetically fixed variables can diffuse with no contradictions, diffusion of logical systems need not be without creating logical systems that contain contradictory decisions within the logical structure. Although initially the contradictory axioms might carry little weight in the correlated spin structure, these weight factors are subject to modification with an evolving system placed with other clusters and also with nature. As contradictory axioms start carrying higher weights, the cluster will become less cohesive, and it is also possible to have weakly correlated genetic markers and contradictory logic systems or a cluster with simply self-contradictory logical systems. When the sub-clusters have unequal labor bargaining power, one sub-cluster might decide to flip its low cost preference variables in trade of a partnership and for a logically cohesive cluster. However, since the axioms underlying the decision preferences cannot be proved within the logical system, as long as the diffusing clusters have equal or close to equal bargaining power, one set of logic tree cannot be preferably replaced by the other. Again, an agent willingly flipping his preference variables will signal a lack in bargaining power.

We try to simulate a lattice which is initially consisting of several sub-domains consisting an exclusive set of genetically fixed variables and an exclusive set of logic systems, but with equal and different skill bargaining powers. We let the markers and the decision preferences diffuse slowly. The simulation results and the equation are discussed in the later version of the paper.
K. Rate of Change of Utility

The rate of change of utility is used for a corrective feedback mechanism. A sudden rate of change in utility will imply either a sudden change in flip in others leading to a sudden decrease in the agent’s utility, or a sudden need for reorganization of variables. A sudden need for flipping one or more variables requires a large investment in flipping energies. A sudden change in utility in a variable will lead to the agent to adjust weight factors in other variables while trying to maintain the status quo. Also, a sudden change in utility in one variable due to actions in part of other agents will lead to the acceptance of defection or betrayal if the agent adapts to the change quickly. Any cluster must have a built-in mechanism to punish defectors. An agent interprets other agents’ weights in preferences by looking at past data sets of actions, and a data point corresponding to an act of defection or betrayal will lead to other agents in a position to gain from leaving the cluster to provide an incentive to leave.

L. Weight Factors of Variables

Each agent can be described as an array of an infinite number of variables. We consider cases where a finite number of variables carry a changeable but large portion of the total weights. On the other hand, if the weight factors were distributed thinly among many variables, which are uncorrelated among agents, no clustering would occur. However, we consider the weight factors to be also dynamic. Let us consider \( n \) leading variables among \( m \) agents. Let us say that agent \( i \) has a weight for variable \( k \) to be \( w_{ik} \). In that case agent \( i \) will also invest \( w_{ik} \) proportion of its energy in optimizing in variable \( k \). Also, agent \( i \) will form positive or negative bonds with other agents which will contribute to the agent’s “affinity utility” as a function of \( w_{jk} \). However, if agent \( j \) has a weight \( w_{jk} \) for variable \( k \), agent \( k \) will gain from agent \( j \)’s affinity utility as a function of \( w_{jk} \). Also, flipping a variable \( k \) will affect an agent as a function of \( w_{ik} \) and \( \sum_j w_{jk} \) and the alignment of \( k \) in other agents.

The weights come into play significantly in the following way: The agent can only afford a limited amount of change in entropy, or in other words, the agent has only a certain amount of time and energy available for spending. This constraint will be taken into account when net utilities are maximized. The agent will start at optimizing the highest weighted utility, or existence, and will go down the tree by optimizing utilities that are connected to self by taking the weight factor and the net utility into account. The variable to be looked at is the utility scaled by the weight factor with the entropy factor subtracted. When several nodes are reached from one node that represent the same net utility within a certain error range, with the weighted utility put in, the nodes are pursued in parallel as we go down the utility tree.

M. Weight Factors, Risk Factors and Integration over time

We assume that agents placed in a social lattice will play against one another and also against nature to optimize their utilities. However, with every game, we can associate a risk factor. For example, if several agents are placed in a market, and each of them values two different commodities differently, each of the agents will try to deduce the other agent’s valuation in order to maximize his/her own profits in the futures market. The other agent’s valuation can be guessed if enough information is collected about the second agent’s past decisions. However, the utility curve of the second agent is also subject to change. As each of the agents interacts with the environment separately, they acquire more and more information, and their needs may reflect a changed set of information possessed by them. The importance of a certain utility may also go down or up as new information is added to an agent’s information system. This possibility of change can be lumped into a risk factor.

How a certain agent calculates this risk factor also affects his/her decisions. Again, calculating the risk factor or possible future actions requires an investment of time and energy. Since each agent tends to minimize the energy spent, how much energy an agent will invest in interpreting the second agent’s future actions will also depend on the first agent’s interpretation of the “importance” of the second agent’s actions.

The weight factors are very similar to diversifying ones portfolio; an estimation of investments made into different utility-stocks with long term and short term options. Utilities will be connected with weight factors that will be proportional to the risk factor associated with the certain utility. Also, possible changes are taken into consideration when integrating all utilities over time. In a many step game, the expected payoff from the \( n - th \) step depends on the on integrating over all the risk factors over time. The weight factor will also depend on the possibility of the maturity of an \( n \) step game. The other term to be taken into consideration is the possibility that the utility variable that the game is optimizing on will not flip by the maturity of the \( n \)-step game, as with a flip, the payoff from the game will become negative. Other minor terms to be taken into consideration are possible inclusions of agents in strong affinity clusters that will distort the utility curve and shift the value of the payoff relative to the agent. The existence axiom must be the most highly weighted variable, which we assume to be fixed. The existence axiom, as defined in our previous paper, can be described in detail as an agent’s utility in perpetuating the array of weighted variables in the closest possible unchanged form so that the highest possible utilities are obtained from the variable, taking the weights into account. However, when the utility fall below a threshold, a variable can be updated, as the utility is not contributing to the existence axiom then. If, taken the flipping energies into account, a flipped variable pro-
roduces a higher than threshold utility, the flipped variable will redefine the definition of self. Again, some variables are connected to the self axiom with a high flipping energy threshold and also a difficult to modify large weight factor. These are the variables that connect the agents with the environment or nature in a material way, so that flipping them will inevitably cease the existence axiom. For example, eating or shelter are utilities that are very difficult to flip, though the preference in eating might be somewhat modifiable. So some variables that are used for linking with nature have a high flipping energy. This is somewhat similar to a spin system being linked to a larger thermodynamics system where the variables are controlled more by the larger system’s average than the individual fluctuations of a small system connected to it. The utility variables linked with the existence are again optimized because they are expected to perpetuate the existence. The existence axiom will also take into account the coupling strengths among the variables when defining the meaning of existence. For example, the variables inside an agent are inter-connected closely, and flipping one of them affects other variables in the agent’s array strongly. However, the couplings with other agents’ variables are long range, and an internal shift in an agent’s variable will have a long range effect in other agents’ similar variables. As a result, the idea of self is concentrated most within the physical agent himself and fades away as longer and longer range couplings, and also couplings with agents with more and more dissimilar variables are reached. Some of the weights might be easily shifted, whereas others might have a hard shifting possibility. For example, material needs such as food and shelter have a high weight factor determined by nature. These weight factors depend on the agent’s game with nature rather than the agent’s interaction with other agents.

N. Mutations

In this term, we try to explain the possibility of the mutation of a utility curve or preference. The mutation term explains sudden changes in utility curves in random agents. This sudden change occurs in individual agents due to local interaction with nature or other external factors instead of interactions with other agents. Mutation, hence will be a flipped spin or a new axiom connected to the tree of an individual agent by local interactions with nature, and may occur even when the thresholds to flip have not been reached. Let us focus on the difference between the regular flip by reaching a threshold low utility in the flip variable and a mutated flip. A mutated flip will occur regardless of the current utility in that specific variable. As a result, two things can happen:

1. The process may simply speed up a change that was slowly taking place, or a change in utility which was happening very slowly at the cost of efficiency to the whole system. For example, if a system is held right above the threshold utility in a certain variable for an indefinitely long time, naturally, there will be no flip in the variable. However, the integration over a long time in maintaining the variable at a value just above the threshold may be in general more costly to the system in total energy minimization than a mutated flip that would reorganize the system. We can write down the equation as

2. A mutated flip in a variable that is already optimized will cost a flip in other variables or cause a huge contradiction.

Later the change may or may not diffuse across the network, depending on the parameters in the diffusion network and the specific advantage against nature and other clusters gained from adapting to the new axiom and the cost of replacing older axioms. As a result, the probability of a cluster undergoing sudden change

\[ P(mutation) + P(\text{diffusion}) \]

The diffusion of any mutation will be opposed by any agent with a high investment in a variable contrary to the mutated variable. Now, the probability of the diffusion across the cluster to other clusters will depend on the relative gain of the mutated cluster against other clusters by holding the mutated variable to themselves. When a mutated flip is actually reducing the total efficiency of the system, a diffusion will be resisted by most of the agents. Even if the flip is increasing the efficiency of the system, diffusion will be resisted by agents who have long term investments in the unchanged variable. The other type of mutation is the addition of a new axiom or preference. This new preference may or may not be contradictory to the existing preferences.

IV. RISK AND AXIOMS

A. Risk, Insecurity and Spurious Axioms

As the agents interact with nature to find more axioms that become fixed with nature, more axioms remain to be found. Also, there is no such determined linear correlation among knowledge, calculations and the actual gains. In every decision, some risk factors are associated, and some of these risk factors pose minute chances of gain against huge odds. If we examine history, most social faith systems were created on the verge of deaths and extreme decays of societies where large risks were required with odd gains. An agent can invent his own faith system in order to create a virtual gain that is guaranteed if a certain risky action is carried out.

If we look at possible futures in the point of view of the many universe theory [10], and possible decisions with high and low risk factors, with unknown or unexpected results, a rational human being will always choose the decision with the highest expected utility which will usually be associated with low risk if the risk factor contains a non diversifiable portfolio of investment such as the cost of an agent’s life.

However, this choice of decisions may not be the best possible choice for a system as constant low risk decisions
must be associated with constant slow changes. However, a high rate of change in utility may not be countered by slow changes. As a result, high risk decisions may be required to move a system from a fast decaying utility curve to a stabilization by adding risky pieces of knowledge.

B. Scarcity and Non Fixed Preferences

When an agent fails to meet the minimum threshold in an unflappable axiom, he tries to rearrange the weights so as to minimize the effect of the loss. However, if the weight of the certain axiom is also fixed, then as a strategy, the agent might create a spurious set of axioms to add to the "existence" axiom so as to keep it from flipping. The spurious set of axioms might be contradictory to the original set of axioms, and might, with time, fail to correct for a situation where possibility of optimizing the original utilities has been restored. Just as any other set of axioms, the change of a spurious set of axioms will be opposed by the agent’s tendency to maintain the status quo.

C. Diffused Logic Systems and Inconsistency

A diffused logic system will contain diffused axioms from both pure logic systems. However, a diffusion from both parts will occur with a low resistance only when high weight terms do not contain contradictions, or forcibly one set of logic terms are chosen over the other to maintain consistency. However, any well developed logic systems containing many preferences based on its axioms must allow diffusion of contradictory terms in low weight positions as sorting and correcting inconsistencies in all terms will take a huge amount of time and processing power. These new logical systems may then be passed from one generation to another as a given faith system or a system of axioms that are inherited or taken for granted. Over generations, the visible tags of the two populations can get mixed to produce a homogenous population with an almost homogenous logic system with contradiction only in minor low-weight terms.

The interesting phenomena occurs as with time and interaction with nature and other clusters, the weights for the preference terms need to be modified. As the spin array with its associated weights is allowed to evolve, we may come across phenomena where the low weight terms ignored for inconsistency correction purposed during diffusion become leading terms. This may happen due to a sudden scarcity, or a new knowledge acquired from nature.

If the weight factor is changed with leading inconsistencies in a person’s logic system or in the logic system of agents placed in the same logic pool, as the contradicting axioms will tend to make macroscopic changes with costs in entropy but leading to opposing macroscopical changes, conflicts must arise. The magnitude of the conflict will depend on the agents’ perception of the weight of the contradictory preferences.

D. Creation of New Logic Systems and New Faith

A faith system can be created by choosing a set of axioms exclusive to the axioms already possessed by an agent, given that the faith set of axioms do not contradict with the existing axioms or preferences. A faith system may carry a very high weight depending on whether it is connected to an axiom with high flipping energy.

As an agent interacts with nature and other agents to acquire new "collapsed" axioms shared with other agents, the faith system always has a chance of possessing contradictions to one of the newly acquired collapsed axioms. However, since the collapsed axioms are shared by agents in the clusters, and may be coupled to nature with very high flipping energies, contradictions with an existing faith system may create large contradictions within the agent’s logic system. If the faith system is coupled with some other variables with high flipping energy, but not shared by all members of the cluster, then the contest between the faith axioms and the newly acquired axioms will be subject to cluster efforts, as sharing a common axiom will lead to strong clustering and group efforts in maximizing utility in that certain preference axiom. Now a faith axiom can be discarded by an agent who is able to devise a new set of faith axioms that is not contradictory to the agents redefined set of axioms. However, the shift in the faith axioms must also be justified by another set of axioms that do not tend to flip the vital axioms the faith axioms are coupled to. In a nutshell, a substitution of a faith axiom must be designed so as not to disturb the agent’s value of the vital spins.

As more and more collapsed axioms are acquired, entropy in nature increases. However, this leads to a more complicated system. If there are only finitely many axioms to be acquired from nature, then after an n step game, all the rules of the game would be acquired and knowledge would be complete. This situation will imply maximum entropy in nature, as absolute knowledge would imply absolute knowledge of the future, and also no choice in future moves. In any such system, no spurious system of axioms can exist, as all axiom or anti axiom will already be acquired, and hence there can be no faith system. However,

V. DEFINING THE ENTROPY FACTOR

The entropy factor takes into account the disorder created in the agent’s environment. Now this entropy may not be a simple function for disjoint states. To start with, this entropy must takes into account long range correlations among matter. For example, an increase in entropy at one space point may appear as an increase in entropy at another point because of the connectedness.

The entropy factor takes into account the disorder created in the agent’s environment. Now this entropy may not be a simple function for disjoint states. To start with, this entropy must takes into account long range correlations among matter. For example, an increase in entropy at one space point may appear as an increase in entropy at another point because of the connectedness.
of events. In a simple system where long range correlations are present, often Tsallis entropy can take into factor the corrections corresponding to the correlations. However, an entropy associated with a more sophisticated network where each of the agents are themselves complex agents should intuitively be more complicated. In a specific way, the entropy is the agent’s calculation in the damage caused by either disturbing the ecosystem.

In the mathematical term, the first utility term could also be called entropy, as an increased utility is what an agent perceives as negative entropy. So an agent tries to maximize negative entropy and minimize entropy. Any action that decreases an agent’s utility is actually causing an increased entropy. However, we have separated the two terms for the following reasons:

1. utility may include terms that are completely non materialistic and clauses like beliefs and faiths. These terms may simply reflect an agent’s estimation of insecurity and risk, and not the proper entropy.

2. the utility terms are weighted, and may put a very low weight to a term that is causing a high entropy change in the environment. However, optimizing in one of the utility terms may come at the cost of suddenly or slowly lowering other terms. Most agents would put a higher weight on immediate utilities than on long term utilities because long term utilities have higher risk factors associated with them. However, small constant changes in the low weight entropy factor may at one point exceed a threshold that causes other utility functions to flip because a critical increase in entropy interferes with the optimization of one or more vital utility factors.

So we take entropy to be a switch like function connected to one or more vital utilities. The model behaves as follows: The entropy function usually increases slowly with any action the agent carries out. As a result, the entropy term is very low compared with the agent’s other cost functions such as energy and time spent. So entropy does not play a role in an agent’s utility weights. However, as the entropy function is connected to several vital utility functions, so that when the entropy function reaches a certain threshold, one or more utilities with very high flipping cost, when total or accumulated entropy reaches a warning level, some of the less vital utilities are flipped to minimize the change in entropy in the local environment. The other two things to be taken into account here are the local and global nature of entropy and also the time steps. Entropy can be split into two parts, local and global. By optimizing the utilities connected to the existence axiom, an agent tries to persist longer, or decrease local entropy. In order to do that, he must interact with nature or gain knowledge from nature. By doing so he increases global entropy. The decrease in local entropy must be a constant process, as the game is played against nature, which is increased in entropy continually, and a pause in the action will increase local entropy. However, an action carried by an agent alone will cause a fractional change in global entropy and will thus have a low effect on the agent’s own local entropy. If rate of change of global entropy as opposed to the rate of change of local entropy due to an agent’s action is lower, the global entropy will have a low weight in the agent’s action, ie. An agent will do nothing to offset the cost of the increase in global entropy caused by his action. However, small constant changes in the low weight entropy factor may at one point exceed a threshold that causes other utility functions to flip because a critical increase in entropy interferes with the optimization of one or more vital utility factors.

So we take entropy to be a switch like function connected to one or more vital utilities that have a high cost function for switching; hence, exceeding a certain value in the entropy will require one or some of the high cost utility functions to flip, making the agent incur a large cost. This can be balanced by flipping several other utility spins. The spins will be chosen such that the immediate entropy increase can be minimized at the minimum flipping cost. The time factor is taken into account here because of the risk factor associated with the maturity in any long term investment.

A. Short vs. Long-term Risk in Local and Global Entropy

Minimization of local entropy is in many cases connected with short-term gains. However, increase in global entropy is a slow process and is associated with long term risks. Hence, the energy invested in the minimization of local entropy vs that in calculating the cost of global entropy is that of investing in short and long term stocks. A long term investment may or may not mature (an agent may die), or a long term risk may be countered by other branchings in actions and technology. The longer the investment is for, the more the chances are of the result being affected by probabilistic changes.

B. Imposed Check in Global Entropy

A check in global entropy can be forced by associating with the local entropy function. However, any such association will come with the cost of the allocating an agent’s limited time and resources to calculating global entropy at the cost of optimizing other local utility curves.

VI. SPECIFIC EXAMPLES CONCERNING CLUSTERS

A. Clustering and Sub-domains in a Stable Phase

If we consider the labor market, and the division among jobs, several factors need to be taken into account:

1. An agent’s aptitude for a job, which again depends on a. The agent’s propensity for that skill b. Investment made in acquiring the skill
2. The other agents’ aptitude in measuring the skill
3. The demand for the skill This process can be summarized again as maximizing the net utility of each of the agents. However, there are several factors that are noteworthy here:

1. Net utility is not the same as utility. When an agent is trying to find the maximally skilled agent for a job, he also needs to invest energy and time for the search. An agent will try to find the most skilled for the minimal energy spent. If an agent calculates a generalized correlation among two variables, one of which is hard to measure and the other easy, as long as the cost for neglecting exceptions are calculated to be not very high, an agent might tend to measure the easily measurable variable to deduce the value of the more difficult to measure variable. However, since each agent also is trying to maximize net utility, one agent’s inaccurate measurement of a skill might reduce the total net utility of other agents who have a demand for that skill and will share the skill.

2. An agent’s skill depends on an agent’s affinity for a skill and also the agent’s investment in acquiring more information to improve the skill. Again, an agent with an affinity for a skill will need to invest less to acquire mastery in that certain skill.

Creation of Labor Clusters and Tags: security and Long Term Risks The resultant clusters in the labor market might not necessarily reflect every individual with the optimal skill at the most appropriate job sector because of each individual’s tendency to maximize net utility and not utility itself. Also, besides utility, we must include a security term in entropy. The problem of security is also very closely related to entropy and the “existence” axiom that we argued about in the previous paper. A labor domain is not necessarily the same as an affinity domain. Again, a certain skill is only one of the many variables that can be coupled into a group. However, many variables have no correlation with respect to games with nature or “quantitative” utility whereas some others do. As a result, affinity domains and labor domains will be two different coverings of the set of all agents. In order to play successfully against nature and environment, it is efficient to create forced clustering in skills, or trade skills. However, the agent whose skill is important may or may not belong to a strong affinity cluster with the other agents in the trade. Hence, the clustering here is “forced” on need, with obvious possibilities of betrayals in the last step of any game.

The following equations can succinctly describe the game: An agent will make an investment of $I = f(A) + g(tagging) + h(demand)$ where $f(A)$ is a function of aptitude. A person with higher aptitude will need to invest a smaller amount in order to achieve the same skill level as a person with lower aptitude. A person with lower aptitude may not be able to overcome a threshold in acquiring the skill. $g(tagging)$ is based on the tagging barrier. An agent carrying a variable which is difficult to flip, but acting as a tag against a certain variable will need to invest an extra energy equivalent to the tagging potential in order to be credible as a carrier of the certain skill $h(demand)$ is simply a function of demand. A skill with higher demand will yield a high pay. Hence investing in a skill with a high pay will yield a higher degree of freedom and more free time that can be used elsewhere. An agent in charge of assigning a correct labor position to the qualified agent will try to maximize gross efficiency in terms of the minimum effort spent. The utility of the assigner will be a function of the aptitude of the candidate and the difficulty in interpreting the aptitude. This can be written as $U(\text{assigner}) = f_1(u, \text{tag}).$ $f_1$ is a function that is dependent both on the total aptitude of the candidate and the difficulty in finding the aptitude. The total utility of a person only benefiting from the labor of an agent is $U(\text{consumer}) = f_2(u) - f_3(\text{cost})$ Where $U$ is only a function of the assignments of the assigned agents. As a result a consumer will be willing to invest in a cost term that will punish the assigner against a gross tagging scheme that will bring down the total labor skill, as long as the total salary paid for the skills purchased is the same. The total utility of a competitor will be a function of both his aptitude and the negative of tagging against his competitor. However, when we look at the utilities of the assigner and the consumer, we see that tagging must go down as the aptitude of the candidates fall far outside median mainly because of two reasons: (a) candidates with aptitudes far outside median will be easily discernible, (b) eliminating candidates far outside the median will bring down the total labor to the consumers by larger amounts, and hence excluding candidates with high aptitudes by tagging will be automatically checked by consumers.

However, the correction terms imposed by the effects of clustering have yet not been imposed. A further game can be developed if we connect negotiating power of the agents with these variables. A detailed game will be sketched in a paper being developed.

B. Forced Clustering

Let us assume that cluster $A$ and cluster $B$ have two dissimilar variables in location $x$, and that clustering is created by filtering on that variable. However, let us also assume that in both the clusters, there are two other variables to be considered: an easily discerning variable, $y$ and a skill variable $z$. Now let us assume that there is a weak correlation between $z$ and $y$, so that agents with $y$ are correlated with $z$ and is discriminated against when skill $z$ is considered, however, we also consider that there is no correlation between $x$ and $z$. Now any skill is a combination of both aptitude and investment in the skill. If cluster $A$ is in a more economically advantageous position, so that cluster $A$ can pay higher for skill $z$, then cluster $A$ can cluster agents in the basis of $z$ in cluster $B$ and offer higher pay to the $z$ agents possessing $y$ as well. Then a forced clustering on the basis of $y$ with the expectation of high affinity contribution with respect to
y will serve the purpose of cluster A, as long as y’s in cluster A have a higher affinity for variable x than variable y. Now agents from different clusters or domains are discriminated against over the possession of a certain variable does not mean they can naturally be forced into a viable cluster. Agents who are expected to pay dearly because of the forced clustering at the cost of agents unskilled z might as well prefer getting isolated and sell their independent skill in z in a strict one step negotiation. The other very important part here is whether a weak correlation with the lack of skill z in agents possessing y implies the existence of say a weak correlation with skill w and a natural preference and inclination towards that skill. In a later paper we expand in the possibility of valuations of skills and negotiation power and design a game based on forced clusterings of specific variables. Also, since the y tag biased discrimination is applied to the initial evaluation process, where the evaluator must apply extra energy in identifying the few qualified y’s, if the qualified y’s in cluster B get isolated and by a higher investment than average make her skills credible, or have an aptitude above a certain threshold, where the z aptitude is clear, and requires little investment in identifying the aptitude, then it might be more advantageous for an agent to not join the joint forced cluster. In these situations, it might be efficient for agents without y to include the minority distinct isolated agents. This assimilation will also depend on the long term effect of the perpetuation of the y tag. If the probability of an agents’ perpetuating the y tag does not depend on the agent possessing it, then there is no long term threat in an agents’ self perpetuation by including the exceptional y’s. However, if tag x has a correlation with the agent possessing it, then a clustering in x will have a more long term effect that will span generations than a clustering in y for skill z, which will be merely a function of efficiency in the investment made in isolating the skill. Now the forcible clustering in tag y, when a clustering in x already exists will prove to be advantageous to the agents in cluster A as long as there is no guarantee that the variables with the highest weight factors of the incoming y’s from cluster B are will be perpetuated in cluster A. Again, any such assimilation of variables comes with the usual risks of defection. When the defection is associated with the defection of easily discernible variables, at the cost of flipping the easily flappable variables to offset the total price, the long term risk remains the probability of the entire clusters undergoing phase transitions in the easily flappable variables, keeping the difficult to flip variables as the dissimilar variables, and the possibility of that dissimilar variable passing from generation to generation.

We try to model the situation with the following equations Let us assume that \( f(x) > f(y) \) By f we mean the filtering effect. This will happen when

1. \( J_{ijx} > J_{ijy} \) and 2. \( \sum S_{lzi} > S_{lyl} \)

(here S is the internal spin weights between nodes l and x or y) for majority of agents.

Now let us assume that a clustering in variable x distorts the preference curve of y by \( \epsilon_1 \) for agent I and a clustering in y distorts the utility curve of agent I wrt x by \( \Delta_i \). Now if \( \epsilon_1 > \Delta_i \), then a forced clustering wrt. y will create sub-domains within the cluster with strong affinities outside the y based domain.

Now let us assume that since y agents are tagged against z, only the exceptional members of y are seen in z, and the number is equally distributed among both x or y, or since the tail part of a gaussian distribution of aptitude is sparsely distributed, let us assume that there are only few y’s in z at a certain time point which might have equal or unequal distribution of x’s since the sample space is small.

Now let us assume that some y’s are clustered together based on the tag, and are forced to contribute equally to the cluster. They are also given a quota or a proportion of the total z labor market.

For the exceptional y’s: personal tagging cost = 0 or very low. As a result, the equations for the exceptional y’s are cost for imposed distorted utility contribution in forced cluster C, cost for credibility of actual aptitude in a forced cluster with large shared utilities = \( CC_C \), cost for extra competition in a cluster where most agents would have been cut off from competition in the absence of the forced clustering = \( C_{co} \), cost for competing against affinity clusters of competing sub-domains to force one of their affinity agents into a predetermined quota based position = \( C_A \), gain from being able to gain a position with lower investment in acquiring skill = \( GL \), cost for being in the same category as agents who has acquired the same low skill level, and are backed by their affinity clusters = \( CL \) cost for joining an affinity cluster based on x in order to compete with lower skilled y’s from the competing affinity clusters = \( CLC_i \).

An agent with exceptional aptitude will agree to the forced clustering situation only when all the costs of joining the cluster are offset by the gain. If the y tagging is not guaranteed to propagate to his/her progeny with a higher probability than those with no y tagging, there is no long-term gain from joining the forced cluster.

C. An Affinity Cluster in Peril in Terms of the Spin Model

An affinity cluster may for many reasons be at the point of dissolving. In his recent paper, Samuel Bowles tries to explain why altruism in some agents is an evolutionary stable strategy by arguing about how when at the verge of dissolving, it is economically most advantageous to leave a society, it is altruism that can keep a society together. Again, in his book, "The selfish gene" Richard Dawkins argues that altruism is an imposed behavior which actually reflects the self interest of the "selfish people" of the society. Here, we try to blend in the modified definition of self and the affinity utility to these ideas. (how do agents react at that point.. when
Let us imagine an agent $A$ in a cluster $C_A$ at the point of dissolving. As we argued before, as long as the agent was not a bluffing agent, and the cluster boundaries were not drawn forcibly, the agent will contain a reasonable amount of weighted variables in common with the other agents: either genotypical, philosophical or a mixture of both. Now, let us imagine that the cluster is at the point of breakdown. i.e., let us say that most of the agents attain a negative net utility from being in the cluster. In classical economics, one would argue that it is economical for the agents to leave the cluster at that point. However, here, we take into account a few more correction terms. First of all, to be accepted as a member of another cluster, an agent must have or at least credibly bluff to have some variables in common, as the "affinity utility" of the other agents used by the new agent must be offset an incoming affinity utility. Otherwise, the common utility shared by the agents in the cluster needs to be balanced by an incoming trade or gain. This incoming gain in the lack of an affinity term will come with the risk of betrayal at any step and leaving the cluster. If, on the other hand, and agent flips some variables, each flip comes with a cost. Now the agent can leave the cluster and join another cluster only when the total cost of flipping and making the flips look credible to the incoming cluster is affordable. Then again, a flip changes the overall utility of the variables as the incoming cluster gains the data about what cost the incoming agent is willing to flip variables and move away. It also comes with the cost of the outgoing cluster losing the affinity term from the deserter, and the cost of the "trust" factor that allowed the agent to share other agents' affinity points. A deserting agent signals either a flipping or a bluffing. However, altruism is defined as an act that is done by an agent in order to help optimize the utility curves of other agents with no expected return. Even, when we take the cost of flipping the variables and the risk of losing credibility into account, the total investment made in part of the altruistic agent may actually overweight the hidden cost incurred by simply not being altruistic. For example, an agent may simply sacrifice his life. There is no further step in the game for the agent himself, and hence so no expected return. The existence of at least a few such altruistic persons has been proved to be an evolutionary stable strategy. This phenomenon can be described by in two ways at least in terms of our spin model 1. In our previous paper, we described the existence of spurious axioms. Spurious axioms may be traded or even generated by the agent himself in order to compensate explain any insecurity connected with the existence axiom. A spurious axiom might contain a clause that might make the agent inclined to be altruistic. A spurious axiom will be successful in over-weighting an agent’s self perpetuation axiom only when it can propose another way of self perpetuation that is stronger and even after weighing over the risk factors provides a higher chance of perpetuation for longer. Hence, in the agent’s own logical system, an agent will act rationally to optimize his "self perpetuation." However, since all agents do not share the same set of spurious axioms, the act can appear as irrational to other agents.

2. The distorted idea of self can account for altruism. Many models involving genes and memes have been proposed in this regard. We propose a similar but slightly modified version in terms of the spin glass model. An agent is described as an array of variables. However, unlike previous models, out variables in the definition of self are weighted, and the weight factors can be modified. The variables themselves can be flipped. Some variables are inherited genetically and have a high flipping energy, whereas some other variables are axioms or utilities and faith. These can be flipped at costs dependent on the interconnection of these variables with other variables, and also the cost of credibility. A person will have a distorted idea of self, that will take into account his own array of variables modified by a weighted factor of other agents possessing similar variables. An agent will try to perpetuate his own array, and will modify the values of the variables in his array according to the costs incurred in order to protect the entire array. However, at certain steps the necessary modifications needed to flip the number of variables in order to retain the integrity of the entire array may be higher than the amount of energy and time available. At that point, the agent might choose to invest in perpetuating similar variables in other agents at the cost of his own array.

VII. SIMULATION OF A TOY SOCIAL NETWORK

Let us now consider a cluster of agents $\{a\} : a = 1, 2, ..., N_a$, each with the attributes $\{i\} : i = 1, 2, ..., N_s$. Let us consider as the negative of the utility the function

$$H = (1/2) \sum_{a_{ij}} A_{a_{ij}} s^a_i s^a_j + \sum_{ab_{ij}} B_{ab_{ij}} s^a_i s^b_j + h \sum_{ai} C_{ai} s^a_i$$

(1)

Here the superscripts $a, b$ indicate the different agents, and the subscripts $i, j$ denote the particular attribute and the state is a "spin" state which we keep within $\pm s_{max}$, to indicate the projection along a natural axis.

The $A$ term indicates the coupling of the different attributes in a particular agent, the $B$ term stands for social interaction between different agents affecting the attributes of each agent, and the $C$ term used to represent the interaction of with nature $h$ of each agent in a particular set of attributes.

Taking the derivative with respect to $s^a_i$ of $H$ indicates how a change of the attribute spin towards a more positive value will change the utility, i.e. in our simulation we shall increase $s$ by a unit if the derivative is negative, and diminish it by unity if the derivative is positive:

$$\partial H/\partial s^a_i = \sum_j A_{a_{ij}} s^a_j + \sum_{bj} B_{ab_{ij}} s^b_j + hC_{ai}$$

(2)
determines the augmentation of the spin up to $s_{\text{max}}$ or its decrease up to $-s_{\text{max}}$. In our case we experimented with the $A$, $B$ and $C$ matrices, after taking the simplest nontrivial set with $N_a = N_s = 3$. We also added a random component to the matrices as is appropriate in a spin glass ([12, 13]), and as one might expect in a social context from inexplicable sources.

In Figs. 1-3 we show the time evolution of the attribute $i$ of agent $a$, i.e. of $s_{ia}^a$ for three different combinations of $a$ and $i$. The other 6 possible figures are quite similar to these three for our choice of the link matrices.

We note the interesting fact that in Fig. 1 for $s_{11}^a$ we see static phases alternating with rapid fluctuations, which reminds one of punctuated equilibria ([14, 15]). However, the analogy is not exact, because in our case the static states correspond to a constrained extremum value of the spin or the first agent's first attribute's orientation in natural space.

In Fig. 2 we see a virtually periodic oscillation with no sign of the small random external noise fed into the different interactions. This corresponds to the third attribute of the same agent, whose $A$ and $B$ matrix elements are now taken to be different from those for attribute 1.

In Fig. 3 we show $s_{13}^2$, i.e. the first attribute of the second agent. Here too the orientation shows a periodic oscillation. But the pattern is somewhat different from Fig. 2, because there we have short static periods with alternate orientations, whereas in Fig 3 we have quasi-static orientations only in a particular direction, the oscillation to the other direction being relatively short-lived.

VIII. CONCLUSIONS

In this report we have outlined the possibility of developing concepts and relations related to the evolution of social clusters, analogous to spin systems, and the importance of the concept of the "self" of each agent with variable attributes which may be quantifiable. Simulations with weight factors for different couplings between agents and their attributes and spin-type flips in either direction from consideration of a utility function in a simple toy system seem to show the possibility of chaos, or at least highly aperiodic behavior, with also the possibility of punctuated equilibrium-like phenomena. It would be interesting if the reverse process of obtaining the $A$ and $B$ matrices from real data can be successfully realized. However, because of the very large number of parameters available, it would probably almost always be necessary to reduce the problem to simpler systems with a manageable set of matrices of links, using assumptions of fuzziness or symmetry or some other consideration.

Acknowledgments

I would like to thank Professor P.W. Anderson at Princeton and Professor Samuel Bowles of Santa Fe and Professor Josh Angrist of MIT, as well as Professor Bertrand Roehner of the University of Paris for useful discussions.
APPENDIX A: OVERLAPPING PERCEPTION AND UTILITIES

Einstein spoke of an ant going on in a circle on the surface of an orange and assuming that it is traveling on an infinitely long one dimensional line. The other example he gave was of a two dimensional being living on the two dimensional shadow of a three dimensional object. The knowledge of the two dimensional being will be bound by its perception of the projection of the three dimensional world onto that two dimensional surface. Our perceptions are also bound by what we can feel from the world, and our logical system is constrained by the axioms or information obtained by these perceptions. Now, the fact that most human beings can communicate in a rational manner is supported by the idea that a large portion of these perceptions are overlapping. However, we cannot prove within a system bound by our perception that some portion of our perception is different from the perception of other beings. We cannot disprove that the projections of a higher dimensional world that we perceive are exactly the same for all agents, if we are a 3-1 dimensional world embedded in a higher dimension. The difference in human expectations and fine understanding lead to the idea that we are able to project slightly varied images of a world which might be embedded in a higher dimensional manifold.

[1] F. Shafee, "A Spin Glass Model of Human Logic Systems", [http://xxx.lanl.gov/abs/cond-mat/0211103](http://xxx.lanl.gov/abs/cond-mat/0211103) (2002)
[2] B. M. T. K. Gödel, On formally undecidable propositions of Principia Mathematica and Related Systems, (Dover Pub., reprint edition, 1992)
[3] J. von Neumann and O. Morgenstern, Theory of Games and Economic Behavior, (Princeton University Press, Princeton, 1944)
[4] S. Bowles and H. Gintis, "Persistent Parochialism: Trust and Exclusion in Ethnic Networks", forthcoming in Journal of Economic Behavior and Organization (2003)
[5] S. Bowles and H. Gintis, "The Evolution of Strong Reciprocity: Cooperation in Heterogeneous Populations", forthcoming in Theoretical Population Biology (2003)
[6] P.F. Lazarsfeld and R.K. Merton, "Friendship as a social process: A substantive and methodological analysis", in Freedom and Control in Modern Society ed. M. Beger et al. (Van Nostrand, 1954) p.18
[7] Richard Dawkins, The Selfish Gene, (Oxford University Press, 1989)
[8] K. Henson, "Memetics", Whole Earth Review 57, 50 (1987)
[9] D. Hofstadter, Metamagical Themas (Basic Books, 1996)
[10] S. DeWitt, R. Neill Graham, eds, The Many-Worlds Interpretation of Quantum Mechanics: Bryce Princeton Series in Physics, (Princeton University Press, 1973)
[11] J. D. Collier, "Information Originates in Symmetry Breaking", Culture and Science 7, 247 (1996)
[12] D. Sherrington and S.K. Kirkpatrick, Phys. Rev. Lett. 35, 1792 (1975)
[13] S.F. Edwards and P.W. Anderson, J.Phys. F5, 965 (1975)
[14] D.M. Raup, Science 231, 1529 (1986)
[15] S.J. Gould, Nature 366, 223 (1993)