Conflicts as Emergent Phenomena of Complexity

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Abstract

Complexity Theory as a model of interacting parts applicable to social situations is introduced. The application of such ideas to conflict situations is considered and new paradigms are suggested with which to view conflict resolution within an evolutionary social context.

1. Introduction

The study of systems consisting of large numbers of interacting components is the basis for the new science of Complexity Theory. Unlike traditional scientific approaches which concentrate on the analysis of systems in terms of their component parts, this new theory considers the synthesis of emergent wholes from the associations of individuals, restoring the dynamics lost by previous static treatments. In the abstract viewpoint employed in Complexity Theory we make the assumption that the dynamics of systems are independent of the physical manifestation of their constructions and depend only on the logical nature of their interactions. In this way the findings can be shown to be equally applicable to all forms of system - inorganic, organic, biological, psychological or social. In each case the emergent features will show equivalent properties relevant to that level of description.

This science is still very young and much work remains to be done, yet many insights into the workings of complex systems are already evident and can suggest new directions of thought in the treatment of social and political problems. The paradigms of Complexity Theory are rooted in evolution - the continuous development of systems over time; in state space - the vast numbers of unexplored options available; in attractors - stable options in times of change; in unpredictability - a divergence from expected results; in co-operation - the survival of the fittest; in edge of chaos - balancing static and dynamic behaviour; and ultimately in the integration of diversity.

2. Key Concepts of Complexity Science

In this section we will very briefly introduce the main theoretical concepts that are required to follow the later discussion.

2.1 Structure of a Complex System

All complex systems are taken to comprise a collection of agents (or actors), which may be passive (as in a molecule) or active (as in a person). These agents are assumed to interact with each other in known ways, but such that the total interactions are too complex to be followed by analysis. The agents here have individual rules of behaviour and their interactions are regarded as the connectivity of the system (the number of agents with whom they interact). The agents react to their environment (i.e. the other actors and any static features) without reference to any global goals - in other words they are undertaking purely local transactions. The net results of these local interactions and decisions are phenomena that emerge at a global level.

2.2 Emergence

Generally emergence is defined by saying 'the whole is greater than the sum of the parts'. In other words we cannot predict the outcome from studying the fine details. In some cases if we 'know' the outcome we can develop reductionist explanations to describe it - this is a one to many process, we break down the trait into multiple isolated parts. The reverse process, many to one - explaining from first principles what global features will appear, seems beyond us. The essence of the emergent phenomena however is that 'new' descriptive categories are necessary, in other words the features cannot be described within the vocabulary applicable to the parts, we require new terms, new concepts to categorise them.

2.3 Multi-Level Structure

The emergent properties can themselves interact with each other (e.g. interacting molecules produce emergent cells, these interact to form organisms, which interact to form societies). What we are saying is that there are a number of nested levels of detail, each has properties different from those levels that comprise it, and so needs a new type of description or label to be applied. Despite these different labels the properties found at the different levels are considered equivalent, each being due to the same form of connectivity applied within the specific space and time framework applicable to that type of structure. The labels are level dependent, but the properties are universal. By studying the lower level connectivity of each system we can determine the statistically expected emergent features, and conversely by relating the features to those of systems whose connectivity is known we may be able to infer their internal connectivity also.

2.4 Fitness Landscapes

Each agent tries to do the best for itself that it can. We can regard the choices that it has open as having different fitness' (or rewards). Each time a choice is made the agent is regarded as moving to a new starting position (viewed as a point on a landscape). The surrounding positions are the new choices available at that point in time, and each will have a fitness. The agent evolves through time by choosing (deliberately for an intelligent creature or randomly for genes) a new option (or mutation). As the landscape fitness varies from place to place, this is regarded as a process of hill climbing, where higher fitness is up.

2.5 Co-Evolution

Since we have a number of agents, each making choices, the fitness of each will depend to some extent on the choices made by the others. This is regarded as a co-evolutionary system (like an ecosystem). We can regard the fitness landscape of each agent as being changed by the actions of others, so the landscape distorts and changes over time. The larger the change made by an agent the greater the effect on the landscape of the other members of the ecosystem.

2.6 State Space

The landscape can be regarded as a map of all the options available to the agent, for all combinations of circumstances. This we call mathematically its 'state space' or 'phase space'. For a complex system it is vast and multi-dimensional (one dimension for every variable of every agent). Each agent will try to explore this state space, but due to the size of the space they will not be able to do more than sample the options available. Thus a search of this space is needed to find those few states of greatest fitness (the global optima). In any region of state space the agent may find an optimum, but typically this will a local 'hill' and not the highest possible. Any small change from that hill will be disadvantageous to the agent, yet there will be better states available in the landscape - if they could be reached.

2.7 Perturbation

The changes by the agents are in effect disturbances to their coupled fitness landscapes (which we call perturbations). We mentioned that large changes disrupt the landscapes, so we would expect this to lead to breakdown of any structure (this breakdown we call a chaotic state). Conversely small changes will cause gradual shifts in the peaks, allowing the agent to hill climb slowly to a nearby optimum and then to follow its deformations. An intermediate technique called 'simulated annealing' uses controlled disturbance to shock the system out of one fitness state and into a nearby higher one.

2.8 Power Law

In large populations, combinations of perturbations will occur. It is found that in general (as might be expected) that the number of large perturbations is very much fewer than the number of small ones. Most perturbations have only local effects, while a few can disturb the entire global system. If we plot logs of number against size they form a straight line power law graph (similar to the earthquake Richter scale).

2.9 Chaos and Non-Linearity

Complex systems of the sort treated here are considered as non-linear systems. This means that the effects resulting from a cause will not be proportional to the stimulus. This feature is crucial to understanding the behaviour of such systems. These can exhibit the feature of 'sensitivity to initial conditions'. This means that feedback couplings can cause unwanted escalation of effects far beyond the predictions from the cause (this is called the 'Butterfly Effect'). In the system context, it means that the effects of a perturbation bear no relation to its size - a minor change can have global effects, yet a major one may be absorbed without effect. There is an inescapable unpredictability inherent in these systems [5].

2.10 Edge of Chaos (EOC)

Systems tend to have two extreme states. In one the system stabilises to a static state (corresponding usually to a low level of interactions), in the other it changes chaotically all the time (corresponding to very many interactions or perturbations). There is an unknown evolutionary force that drives each of these towards a middle state. This we call the Edge of Chaos [7,9]. Its feature is a self-maintaining balance between areas of stability (static) and areas of change (chaotic). Where selective forces act on a system the highest fitness peaks in co-evolutionary systems are found to lie in this region. It is found that highly connected systems have large numbers of optima of low average fitness, poorly connected ones have few optima of better but not maximal fitness. The middle state has closely associated optima with the best fitness distributions. Being in this state gives the system the optimum responsiveness to new situations, so as to maintain fitness.

2.11 Attractors

Systems that are drawn (for any reason) to a certain state are said to be attracted to that state. This has allowed us to describe the states that a system exhibits in terms of attractor theory. Attractors exist in both physical systems and at higher levels. There are three main types: Fixed attractors - a single 'final' point (e.g. the bottom of a bowl for a ball), cyclic attractors (e.g. a planetary orbit) and 'strange' attractors (chaotic motion). The Edge of Chaos state is one in which there is an unstable mix of these attractors. The main feature of any attractor is that once in the attractor basin (its area of influence) then the system cannot escape that state, unless changes are made to the attractor control parameters (those features that specify its form - in the case of complex systems this is a combination of the connectivity and the agent rules).

2.12 Bifurcation

When control parameters are changed, the attractor structure also changes. When the system is more strongly driven (increased connectivity say) then this takes the effect of a doubling of the attractors present (called a bifurcation), in other words one 'choice' becomes two. This increase can continue happening until the system becomes chaotic (with infinite attractors). Conversely, attractors can merge, reducing options, with any opposite movement in control variables.

2.13 Canalizing Functions

These are special control parameters that can express or inhibit chains of agent behaviour. They work by forcing an agent to a fixed state. Its interconnections then can result in other agents also becoming frozen, so 'damping' the system and reducing instability.

2.14 Diversity

It has been found that there is an ability of diverse co-operating groups to achieve an higher overall fitness than homogeneous (similar) ones. This is due to the ability of co-operation to find a new optimum, better than the ones available to agents in isolation, a symbiosis effect.

2.15 Patches

By allowing interactions to be obeyed or ignored selectively it is possible to achieve an even better balance of global success than in either of the two fixed cases (of always interact or never interact) [6]. In this case the optima seem dynamic and can only be stabilised by constant changes to interactions (via a sampling or stochastic regime). The idea here is that too much data causes chaotic thought, so by restricting the data considered at one time, but considering all data at sometime, then a stable optimum can be discovered and held.

2.16 Dissipative Systems

Complex Systems that maintain their form only by the consumption of energy are called dissipative systems. All living systems are of this form. Energy availability is a controlling parameter in its own right since the agent performance (rule execution) depends upon it. All such systems operate far from equilibrium, in a stable but dynamic balance [8].

2.17 Complex Adaptive Systems (CAS)

This term is given to complex systems that change in response to changes in their environment, the agent structure altering in some way. Where this is in the form of learning within a lifetime the alternative term Complex Evolving Systems (CES) can be employed.

2.18 Artificial Life (ALife)

Applied complexity research often takes the form of computer simulations where collections of agents with known structure are allowed to interact over many generations, with a view to discovering the emergent properties and their likelihood. These systems go by the name of Artificial Life and can model many aspects of biological and social systems [3,4]. Many of the findings outlined in this paper come from such research.

3. Metaphysics of Complexity

This section positions complexity concepts within the wider world, and explains some of the philosophy behind them and our view of conflict.

3.1 The Three Worlds

It is often considered that there are three worlds, the objective physical, the subjective mental and the abstract mathematical or Platonic. We may consider these as progressively emergent realms arising from interactions at more powerful levels. Thus a continuum of levels allows us to model, in similar ways, all aspects of our Universe.

3.2 The Self

The concept of 'I' can be regarded as a sum total of the emergent states of the mind (a multi-dimensional concept), an holistic 'me'. We need to distinguish 'self' from 'conscious self' here. A lower animal also is an holistic unit, but 'self-consciousness' is a yet higher level of emergence.

3.3 Determinism and Indeterminism

As we ascend the levels, we go from deterministic laws of nature, via progressively more powerful mechanisms of choice (culminating in humans) and progressively more general concepts until we reach pure abstraction. This we can view as a progressive reduction in constraints and an increase in freedoms (indeterminism). On a complexity viewpoint this is analogous with a move from a static to a chaotic system, so it would be true to say that higher levels of our reality are less fixed, and both more amenable to change and more suceptible to it.

3.4 Conflict

It is the availability of choice that makes conflict possible. Only by being able to differ can we have opposing views. There can be no conflict between purely physical entities (e.g. rocks) and there is no conflict between the physical and subjective worlds. The physical word is passive and has no 'viewpoint' so it can't oppose ours - other creatures can, but then they have choice also, that is the essence of co-evolution - the interplay of 'choices' . Conflict resolution presumably then is restricted to situations where both parties can communicate, (or where a mediator communicates, say, to a party harming the environment on 'behalf' of the affected parties). In the Platonic world any conflict has no physical effect, so conflict must be a Subjective world phenomena.

3.5 Values

We can regard our values as desired fitness'. Thus each person attempts to affect their world in order to maximise those values. Values are what we want to achieve - in an ecosystem that would be a fitness peak, in society this relates to physical, mental or financial adaptation or whatever is desired. For most people this would seem to involve a combination of some stability (security) and some change (choice), in complexity terms this is our Edge of Chaos.

3.6 Unity and Difference

The driving force behind any real conflict (based on a Platonic intuition) is an aspiration to absolute unity (wholeness) or control, and the removal of differences (parts) or opposition. If truth is singular, then if we encounter two views, different essences or beliefs (that is if we distinguish a difference) then one of them seems to be an error or lie. So the metaphysical cause of conflict lies in the distinguishing of differences. These differences can lie in any aspect of our world, but the well known ones are of course religion, politics, economics, land, race and nationality. Taking a idea from Quantum Theory we can transform such divisions, perhaps, by regarding them not as opposing but as complementary views of the world, not right or wrong but each being a part truth. This is in essence the complexity view, ideas are options in fitness space - the more ideas the better optima that can be reached, providing we allow the necessary changes to occur.

3.7 Evolutionary Duality

Seen from an evolutionary point of view it is apparent that our mind divides (classifies, categorises) as a natural operation - it is the basis of our recognition. The divisions so made are intended to be of positive value in our lives, yet are often treated as unquestionable givens. We need to recognise that such barriers are arbitrary and not immovable walls between us. They are created in our Subjective world, as higher level emergent features, and do not exist, as such, in the Physical world.

3.8 Dynamics

There is a tendency to consider systems from a fixed viewpoint, as if they remained permanently in the same state. This is invalid, all systems change constantly (although the rate varies). For complex systems the process of co-evolution and edge of chaos means that there is forever a balance between changing and static parts (which can also change places over time).

4. Social Complexity

Here we apply complexity concepts to social systems in general and suggest that they are equally valid as models of many social situations.

4.1 Beliefs as Attractors

We will assume that our beliefs are themselves attractors. They come into being as a result of experiences changing our neural connectivity. Like all attractors we cannot escape them unless we change something crucial - this requires new information to effect a change to their control parameters.

4.2 Scale Independence

Complexity concepts are applicable to the self, family, group or nation with similar results. The emergent properties cover a wider scope as the system enlarges (and some new properties appear - the concept of nation itself for example), yet a caution is required. We must be careful not to transpose properties from a lower level to an higher one, for example in personifying nationality - the emergent property of 'speech' belongs to an individual and is not a collective property - the nation as such cannot 'speak' or 'think', its emergent properties are of a different higher type (e.g. statistical distributions).

4.3 Autonomy

Complexity implies that all agents are autonomous, and potentially of equal importance. Thus there is no hierarchical structure to a complex system based society - no controlling political structure by design. If one appears it must emerge as a stable optimum, but essentially it will be a distributed power structure since the EOC criticality is a globally undirected feature (disturbances have local effects, but can occasionally perturb the entire system). Interactions between agents on our view aim to maximise their fitness (or values). This is neither selfish nor altruistic in nature but opportunistic, and typically a mixture of both. In any situation an agent will choose the best option available or may make a stochastic choice if their information is inadequate (random walks on the landscape). What is the true best option is often unknown, agents make a 'best guess' based upon their limited look ahead abilities.

4.4 Social Rules

The individuals making up the society can each be regarded as having a (complex) rule by which they interact with other individuals. The emergent features of the society depend both on the rules in use and the connectivity between the interacting agents. Education is a method of changing an individual's ruleset and thus a method of affecting the emergent behaviour of the society. Non-uniform rulesets (individuals with different behaviours and interests) can improve the evolutionary power of a system, increasing the speed of problem solving and the quality of the optima obtained.

4.5 Social Structures

Social structures in the complexity view are emergent features of the interactions of agents. Due to this they are not fixed forms in their own right and cannot be initially 'designed' from outside and then imposed on the structure, but must be allowed to evolve. Social Engineering, as an attempt to impose 'desired' aims (by whom?) on society must thus fail. Social structures can be divided into two contrasting types, collectives (groups with fixed ideas - which corresponds to the static type of complex system) and individualists (associations of independent agents - corresponding to the chaotic type of complex system). These extremes meet in practice in a range of social structures, merging the two types of interaction to different degrees - a self-organizing approach, towards an 'edge of chaos' system with a varying degree of stability (criticality).

4.6 Utopian Societies

The concept of fitness landscapes implies that there isn't an obvious optimum or 'utopian' state to which the society can aim. Even if there was, the very act of implementing it would distort the landscape and change the result unpredictably. Future optima will appear as a result of the ongoing changes and cannot be predicted in advance (as they don't yet exist). Existing optima will eventually disappear by the same process

4.7 Social Groupings

Social groupings allow a vastly increased number of combinations of interactions (when compared to families, say). This permits the division of labour (specialisms) and thus more efficient behaviour by the agents. In this way the collective fitness can increase since new modes of working (optima) can be explored. The more diverse the group the more stable it tends to become. This result in part from the system dynamics and partly because the diversity allows the vast landscape to be searched more efficiently (in parallel, rather then one step at a time). This allows the discovery not only of higher individual optima but also of co-evolutionary optima, called Evolutionary Stable Systems (ESS), in which no agent can improve its situation by any available action.

4.8 Group Psychology

The individual is the driving force for social occurence (as it is the only active agent in the system). This 'lower level' system underlies social emergence. The changes in individuals are the main perturbations of the system (individual 'rule' changes change the local attractors). The individual can then cause changes in those with whom they interact, so this perturbation can grow. We can regard the group view as a transient change. It may die out, but if it grows it may become a movement and extend throughout society (this corresponds to a chaotic disturbance - an exponential growth of change). Existing beliefs can act as barriers to such change and partition the system into static, self-contained ideas with ripples of new ideas. Emergence at a social level is an unpredictable effect of such participant interactions. We have a need for new levels of description to cope with novelty, the 'new features' that nobody could have predicted (e.g. the rise of the global ecological 'green' movement).

4.9 Maintaining a Society

If we achieve a Society that suits us then in view of what we have said how can we stop it disintegrating ?

4.9.1 Resource Flows

Changes in the global or local flow of resources will disrupt the stability of the dissipative system and force it to find a new stable position or attractor. Changing the flows is thus a method of controlling a static or chaotic system (increasing or reducing flow respectively so as to maintain the current emergent balance).

4.9.2 Perturbation Limitation

Too much change is likely to totally disrupt a system. By self-limiting to small changes at a time we can 'hill climb' slowly to an optimum or track moving optima. This requires a 'gradual improvement' policy - incremental change with monitoring.

4.9.3 Dominance

Achieving control by dominance (in effect creating a static system) will prevent the Society tracking the inevitable movement of the optima with time. This sets up stress in the system and opportunities for it to be invaded by alternative viewpoints. Any Society must be composed of individuals, each with an independent mind. It is part of the human condition not to agree with each other all the time (how could we, we all have differing experiences and thus differing mental categories, concepts and ideas) so there is the inevitability of perturbations of the system. A stressed system at some stage will collapse due to a minor change, as this is an inherent feature of complex systems (related to the power law unpredictability).

4.9.4 Education in Co-Operation

Agent behaviour creates the emergent system, so this is a key to its maintenance. If we cannot predict what features we will obtain, then at least we can recognise them when they arise. We are able (as intelligent agents) to monitor our society, so can recognise deviations from the required norm. For a diverse society (and complex systems suggests all societies must become this as a matter of course - although many forms of diversity may be equally good) our education system should both support individual diversity and set limits to the perturbation of one individual by another. A balance between stability and change. Co-operation can increase the absolute fitness of all groups. We can relate this to niche behaviour in ecology, which is the ability of multiple alternative strategies or value systems to co-exist in one ecosystem. In this way individuals do not compete with one another (a potential conflict situation) but each contributes different ideas/skills to the overall community.

4.9.5 Feedback Mechanisms

To maintain any particular social optimum, self-regulation (negative feedback) must be employed. This is common in control theory and forms a part of most machines. The general idea is to balance the movement in an undesired direction with a corresponding opposite movement. It is essential here to balance the two directions. If this is not done then the two perturbations will become independent with positive feedback reinforcement and this will cause an escalating and polarizing division in society. The idea here is to restore the same composition to the society, in this way the same emergent (wanted) features should arise. It is a change in balance that drives change in complex systems.

5. Conflict in Complexity Terms

Concentrating now on conflict, we suggest that complexity ideas can effectively model these sorts of situations in evolutionary terms.

5.1 Conflict as Co-evolution

The general view that complexity theory gives about conflict is to regard it as just another form of interaction. In evolution we have a large number of types of interactions. These can be between members of the same species, between species on the same level of the food chain, towards food or predator species, or towards inanimate objects. In human society the interaction additionally has an element of rational choice, and in this way has an extra level above that of lesser animals. Conflicts force change and it is change that allows evolution.

5.2 Transaction Sums

Two useful viewpoints on interactions are 'zero-sum' (what I lose, you gain and vice-versa) where creation must be inversely equal to destruction (in other words agents 'exchange' a particular resource); and 'non-zero-sum' where the result can add or subtract overall value or fitness. This has two forms: 'positive sum' (creation greater than destruction) as in mutual benefit trades, and 'negative sum' (destruction greater than creation) as in armed conflict. We can also regards this mathematically in the form of lowering (order) versus increasing (chaos) local entropy, with the zero-sum case as one of constant local entropy.

5.3 Iteration

In most situations involving a simple interaction the action taken is blind. In other words only the immediate effect is considered. In evolutionary terms however, if we assume that the participants will meet over and over throughout their lifetimes, then the interactions are iterated (performed over and over again). In this scenario some very different perceptions and problems can become evident in conflict situations.

5.4 Prisoner's Dilemma

Two prisoners are both charged with a crime. If both stay quiet they get 3 years jail each. If one says the other did it, he gets off free, the other gets life. If both implicate the other then they get 10 years each (the values vary with who tells the story). In this simple and well known Game Theory scenario the results are as follows:

If both co-operate (stay quiet) they get a better result than both defecting (implicating the other), but from a selfish point of view defecting is the 'safer' option (it ensures they don't get the life sentence). This conflict between overall and local interest is the key. For a single encounter (conflict) selfishness is best, but if the two parties will encounter the same problem over and over (Iterated Prisoners Dilemma) then co-operation can be shown to be the option giving the higher fitness [1]. Conflicts in our view rarely are resolved by one-off actions, so recur over time, fitting the iterated case.

5.5 Perception of Conflict

In the above scenario, what drove the fear causing the defection ? Lack of trust seems the most evident feature to explain this. In general conflict scenarios do the participants regard the problem as a zero-sum or a non-zero-sum issue ? Fighting about land, say, may seem at first glance to be zero sum, either I have it or you do. Yet we must evaluate not just the obvious resource but all others involved. If we do this then it is clear that it is a negative sum transaction. Both sides lose far more resources in total than they can ever gain. In evolutionary terms we would expect an agent pursuing such a strategy to become extinct within a very short time.

5.6 Results of Conflict

Can a conflict ever be won ? All conflicts involve change, at least the destruction of some opposition. Change in a complex system sense affects all aspects of the system equally. In other words the 'good' aspects can be replaced as well as the 'bad'. A perturbation cannot be easily targeted. Trying to force a conformity or a particular view to prevail therefore can lose the creative as well as the destructive aspects of the agent interaction situation, making matters worst. This is over and above any material/human losses that may be 'accepted' (usually by those not affected...) and results simply from the behaviour of complex systems. In other words the 'winner' will likely suffer unforeseen later effects that make the action counter-productive.

5.7 Protectionist Strategies

People under threat try to maintain a fixed position regardless of whether it is useful to do so or not. There is an old English saying: 'better the devil you know than the one you don't' - this we can relate to evolutionary theory. Any mutation in a system is far more likely to harm it than to improve it (e.g. genes or computer programs). So it is essential that we adopt a monitoring technique and eliminate changes that are harmful overall (nature does it by killing the less fit, but we should be able to do better). But we shouldn't stop all changes, otherwise we can't grow at all, and will degenerate with the inevitable landscape distortions. We saw earlier that large rates of uncontrolled change can create unexpected global effects, so conflict can be regarded as such - excessive sudden change that destroys rather than achieves the desired result.

5.8 Conflict as Perturbation

Perturbation can be viewed as part of the fight, each party tries to perturb the other. Nominally there is an aim - perhaps to 'destroy' the other party, but the unpredictability at EOC means that the result is often not as planned and can result in self-destruction (extinction) - while the other party bounces back to dominate the remaining resources. The key idea is, perhaps, that the opponent reacts, and that changes the system upon which your decision to act was made (the fitness landscape) - thus your action is no longer the right one and if continued unchanged (locked in an attractor) can then be disastrous to you also. A perturbation changes the basin of attraction of the system. Events can then take their course regardless (the unstoppable war machine), until a shift to a new behaviour (attractor) can be forced.

5.9 Alternative Optima

Recognising the available attractors, identifying the best and tracking the change in landscapes are all difficult problems. It is partly this lack of firm data that enables conflict to develop. People tend only to see what they have experienced, disbelieving that any better alternatives could exist. Yet our experience of complex systems suggests that state space is so vast that there are always many optima still undiscovered. The demands of both sides in a conflict can often be simultaneously met by a minor change in perspective and the exploration of new combinations.

5.10 Identity Threat

Our fear of change without control and our attachment to the concept of identity (either to self, group or nation) gives another view of conflict, as a threat to identity (the destroying of identity in the subject-subject interaction). New possibilities arise and old possibilities disappear so fast, that the subject can not build a stable map of the changing attractors. For this reason we search the edge of chaos (the edge of conflict) - the optimal balance between the possibility of increasing our identity and the danger of losing it. Identity here corresponds to the control area of our world, the coherent scope of our influence. Any restriction of that is perceived as a 'conflict' situation but conversely any expansion could be viewed as an 'opportunity'.

5.11 Noise Masking

Many conflict situations are surrounded by much irrelevant information. Multiple factors are involved in any situation, but the essence of the scientific method is to concentrate on the relevant ones. In complex system studies it is found that levels can operate independently, one may be static, another chaotic and a third at edge of chaos. For example in the 'cold war' between USA and USSR much of the rhetoric was the same on both sides, but the critical point (arguably) was that both sides insisted that their dogma was correct and they would be 'safe' only if the 'other' side was destroyed - a 'one off' solution. We seemed to have there a chaotic individual rhetoric level covering the entire system, a static division partitioning the two camps at 'superpower' level and identical island groups of strategists on both sides each proposing the same idea - a 'final' solution. Luckily sanity prevailed, and once it was recognised that both sides had good and bad ideas the ongoing (iterated) dialogue then showed that co-operation not conflict was beneficial for both sides. Interestingly the Iterated Dilemma scenario predicted that all along...

5.12 Universality of the Edge of Chaos

The tendency of stability and change to balance in any system, by self-organisation to an unstable balance should be stressed. This occurs in both inorganic systems (sand piles), unthinking ones (ecosystems) and human societies [2]. Despite opposition from both sides the system dynamics will prevail ultimately. This can be affected by individual decisions (people withdrawing from the 'rat race' damp the system towards more static behaviour, those pushing for change move it towards the chaos zone) but it seems to be a natural trend in these types of system. Conflicts are in some respect inevitable, but can perhaps be handled in a more effective way if we understand the underlying dynamics (upon which specifics of a particular conflict are superimposed).

5.13 Conflict Dynamics

In a sense a group is a set of co-ordinated views - a block vote if we like. If we regard it as similar to a static solid (all molecules/people linked and self supporting) then perturbation from outside is hard.

If we regard it as the perturbation itself, affecting a chaotic gas (free for all) system then it can carry all before it (dominate). Two such blocks and we then have our potential conflict situation, neither can shift the other. If the groupings are more flexible (liquid) then the two groups can slide past each other intact without mutual damage. The liquid state in complexity terms is the edge of chaos, where systems have sufficient flexibility to bend and absorb new ideas and challenges without breaking.

5.14 Identifying Conflict

It would be useful to have an early warning of impending conflicts, so that they could be defused before they became major problems. Some of the ideas raised in this paper may help in this respect. If we take a potential conflict to exist once two parties have ideas that cannot simultaneously be 'true', then we can expect perturbation size and frequency to increase between them, as they begin to struggle for dominance. This represents a move from a static towards a chaotic system. Mathematically this shows as an increase in the divergence statistic representing the relative movement of two close points in state space (called the Lyapunov exponent). Unfortunately applying this to social situations remains problematical, it unclear how we can best relate the low dimensional systems to which this idea has so far been applied to the much higher dimensionality of human interactions, to identify measurable parameters.

6. Conflict Resolution Ideas

Having positioned conflict in complexity terms we now concentrate in using the concepts to suggest resolution approaches and alternative control strategies.

6.1 Opportunity

Seeing opposition not as a threat, but as an opportunity to expand our world may be a way to resolve potential conflict. The idea here is to use the opposition positively to reach a higher optimum for yourself, one which is out of reach individually. This allows the opposition to form a bridge between your current 'fitness hill' and a higher one nearby - without forcing you to lower your fitness in the meantime. This can happen in the same way as a catalyst works, the landscape is distorted so that the peaks temporarily join. A mediator can help the parties to search for new optima in this state space, acting as the catalyst or bridge.

6.2 Sum Conversion

In our game scenario we had two forms: 'positive sum' (creative), and 'negative sum' (destructive). The role of Conflict Resolution perhaps is to convert the latter to the former. By regarding conflicts as cases where the 'players' see only one case, yet the mediator can see the same thing returning forever in time, we think that it should be possible to apply complexity models of this scenario to these cases. We can see it as a selection of alternative perturbations, they can choose to conflict (negative sum) or to co-operate (positive sum). The latter is the only sensible choice for both parties in an iterated situation. Most conflict situations we'd suggest don't fully take into account the long term negative effects (some even swap the two - e.g. in 'glorious' death for the fatherland/religion...). Viewing destruction as a loss of potential diversity does, in an ecological sense, imply that the remaining society is less fit, not more.

6.3 Scientific Gradualism

Speed of change means reduced control and thus conflict. Where our attractors are fixed (and many are - language concepts, memories and the like rarely change) we feel no threat. That comes when we feel perhaps that the world is changing (or has potential to change) without our co-operation - we assume that the change will be for the worst, but that may not be the case. All new experiences add value to our being, all we need to do is try to ensure that no current values are lost - and here we get back to the difference between incremental change (monitorable and correctable) and utopian change (knock on effects unpredictable and not controllable). That is the difference we think between scientific sociology and dogmatic sociology - one monitors the 'corrective action' taken, one does not.

6.4 Symbiotic Coexistence

Humans have much more in common than we have differences. If we stress our commonality of belief/behaviour as a symbiosis, mutually supportive, then we can view our differences as a much smaller part of the whole and in a better perspective. In complexity terms the differences are small perturbations on a much larger whole. Neither party want the whole to collapse in an attempt to preserve or enhance a minor detail.

6.5 Business Analysis

There is much in common between business competition and conflict in society, and Complexity Theory can be applied to both. Using similar logic here can highlight the advantages of co-operation in contrast to the apparent short term gains (which are not realisable in practice without considerable loss also to the one who thinks they will win). Essentially it is a profit and loss account in business terms. Gaining land (say) at the loss of 50% of your resources (including people) isn't a transaction a sensible company would make. Thinking of decisions and options in terms of 'would you take that chance if it was your money/resources ?' can show clearly that what seems a good emotional idea is completely ridiculous in terms of the actual effects and risks.

6.6 Control Identification

Canalizing functions were mentioned earlier as 'damping' factors, operators than can reduce instability in a system. The idea is that any system can have built in 'overrides' - actions that force a particular solution regardless of any other activity. To take a trivial example, immobilising a car by removing a vital part would be a canalizing action, a thief could do anything with the other parts but unless that one was replaced (in some way) the car couldn't be stolen. Socially perhaps the Berlin Wall was a canalizing feature - a forced separation of two groups. Looking for inherent features within conflicts that work this way could help control them. Essentially they activate or de-activate connectivity and thus can tune the system to EOC if we can manipulate them. Complexity Theory would start from the fact that real conflicts have some basic regularity (numerical, statistical or quality) in spite of the fact that an individual conflict is extremely complex phenomenon and process. We would highlight that the conflict is perhaps an emergent feature of complex interactions, any one of which could be crucial in escalating or defusing the problem.

6.7 Duality

Conflict ultimately can be seen as a very simple problem, which takes complex forms as it develops. There may be many contributory causes to any single conflict, but surely all come down to just one thing - a division between 'us' and 'them' in which it is thought only one party can win (what we called a zero-sum scenario). What Dilemma and such simulations can tell us is that in an evolutionary environment better fitness overall comes from diversity (more possible combinations to changing fitness landscapes). This is a non-zero-sum mode, (in Marxist terms the synthesis is better than either the opposing thesis or anti-thesis) - both parties can gain from the encounter, providing they can recognise that the opposition are also humans and will co-operate if they can see an advantage to doing so.

6.8 Connectivity

Here we need to re-introduce our 3 modes of complex systems, simple systems (which are unconnected - like primitive groups living on isolated Islands), chaotic ones (highly connected - where multiple contrasting groups try to occupy the same space, a war situation) and complex (optimised connectivity - where groups maintain their own autonomy, yet connect to neighbouring groups sufficiently to allow an exchange of ideas to the benefit of both). In this approach Complexity Theory tells us that changing the connectivity will change the stability. A connection is a perturbation source, so the more connections the more unstable the system will be (out of control, therefore fear driven), yet without connections the system will stagnate and be in danger of disintegrating (the inherent fear behind most conflicts perhaps) due to unforeseen changes around and within it. For maximum stability, adjustment to the actions of 'opponents' should be allowed, but maintained at a slow rate (tracking the changing landscape, but not over-reacting and causing an escalating 'knock-on' effect). To control these sort of systems we can adjust connectivity (this perhaps also relates to standard conflict strategies - if a stalemate, then try to add dialogue or perturbation, if in conflict, then try to interpose separation or static barriers, if a resolution is progressing leave well alone). Complexity Theory allows us to globally see why this can work. The process that is taking place is either pushing the system off a local optima to allow it to find a 'common' higher one or alternatively reducing the rate of change of landscapes to allow an elusive optima to persist and be tracked.

6.9 Sustainable Change

Adaptability - sifting the 'good' ideas of our opponents from the bad and being willing to recognise and replace our own bad ones (we all are human and will have some of each). This suggests a gradual, controlled evolution which enables us to monitor change and correct it if it starts going astray. In the same way as we consider sustainable ecological usage (e.g. in forestry) we can do the same for society, making only so much change as the system can comfortably adopt at any time.

6.10 Controlled Disturbance

Essentially this is the idea that change improves a system (EOC). The static situation is a balance (the symbiosis) an Evolutionary Stable System. In this view any change by any party will worsen their position (reducing their value satisfaction or fitness). Yet they are not at the global optimum, so improvement is possible - they just can't reach it by minor changes to strategy. To show this is the case we just ask any party if they can imagine any 'better' world for them - all will be able to of course. A chaotic (conflict) situation causes continuous distortion of the fitness landscape, yesterday's decisions are made invalid by today and today's will be invalid by tomorrow - thus no planning is possible and no balance is maintainable, all order is disrupted. The alternative is for a static situation (ESS) to allow itself to be perturbed sufficiently in the short term to escape the fixed attractor which contains it. This can be done, by example, by taking on a new idea (perhaps from the opponent) and seeing where it leads. It may lead to an improved fitness, a better set of values or higher local optima for both parties. This is similar to sexual crossover in biology - the swapping of ideas (in genes), which allows biological systems to make small leaps in fitness space to innovative new solutions.

6.11 Change Tracking

Because of co-evolution, the shape of the fitness landscape slowly changes, so the corresponding process of adjustment to new ideas and developments must be repeated constantly if the current group fitness is to be even maintained. We must track the changes in our social environment, always looking for improvements (called the Red Queen scenario - always running to stay in the same place).

6.12 Irrational Choices

It may be thought that long logical reasoning does not work in real Conflict Resolutions (as a rule). Instincts, mistakes, fear, habits being the real forces leading to action choices. Yet in Nature the agents are not intelligent, but the same complex system features are found. Random or stochastic change is equivalent to non-rationally directed change. Our task in the resolution of conflicts is to avoid, as far as possible, the worst aspects of the natural forces that drive dynamic evolution. The system will evolve to one of a number of forms of balance, many will be of lower fitness than the current one. In Natural Selection the lower ones are eliminated. This works as there are many parallel species evolving, so some are expendable. There is however only one human species and our extinction is in nobody's interest. These complex system ideas may offer a way for us to direct change towards higher optima and not allow conflicts to force us downhill, as seems inevitable in negative sum games.

7. Complexity Metaphor as Negotiation Technique

Here we use language itself as a weapon in the fight against conflict, suggesting that even in the absence of concrete techniques we may be able to defuse situations by simply restating them in complexity terminology.

Word meanings can dominate our thinking in social situations. How we view conflicts may depend crucially on the concepts we employ in their description. The words we use colour both our beliefs and expectations. People use metaphors widely to focus on problems and these if chosen wisely can illuminate, but if inappropriate can be harmful. Our metaphors, once chosen, tend to become fixed parts of our thinking and do not adapt with changes in the real situation, becoming sub-optimal in time. By seeing how people use metaphors we can often ascertain the assumptions behind their thinking. Adding new metaphors to a situation can expand the views of those involved and enable progress in a deadlock situation. Traditional metaphors tend to assume static situations, those of complexity science relate to change, and may provide a useful addition to the toolbox of negotiators. So let us sum up the main metaphors that can be used.

7.1 Fitness Landscape

The idea of multiple possible local optima, and a few global ones. The deformation of the landscape experienced by the actors as a result of actions by others, its state of constant change.

7.2 Attractors

Situations where passivity causes the situation to evolve itself to a forced position. The need for positive choice to enable the attractor to be escaped.

7.3 Perturbation

Too much causes chaos, too little loss of fitness and the current optimum.

7.4 Evolution

Growth taking place all the time, in controlled and not discontinuous ways.

7.5 Value Add

Co-operation adds fitness to both parties, positive sum transactions.

7.6 Butterfly Effect

Long term prediction is impossible, imposed control will escape with time into chaos.

7.7 Ecosystem

Multiple separate lifestyles and ways of looking at things can coexist. Diverse groups can work together for the benefit of all.

7.8 Multi-Level

A problem at one level can obscure all the successes at other levels. Our evolutionary past causes us to concentrate on the bad (danger) and ignore the good, which can be lost also.

7.9 Connectivity

Adjusting interactions to control emergence and change. Greater connectivity increases change, lower increases stability.

7.10 Autonomy

Agents drive the system. Ignoring them allows perturbations to grow with disruptive effects.

7.11 Adaptability

Avoid global solutions, concentrate on small controllable improvements and let large scale change emerge itself.

7.12 Non-Linear

Effects will not be proportional to cause, so don't expect to be able to set out in advance the solution. Implement monitoring and adjustment strategies.

8. Conclusion

We have looked in this paper at what Complexity Theory can contribute to conflict resolution. We have tried to apply some theoretical background from Complex Systems research to social systems and to conflict situations. We have not been able to give firm answers, since the findings of the theory preclude historically deterministic prediction of emergent features. General statistical trends (tendencies) however can be used to suggest the likely behaviours of interacting systems and to indicate how these will change with modifications to the system. Complexity Theory is not offered as a definitive way of dealing with conflict, just as a new form of knowledge which may help increase the available resolution options, an additional set of tools.

The following references give further information about the concepts used in this paper (and more technical concepts) together with the state of current research. Complexity Theory is explored in more depth at our World Wide Web site at http://www.calresco.org/.

9. References

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