Chapter 3

Information dynamics, self-organization and the implications for management

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I start with a brief summary of kinds of information used in science, showing how they are nested (or hierarchically arranged), with inner kinds inheriting properties of the outer kinds. I further argue that within each kind there is also hierarchical organization, and that the major kinds are distinguished by their dynamics, not just being ordered in a hierarchy, though similar principles apply at all levels. Next I argue that rules applying to non-equilibrium thermodynamics apply also to information systems, and I give some examples of resulting self-organization, or what we have called “rhythmic entrainment” [1]. I point out that entrainment that results from forces within a system are more efficient than ones that are entrained by outside forces. This gives a sort of resilience to such systems, and in higher kinds of information allows for self-adaptation via accommodating both external forces and internally generated forces. I then apply these lessons to management and argue that the most efficient and creative form of management comes not from severe control from the top, or from imposed “efficiency” but through self-organization allowed by a low degree of control and the encouragement of diversity. This form of management I call facilitation. There may be specific people assigned a facilitation role, but this is not required; any member of a group can act as a facilitator. What is required, however, is that members of the group are accustomed to being open-minded and flexible. This form of management is most compatible with anarchism as a political (and management) theory, but has benefits in pretty much any political system.
1. Introduction

Management is a process, so it is possible to look at it dynamically, like any other process. Although management is often represented as a structure, with control from the top down the presupposed structure, it is more general to look at management in a free form, with information being the main currency within any management system. Typically management is of something. I will largely ignore anything external to the management process itself, treating incoming information as data and other externalities as outputs or products. It should be noted that management of some kinds of systems, especially complex ones, does not permit this sort of division between the managed and the management, and concessions need to be made to take this into account. For example ecological management must include the management system as part of the very ecology that is to be managed, thus effectively enlarging the management system by extending interactions from within the management system to the interior of the ecology itself. Viewed slightly differently, the ecology becomes a part of the overall management system. The general remarks I have to make about management can be extended to include such enlarged systems, so much the same principles apply as to management in particular. It is important, however, to move to an enlarged system whenever there are complex interactions between the management and the system to be managed; in these cases treating inputs as data, rather than processes of the system itself, is distinctly misleading. I will assume (hope!) that such situations can be recognized and taken into consideration.

Information plays two roles in management systems. One is as a process that connects the various nodes in the management. The other is as a constraint on such processes. In flexible management systems, and also depending on time scales, the two roles can be interchanged. However Shannon [1949] pointed out that logically the roles of information and constraint are interchangeable. When I introduce the idea of information flow later it will be evident that particulars carrying information are dual to classes that arrange information, which is similar in some ways to Shannon’s equivalence. The duality allows us to see filters of information as informational in themselves, obeying the rules of information dynamics in general; likewise information can be seen as a classification and part of
the structure of management. These dual roles emphasize the nature of management as a process rather than a structure. This more flexible approach has important consequences for what can constitute the most effective management systems.

The first part will deal with dynamical systems in general, noting some properties that I will use later, in particular the efficiency of use of resources. Then I will apply dynamics to information flow and draw some general principles that apply to all information systems. Lastly I will look at management in particular, and compare various forms of management in terms of the principles developed earlier, arguing for their advantages and disadvantages. I will conclude that the most effective form of management is what I call facilitation, which combines a certain degree of control, generated either externally or, preferably, internally within the constraints of what is to be managed, but encourages diversity and flexibility, which together encourage self-organization. I will argue that this form of management, despite appearances, is more efficient than either top-down or anarchistic alternatives. It can be compatible with anarchistic principles understood with Kropotkin’s ideal of cooperation, but it can also benefit other forms of management, even when there are hostile parties.

2. Dynamical systems: energy versus information budgets

A dynamical system mathematically is any system with change, usually but not necessarily over time. I use a somewhat more restrictive notion of a system of interacting processes. Processes are causally connected sequences of states, with an early initial point and a later endpoint. I take it that processes are fundamental, and their states are useful fictions, but not a lot turns on this. Although qualitative processes can be described and included in theories (with many successes especially in movement studies, including speech) it is convenient if quantities can be applied. Most processes are at least restricted by energy inputs and outputs, and many are also best described in terms of information flows and changing constraints (which turns out to be another form of information flow). In many cases energy and information are more or less independent of
(decoupled from) each other (assuming sufficient energy to support the information flows), but in other cases they interact with each other in ways that make them mathematically inseparable. For convenience I will deal mostly with cases in which the energy and information budgets can be separated. But later I will examine the consequences when this fails.

There are some general principles that apply to all dynamical systems with regard to their computability and predictability. In standard Hamiltonian mechanics of conservative or near conservative systems, boundaries are not time dependent (the systems are holonomic). This is the condition assumed in most of modern physics, and, by analogy, to physics, much of modern science. Standard advanced texts on classical physics (such as Goldstein et al 2000) make the assumption explicit when they introduce the Hamiltonian formulation. For this reason I have called such systems Hamiltonian (Collier 2008a, 2014), even though the Hamiltonian formulation can in principle deal with non-holonomic systems. If the system is nearly holonomic, then it is possible to deal with deviations with perturbation theory, a standard method. At the other end we can deal with large changes as step functions between states. This is familiar to quantum physicists since at least the introduction of the Dirac delta function. In changes of state that can be modeled by step functions, both the boundary conditions and the local dynamics change abruptly to new conditions.

Hamiltonian systems are predictable in the following sense: the trajectory of a system is predictable if and only if there is a region $\eta$ constraining the initial conditions at $t_0$ such that the equations of motion ensure that the trajectory of the system passes within some region $\epsilon$ at some time $t_1$, where the region $\eta$ is chosen to satisfy $\epsilon$. Indeterministic systems have probabilistic predictability (at best), but are otherwise much the same. It might be that there is no analytic universal solution to the equations governing the system (in three body gravitational systems, for example, and perhaps systems involving three collisions). Predictability for any finite time is still in principle possible, however, for any holonomic system, given enough computing power (though rounding due to computational limitations can give the appearance of nonpredictability when these systems are modeled on actual computers – this should not be confused with unpredictability in the system itself).
These commonly used methods fail in systems in which the boundary conditions interact with system laws in a mathematically inseparable way. Such systems are radically nonholonomic. I have also called them radically non-Hamiltonian (Collier 2007, 2008a, 2014). They badly fail both reducibility and predictability, and involve the formation of novel large scale properties, i.e., what has historically been called emergence. Conrad and Matsuno (1990) made clear the consequences for dynamical systems:

Differential equations provide the major means of describing the dynamics of physical systems in both quantum and classical mechanics. The indubitable success of this scheme suggests, on the surface, that in principle it could be extended to a universal program covering all of nature. The problem is that the essence of a differential equation description is a separation of itself from the boundary conditions, which are regarded as arbitrary.

Conrad and Matsuno go on to draw conclusions about the application of the method to the whole universe (they claim the system breaks down, but it is actually compatible with “no boundary conditions” constraints on cosmological theories). Of more significance here is the breakdown of the separation of differential equations and boundary conditions in nonintegrable systems, exactly the ones that are nonholonomic. In these systems, computation from partwise interactions fails, and the system is in a sense holistic. In any case, its dynamics cannot be reduced to the system dynamics and constraints arising from partwise relations.

How can a system fail to be holonomic? If we consider systems in which the energy budget dominates, basic physics tells us that energy is conserved, so that the Hamiltonian, which is the sum of the potential and kinetic energies, is constant. NonHamiltonian systems must gain or lose energy. The relevant energy here (to the system in question) is the available, or usable energy. To get this we must subtract the unavailable energy, which is entropic. We can compensate for this, though, through thermodynamics, taking the unavailable energy as heat, a form of disorder. NonHamiltonian systems must be such that we can’t exclude heat energy. But this can happen within a system if it expels entropy to its surroundings, as noted often by Prigogine. In that case the system can do work on itself, altering its boundary conditions, and setting up a new dynamical regime that is more complex, the simplest sort of case being Prigogine’s
dissipative structures. It might seem that we can redescribe the system more inclusively to include (or add in the dynamics of) the system into which the excess entropy is dumped, the larger system being holonomic. This is not always possible, though, at least not without including the whole universe into consideration (Collier 2011), since we may need to go ever outwards to get to an (effectively) isolated system. The problem is that the boundaries between attractors in complexly organized systems are fractal, with any two points in one attractor having a point between that is in another attractor. Complexly organized single attractor systems can be approximated by very carefully controlling boundary conditions and slowly changing the energy, as has been done in some exquisite experiments with Bénard like cells, using liquid Helium, but even in such cases there are at least two possible directions of rotation that are not determined by internal rules (Behringer and Ahlers 1982).

Many relatively simple energy budget dominated systems and the majority of complex ones are of this sort. At a minimum, three factors and external dissipation are required. Reducibility and predictability both fail, reducibility because the equations governing the system have no complete analytical solution, and predictability because a stepwise approximation of the dynamics, no matter how big a computer we have, will never be enough, since the system reaches an endpoint (the new dynamical regime occupying the central region of the attractor) in finite time, solving equations for which would require a non-existent complete analysis rather than a piecewise approximation to an arbitrary degree of accuracy (Collier 2011a). The dynamics of the system cannot be localized, and irreducible (novel) properties are manifested (Collier 2007, 2008a, 2014). Despite this, the emergent properties and general system dynamics will have some highly regular general properties that I will return to below. These result from the fact that the system can do work on itself to modify its own boundary conditions, and this capacity to do work can be more or less efficient. The work done tends to be minimized, resulting in regular states (typically called attractors, though often they are also transitory, but with

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*aMore mathematically, following Bertalanffy (1968), who follows Franks, noncomputable mathematical models occur in linear systems with partial differential equations using many parameters, and in nonlinear systems having more than one parameter, being partial differential, or in nonlinear algebraic systems with many parameters*
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a much longer period than the regularities preceding them, perhaps \textit{quasiattractor} would be better). This shift of system dynamics is a sort of phase change in which the system forms nonlocalizable regularities, with chaotic boundaries between, that get frozen into more local but still holistic regularities as noise dissipates. This can happen very quickly (as in the formation of Bénard cells) or rather slowly (as in planetary harmonic resonances, see Collier 2011a).

Interestingly, boundary conditions in such systems can no longer be described as specific values of physical parameters, since they are dynamic as well (being nonholonomic, after all). As usual, they are constraints on the system, but they are dynamical constraints. As Shannon famously argued (1949) the notion of constraint is an information theoretic notion: constraints are information. If we follow this, then the dynamics of constraints requires a dynamical theory of information. The notion of information in such a system can be aligned with physical properties using methods devised by Szillard in the 1920s to examine the thermodynamics of measurement, using Boltzmann’s constant, and described by Brillouin (1962). For details of the connections, see (Collier 2007) for further developments, including information flow and complexity measures for information devised by Landauer (1961, 1987) and Charles Bennett (1982, 1985, 1987). These ideas also allow connection to the physics of computation, opening up a way to discuss information flow in physical (and biological) systems. The notion of information flow was further developed by by Barwise and Seligman (1997, see below). These methods together allow connecting physical notions and information in constraints, as well as notions of information flow. For an account of causal process in information theoretic terms, see (Collier 1997). I will not go into further detail here, but will merely assume that the strong analogy between energy and information budgets holds for systems in general. A summary of the basic connections justifying the analogy as a continuity of principles are to be found in (Collier 2007).

There are two ways that information can move (be dynamic) in a system. One is information flow, in which information at one point in the system is conveyed to another point in the system. The other is the constraints on the system itself can change. Often, changing the constraints will affect information flow as well. This is because information flows in
channels, and the channels must be constrained to permit the flow, so changes in constraints on channels can change information flow. The information in constraints can change even if there is no information flow, because, as noted, in energy budget nonHamiltonian systems the dynamics allow the system to work on itself to alter its boundary conditions. However, information flow depends on channel constraints. It is possible in principle for the channel constraints to change independently of the information flow, and also for the information flow to be dependent on changes in the channel constraints, but not vice versa. This is more or less like a Hamiltonian energy budget dominated system, if the constraints of the channel represent the system laws and the information flow represents the boundary conditions, and the two are independent of each other. Mathematically there is no difference. Most information systems, e.g., computers with their typical separation of program and data, and biological inheritance on the neoDarwinian model assume this separation. However, as has often been pointed out, there is no essential difference between program and data, so these models may be misleading if taken as generic of information systems. If the two interact, then it is possible for the information system to reorganize itself in much the same way as systems can do work on themselves to alter their boundary conditions. This was proposed by Brooks and Wiley (1988) in biology (see also Collier 1986 for more detail about the conditions and processes required). They argued that biological information could self-organize on a strong analogy to energy dominated systems that are now fairly familiar, starting with dissipative structures and working towards more complicated systems, including evolutionary and developmental processes. This analogy can be strengthened further by noting that self-organization and the emergence of novel information requires the dissipation of information externally (e.g., through organism deaths and population extinctions). This sort of process can lead to speciation and increased diversity (Brooks and Wiley 1988, but see especially Collier 1986). Basically, Brooks and Wiley assumed that the energy budget could pretty much take care of itself, maintaining an otherwise decoupled information budget with self-organizing properties. They gave many examples of cases in which this has appeared to occur in both development and evolution. Collier (2008b) argued that with a proper understanding of information channels (i.e., from
Barwise and Seligman (1997) we can recover a robust form of the expression of information in DNA that in its simplest version is just the neoDarwinian view, but that model also allows the Brooks and Wiley mechanism. On this account information is both substantive and has its own dynamics decoupled from the underlying but supportive energy dynamics. Information of this kind tends to form a natural hierarchy (described in some detail in Collier 2003).

The reader may doubt that information flowing and constraints are really comparable with each other, forming one pool of information. Aside from Shannon’s (1949) observation that constraints are a form of information, Barwise and Seligman (1997) observed that the particulars carrying information and the classes that give it meaning in their channels are duals of each other. The exact details are rather complicated, but I think that the idea can be seen in the process of observation. Red light stimulates receptors in the retina, allowing them to stimulate nerves to carry information to the brain. The signals carry the information of a red impingement, as classified by the receptors, but the receptors are also individual units that carry the information that red light has struck them and a channel exists from the red receptors to the brain. So both the receptors and what they carry can be thought of as information about red. Basically, depending on what is useful for our analysis we can see the receptors as red classifiers or else as conductors of red information, as classified elsewhere in the perceptual system. This dual aspect of classification and content allows us to bring together the system constraints and what they carry as informational under the same heading, bringing together the informational nature of both the flow and what carries it. The two are separate, and have their own dynamical properties, but basically they deal with the same thing. When information flow is able to self-organize, this common basis allows a continuity between the processes, so that changes in the channel and what it carries change together.

We can generalize to information systems of all kinds: under the right conditions (external dissipation of information and system interactions such that the system can do work on its own dynamical conditions) then emergence of novel information can occur. If the novel information stabilizes, then it can provide a bed for further novelty to appear. The result
will be a hierarchically arranged information system, with each level emerging from lower levels, but largely decoupled from them. From basic physics through to social systems increasingly complex kinds of information emerge from simpler systems by pretty much the same dynamic (Collier 2011b). The basic dynamic is that of symmetry breaking (Collier 1996), leading to an intrinsic information grounded in system asymmetries (Muller 2007). Although how the information is used might vary, it is the underlying processes that make it exist. Inasmuch as the causal processes in such systems are objective, so is the information. Information can have dynamical properties that do not depend on whether it is recognized or on how it is eventually used. This allows that there might be much going on beneath recognition of consciousness, or any purpose the information might eventually be put to, although these are certainly interesting issues worthy of scientific exploration. But to limit study of information dynamics just to perception and action would be to ignore much of what is going on.

### 3. General properties of complexly organized dynamical systems

Since I have dealt with various aspects of these processes elsewhere (see Collier and Hooker 1999 for the basics), I will merely summarise the main points here:

- Although the simplest physical systems are Hamiltonian (or near Hamiltonian) many systems (or most, with Hamiltonian systems a vanishingly small proportion, see Robert Rosen 2000) can show emergent properties.
- My main concern here is that boundary conditions deal with forms, and are best described by information methods.
- So the dynamics of information become important for systems with dynamical boundary conditions.
- The concept of information has been used in science from physics through economics, but the meanings and uses are somewhat different and should not be confused. One important difference is between information used as instrumentally, for convenient description and
information used substantively. When used substantively information is assumed to really exist and plays a causal role (Collier 2008b).

- Some major classes of information used in science form a hierarchy (Collier 2011b). Each level introduces new kinds of dynamics (novel properties), and can be said to be emergent from lower levels.

- Within each level of the hierarchy are further hierarchies of organization. These originate by self-organization (of two distinct types, reorganization through dissipation and self-organization through the promotion of perturbations). In some cases these levels are emergent but in others (reorganized information) they are not.

- The same basic systems principles apply across all levels, but new properties appear at higher levels due to new possibilities created at lower levels. The whole fits into the principles of General Systems Theory. There are some basic principles that apply at all levels (see next section).

- Each successive kind introduces further restrictions, which in turn create new immediate possibilities. This in turn feeds inwards, e.g.: the social requires communication between individuals, which creates new possibilities for the individuals in addition to social possibilities. This can be further iterated within the social kind.

- In general, negentropy (difference from equilibrium state, which is unique for each system) creates possibilities for self-organization, allowing the formation of new structural information (a form of negentropy itself). At the same time the new constraints permit variant complexions within the constraints, leading to an entropy of the structural information in addition to the energetic entropy. This can be iterated within through further levels once we have an information budget largely decoupled from the energy budget.

- These principles are grounded in growth and self-organization, but an important aspect is that there are natural system resonances and it is easier (requires less energy) to form and maintain these resonances than others. Spontaneous organization through rhythmic entrainment minimizes required work to maintain it (Collier and Burch 1998, 2000, Collier 2007). These resonances are typically larger scale and often irreducible.
• In many higher level systems in the hierarchy the boundary conditions dominate, with the energy budget just maintaining a maintenance role. This is especially true in biology, but can also be true in purely physical systems, such as mineral formation, which can be surprisingly complex.
• The emergence of mind introduces a novel partially decoupled level that can work on its biological grounding, directing it and even working against its biological interests.
• Communication in social organisms introduces another partially decoupled level, which in turn creates new possibilities for more complex organization. This is most highly developed in human language. In turn, it allows for new forms of organization within the organisms themselves.
• The next level of information, made possible by communication, is social organization. This, in turn, creates the conditions required for management of social organization to be possible. In some social animals, like wolves, this management role is taken on by alpha males, whereas in others, like macaques, it is performed by mature females. In other animals it is distributed in more complex ways. Humans are special in being able to adopt a wide range of differing management styles at multiple levels from families to institutions.
   I will end by arguing that certain management styles are much more efficient than others. These are the ones that work with the natural dynamics of the system to facilitate self-organization, rather than forcing a solution externally.

4. Naturally resonant systems through self-organization
   (rhythmic entrainment)

At the basic physical level we now understand fairly well how the levels of information kinds interact and form. They can be shown schematically as in the following diagram for some of the lowest levels:
The Principles of General Systems Theory apply across all possible levels of organization. Some of the most important (referred to briefly above) are:

- **Growth**: Order and Entropy (disorder) can increase together. Order = \( S_{\text{max}} - S_{\text{actual}} \), \( S \) being a statistical measure of entropy, the difference being commonly called *negentropy*, or information (Brillouin 1962).
- **This “overhead”**, when growth exceeds the formation of order, permits self-organization:
- reorganization to lowest energy state by dissipation – noise dissipated, also natural selection
- spontaneous self-organization (state change, bifurcation) through continuous dissipation of free energy → new information
- Creates new possibilities for interaction (reduced abstract possibility space constrains processes, making them more immediately likely).
These common principles allow the entropy concept to be generalized to substantive dynamical information, so that we can talk of an entropy of information and self-organization and emergence within information systems. The basic principles are as follows:

- The basic physical relation is given by Boltzmann's constant in a suitable form, leading to measures in entropy units or bits.
- Microstates, according to David Layzer, have microinformation. Part of this is the information of the macrostate in which they are contained, called macroinformation.
- Not all microinformation is accessible to a macroscopic entity (2nd Law of Thermodynamics)
- Macrostates, to be real, must be cohesive, binding over space and time.
- The same statistical principles apply to any system in which the microstates are not constrained by anything but the macrostate, so we can apply these principles generally.
- In particular, we can talk of the macrostate of an information that has informational microstates. An example is the gene pool of a population or species. (Variation of the gene pool is taken to be random with respect to the properties of the species – in fact this is not always true and must be controlled for.)

These leads to the possibility for the spontaneous formation of levels through rhythmic entrainment (Collier and Burch 1998; 2000), though it can also be formed through external (or even internal) forcing:

- Rhythmic entrainment is a ubiquitous phenomenon that produces large scale coordination either through the elimination of interfering factors (re-organization) or through the emergence of higher level order (spontaneous self-organization).
- It produces new macrostates.
- In both cases the result is a sort of harmony at a larger scale while permitting variations at lower scales. Both produce new possibilities, as above.
- Entrainment can be produced either by forcing (constraining the system at a large scale), or spontaneously.
- The former requires more work (energy expenditure) to produce and maintain than the latter.
It is worth noting that entrainment produces symmetries, and it is the symmetries that reduce the amount of work required. Externally forced systems are typically in more asymmetric states.

5. Some simple examples of entrainment

The exemplary case with the fewest complications is the simple harmonic oscillator. It is noteworthy that it has a natural frequency at which the least work is required to get the largest response.

![Forced harmonic oscillator](image)

The harmonic oscillator is a paradigmatic case that can be modified by analogies to model a wide range of physical systems such as sound, light, seismic and other waves. However some of the basic principles also apply to a range of physical phenomena, once suitably modified to take into account the specifics of the particular systems. Resonances and phase changes are typical, however. Some examples are:
• Bénard cell convection and other vortices
• Planetary resonances – Earth-Moon, Mercury-Sun, Jupiter’s major moons, Pluto and Neptune.
• Japanese satellite to the moon – energy required was minimized by moving the satellite near a chaotic region in its orbit in which Earth and Lunar orbits for the satellite were close to each other. It took longer than a more direct route, but the satellite had enough fuel to allow the relatively small shift.
• Various climate phenomena (el Niño, North Atlantic Oscillation …)
• Old Faithful
• Geochemical differentiation

My contention is that there are similar phenomena in the information budgets of complex systems, and that similar principles apply. On the border are systems in which energy is important, but information also plays a central role by way of boundary conditions. In general, more symmetrical forms require less energy to form and to maintain. One example is benzene, whose remarkable stability stems from an oscillation between two states.

![Fig. 3. Benzene](image)

Another case involves the comparison between ethylene and butadiene (Harris and Bertolucci 1978: 288-297). Ethylene is a double-bonded 2 carbon unit. Butadiene is a 4 carbon unit with 2 double bonds. To make all
things equal, the energy of 2 molecules of ethylene is compared with one molecule of butadiene. The butadiene is more stable by 12 kJ. The usual explanation is that the bond energy is delocalized, but it is not clear why delocalizing something should lower its energy. The present explanation, that there is increased cohesion in the form of harmonic entrainment of the bonds explains why the energy of butadiene is lower (Collier and Burch 2000).

Presumably more complex chemical systems as found in organisms increase stability through similar nonlocality (although not through double bounds, but networks of pathways, even though the individual molecules are not necessarily especially stable). The thing to note is that it is the whole network that inherits the stability.

These principles allow a remarkable range of mineral forms, for example, the conditions required appearing rarely, with some minerals being known at only one location on Earth. One example is Jeremejevite (Al6(BO3)5(F,OH)3), which requires special conditions to form and is found in only a few locations. You cannot get it merely by condensing the component chemicals.
6. Human systems management

I will jump over biological systems (on which there is now a vast literature concerning self-organization and information) and move to human systems in particular, especially as they pertain to management. The general principles should apply to human systems, especially social systems, but the problem is to find proper analogues of dissipation, energy, information and other properties essential to self-organizing systems. The domain of interest is communication of ideas and behaviours and how these can self-organize. In line with other self-organizing systems, there must be an excess of something that is expelled from the system. In general, there must be excess (unconstrained) diversity in the system and a sink (exit) for diversity in order to allow self-organization. Since information is the main commodity of management systems, then it will be information that becomes organized and which is expelled. From the previous discussion, it seems at least highly likely that forced order and organization (external constraint of diversity) will be relatively costly in comparison to self-organization.

Perhaps the best measure of management effectiveness is not information but some other currency. Given the importance of money to many organizations, from businesses to government, perhaps we should use economic criteria to measure how well an organization functions. Economics has the advantage of giving a clear and measurable currency. Neoclassical economics assumes a sort of neoDarwinian optimality leading to equilibrium in the market. However, incomplete information, variations in trading times in the market, “animal passions”, and most importantly, unequal information, distort the market so that the optimality assumption fails. This is verified by the regular failure of neoclassical economics in both prediction and explanation. In general, the market changes faster than it can equilibrate, and equilibrium assumptions become questionable. Away from equilibrium, however, dissipative but organizing processes become possible. So self-organization should be expected in typical market conditions. It should also be evident that divergent and diversely distributed information will play a role in how the market changes.
But in general the currency of social systems is information, and it is passed more or less efficiently by communication. Money is just a special case. Open lines of communication, all other things being equal, will be advantageous to any organization. But that is not enough in itself, and more likely than not there will be plenty of communication that is or could be detrimental, let alone less than useful.

Productivity is a useful measure of efficiency if it is used wisely – the system should produce useful results relatively efficiently. These might be: sales (industry and commerce in general), societal benefit (governments, social agencies), or new ideas (think tanks, research units), but for society as a whole it should be overall flourishing and individual well-being. These last desiderata are harder to measure, but generally fall under the categories of happiness and satisfaction. These different ends will require different foci (on results) but it isn’t clear that different management organization is required for each sort of end. However, different time scales for returns might justify different management methods. Generally, though, there should be minimization of unexpected (crises, disasters, externalities producing antagonism). Fortunately, these are also important general human desiderata, so there is at least some common ground for various management ends and general human ends.

There are various management systems that have been used or advocated over the years. A common one is a military style of organization with a central command that enforces the structure and function of the organization. Both experience and the theory proposed here suggests that this sort of organization will require a lot of excess effort to maintain. Authoritarian and totalitarian states put a premium on control. To some extent, they must rely on predispositions in their populations, but largely they rule by terrorist methods and fear. This requires a large concentration of both political, economic and political power, since driving a system artificially requires a lot of power and waste of energy. This suggests that such states will be unstable. Unfortunately, whenever there are large concentrations of political, economic or physical power, there will be a tendency to use forced entrainment of ideology, however inefficient. A more efficient but less reliable method is propaganda and advertising, which attempt to drive or create resonances through subtle forcing. Herman and Chomsky (1988) describe a particularly insidious way in
which consent is achieved, though it requires considerable investment by power seeking individuals in media. So this method still requires a concentration of power to exclude competitors. Such a social system is always fighting a gradient towards more efficient organizations. This is one of the primary social lessons we can derive from complexity theory: *forced control is unstable and expensive (wasteful).*

Anarchists, and to a lesser extent libertarians, advocate a kind of flat social system. The idea is that everyone makes their own decisions, so there are no leaders or monarchs, the social relations are “flat”. This yields a form of radical libertarian anarchism in its most extreme form but it is also compatible with some forms of democracy in which everyone gets to vote on everything without any mechanism for forming compromises and concessions. As Hobbes argued, this will likely lead to a vote for a central authority with no limits on its power and we are back at the previous case. Representative democracy comes someplace between, but in effect closer to the top-down model, just as direct democracy with votes required on all decisions comes closer to the flat model. But it is unclear how any of these involve room for the production of new social information, new ideas or visions. Besides, there is the problem of who gets to decide what is to be voted on.

An alternative is a consensus system, which has been used effectively in some communitarian organizations. Consensus governance requires full agreement on any group issue. It can work well with small groups with largely common beliefs, but the worry is always what to do about holdouts. Furthermore, common beliefs constrain possible solutions, perhaps overly (e.g., the Amish). So consensus seems to be either overly restrictive or else too difficult to achieve.

The management model that best fits the self-organized complexity model of social systems is to encourage diversity with minimal top-down control. I call this facilitation. Facilitators concern themselves with attaining group agreement, and focus on the whole. Their role is to suggest, not demand. Facilitators need not be a single person or the same people throughout. It is largely a voluntary role. When a facilitator finds themselves being treated as an authority, it is best they step back.

Facilitation is a variation on anarchism, but could be applied in varying degrees within many different management systems. Facilitators should
encourage diversity while still helping to maintain focus, permitting self-organized solutions. Too much diversity “saturates” the system, whereas too little, or too little communication, makes it unstable. There has to be a certain amount of “overhead” in which ideas can be exchanged, compared, dissected and combined to produce novel solutions, otherwise the system will stagnate. This also requires that members remain actively involved in the management process. This is perhaps one of the hardest requirements to maintain. Often the introduction of a novel point will lead to reorganization of discussion around that point. This tends to be temporary unless resolution is reached. But it can help to keep people involved. A major disadvantage of facilitation style management is that its gentleness implies that it is slow (recall the Japanese satellite). On the other hand, this very fact makes it more likely that it will tend to satisfy human needs that go beyond the basics.

Some degree of control, or vision, is needed for this sort of management, however. It can’t be implemented without the participants understanding its advantages and potential defects, not to mention the principles that underlie it. This will require considerable education before it is generally practical. Nonetheless, a stable social system is best founded on spontaneous entrainment. This is both more stable and more efficient than forced coordination and obedience, and it is more productive and ultimately more stable than a flat system of management. Its main problem is that it may lead to arbitrary and unproductive entrainments, basically pathological, so some control is mandatory except in the most advanced social systems, in which stability is already well entrained, and mechanisms for the dissipation of concentrations of power are already entrenched in the structure of the system. Great variety can be tolerated in such a system, with minimal control, and it allows both the greatest freedom and flexibility. Facilitators should also recognize that much of the organization in naturally self-organized systems occurs below the surface, neither fully recognized nor used systematically.

Otherwise, variety should be encouraged within limits, and organization should be facilitated by the wise manager rather than forced or otherwise controlled. This requires encouragement of variety and judicious application of force near critical points between emerging attractors. In contrast, a strong selection regime is counterproductive for
finding natural solutions to problems, and requires more power to enforce and maintain. It is also more likely to get stuck on local maxima that are not more widely optimal, partly because it works through eliminating diversity.
References


