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Citation
Vree, J. K. de. (1991). Chaos in Europe: An inquiry into the nature of social systems and the methodology of the social sciences. *Acta Politica*, *26: 1991*(1), 25-63. Retrieved from https://hdl.handle.net/1887/3449889

Version:	Publisher's Version
License:	Leiden University Non-exclusive license
Downloaded from:	https://hdl.handle.net/1887/3449889

Note: To cite this publication please use the final published version (if applicable).

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Chaos in Europe: An inquiry into the nature of social systems and the methodology of the behavioral sciences*

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1. Revolution in Europe and political science

Among those who cared to know, the sorry performance of the East European economies, the existence of deep tensions between as well as within the several East European nations, and the corrupt nature of the Communist regimes in those countries, has long ceased to be a secret. Yet, it seems safe to say that, until last year, the overwhelming majority of observers still believed both the Soviet hegemony over Eastern Europe, and the position of the Communist leadership in virtually all East European countries to be basically secure, at any rate for the foreseeable future. For although it seemed to be clear enough that disaffection with Communism was fairly widespread all over Eastern Europe, ways and means to organize such disaffection into viable and powerful revolutionary movements seemed to be largely lacking. And, of course, the Communist leadership, commanding vast police and military forces as well as extensive networks of secret services and informers, reaching down into every nook and cranny of the societal structure, seemed perfectly able and (therefore) willing to cope with any attempt to undermine its position. The Soviet Union, in particular, seemed quite secure in its position of one of the world's superpowers, while nothing would seem to seriously threaten either its internal cohesion or its hegemony over the rest of Eastern Europe. And, indeed, many in the West had gradually come to accept such hegemony as inevitable and even beneficial. After all, it did provide a measure of order and stability in a traditionally unruly and dangerous region.

* This article has been presented as a paper at the American-Dutch Workshop on European Integration: Models and Policy Concerns, Groningen, June 6-8, 1990.

Yet, in the course of but a few months most, if not all, of these impressions, assessments, or expectations were proven illusory or false. In an astonishingly short time, and in an historically unprecedentedly peaceful way, regime after regime toppled as if under its own weight. Virtually everywhere Communist leadership was being exposed as a mere empty shell, thoroughly eaten from within, and both incapable and unwilling to put up a sustained fight for its own existence – not so much against a well organized revolutionary movement as against a changed 'mood' among the population which apparently stopped letting itself be frightened by the regime. And the Soviet Union, notwithstanding the grave and obvious risks all this entailed for its hegemony over Eastern Europe, and despite the presence of its troops in most of the countries concerned, did nothing to help stem the tide. If anything, it rather urged their governments to give in to the mounting pressures for reform. The result has been an exceedingly dramatic shift, not merely in the East European political landscape, but, as a consequence, in that of Europe and the world as a whole, too. Indeed, its magnitude and suddenness well warrant the term 'revolution', even though, as yet at any rate (for we have not seen the end of it), all this has been accompanied by surprisingly little violence.

However, in this essay I will be concerned not so much with these happenings and their possible implications themselves, as with the methodological issues which they raise or, rather, illustrate. For the fact that recent developments in Eastern Europe have taken us so much by surprise is certainly not due to a lack of interest in that region on our part. After all, since the Second World War the systematic, more or less scientific study of Eastern Europe has grown into a major enterprise in most Western countries. As a consequence, and despite the rather secretive nature of the regimes concerned, most of the relevant facts were available – even though it now appears that the situation was generally far worse than we dared believe. How, then, should we account for our inability to foresee the time, form, and pace of the recent Eastern European upheaval?

Most obviously, of course, it illustrates our lack of understanding of social or political life generally. We may well know all the 'facts', but we are unable either to assess their relevance or relative weight, or to relate them to each other so as to form a reliable picture as to the direction in which things are moving. In short, we lack *theory*.[1] As a particularly pertinent example, reliable insight into the general problem of what determines the *stability* of a social or political system, in the sense of its capacity to smoothly and quickly correct, dampen, or, more generally,

process all sorts of disturbances, is still lacking. And as long as this is the case, the responses of political systems to perhaps even minor perturbations in their environment or structure will continue to baffle us.

Over and above this remediable lack of theoretical understanding, however, the evolution of, in particular, the physical sciences since, roughly, the early nineteenth century has made it increasingly clear that, at any level of theoretical development, our ability to accurately predict the actual evolution of empirical systems or phenomena over any somewhat longer stretch of time will most likely be always rather limited. In other words, it has all but destroyed the traditional scientific ideal of perfect and unlimited predictability. Surely, the relevance of the natural sciences to social, political, or economic inquiry is very limited indeed – as far as we can see at present, that is. However, independent theoretical inquiry into the mechanisms underlying human action and interaction brings to light that the very same relationships and conditions which limit the predictability of natural events and which, more generally, have led to a conception of physical science rather different from that inspiring classical mechanics, also turn out to operate in the field of human behavior and of social life.[2]

2. The loss of scientific innocence

2.1 The classical conception of science – According to what may now be called the 'classical' conception of science and of the world generally, the Universe is a kind of gigantic clockwork driven by immutable causal laws which, representing a kind of summary description of the regularities marking empirical reality, science is to discover by means of meticulous and systematic observation. Once you know these laws, you can apply them to the present in order to accurately predict what will happen in the future. Indeed, such knowledge would in principle enable you to chart the entire future as well as the whole past from the present state of the world. In particular, too, it would tell you what would happen should you adopt or abstain from certain policies or actions. In this way scientific insight would allow you to realize your desires, to avoid errors or to prevent the occurrence of what you don't like, and, in general, to control your destiny.

It is a model, or perhaps rather: ideal, which seemed to be embodied in, and to come fairly close to being realized by, the tremendously successful classical mechanics of the seventeenth and eighteenth centuries. And even to the present day not a few, and a great number of social or behavioral

scientists among them, still seem to take it for an accurate description of the nature and aims of scientific inquiry generally. Yet, even in the natural sciences this model or ideal has gradually come to be all but abandoned, due in large part to the advent of such disciplines as thermodynamics, geology, physical astronomy, meteorology, and biology since the nineteenth century. For, rather than with the highly idealized constructions, such as weightless strings, of which the world of classical mechanics was typically made up, these newer sciences had to deal with far more concrete, empirical things, events, and developments. And these were soon found out to be far less tractable, regular, and predictable than they should be according to the original conception.

In a way, the natural sciences have grown increasingly empirical since the late eighteenth century. As it was gradually discovered that even the physical Universe is anything but a simple, if very big, clockwork, the original notion of the scientific enterprise, with all its appealing pristine innocence, too, had to go, and to be replaced by a far more complex, in particular also: exceedingly abstract, conception. And as they increasingly ran up against the very same methodological problems which have always stood in the way of progress in the social or behavioral sciences[3], the distance between these two fields of inquiry, traditionally thought to be unbridgeable, also tended to become somewhat smaller – as far, that is, as their forms or methodologies are concerned. It is worthwhile to briefly review the main issues involved in this development here, and, in particular, to see what shape they assume in our own field.

2.2. The decay of determinism – It used to be believed that the world is governed by *deterministic* causal laws, i.e., laws that allow us to predict or explain one definite state of the world from another such state. In other words, God is not supposed to play dice, as even Einstein still thought. In fact, however, and as far as the real world is concerned (as distinguished from the highly idealized world of classical mechanics, for instance), it appears that most of what we are able to explain or predict regards *probabilities* or *probability distributions* only. So, instead of being able to determine with absolute precision some definite future state of the world from certain given initial conditions, we will at best succeed in explaining or predicting how the likelihoods of several such equally possible states or events will be distributed from any given set of initial conditions. This is rather a far cry from the ideal of total deterministic predictability which is still being thought by not a few to be characteristic of the scientific approach. It is the more so as it also implies that as regards any longer

stretch of future time we will have to predict distributions of probabilities, say at time t+1, from other such distributions, say at t – quite evidently a rather tricky business when you have to repeat this procedure a great many times, as you must when dealing with a more distant future. As a consequence, our ability to accurately predict the more distant future, whether in the physical or in the social sciences, will generally be rather limited.

It is important to see that, contrary to what is often thought, the probabilistic nature of what we can say about the world is *not* the result of our present ignorance, nor a defect eventually to be remedied by subsequent inquiry. Instead, it is inherent in the very nature of the world itself – inasmuch, that is, as it exhibits the possibility of *choice*. And it does so whenever there are several different states, conditions, or courses of action possible, only one of which can be realized or adopted in actual fact. As soon as this situation occurs, we have no choice but to adopt a probablistic language, for the deceptively simple reason that this is precisely the (only) language designed for dealing with such cases.

Nature as a whole, from the behavior of light quanta or gas molecules to the weather, is strongly marked by this feature of choice. But it is perhaps nowhere more clearly visible than in the realm of human behavior and of social life. Indeed, we tend to speak of behavior or action only in case the individual does have the possibility of choosing one from among a number of alternative courses of action, *not*, for instance, when it is swept off its feet by the wind, or with respect to its metabolism, in general: when it is subject to forces that leave it no choice at all.[4] And what applies to individual human behavior must by implication also apply to what happens between, or as a result of the interaction of, such individuals, so also to social or political life and society. But this also means that we can study and understand human behavior, social, political, and economic, life, and history only in terms of probabilities or, rather, probability distributions, that determinism is an irrelevant model or ideal of inquiry in these fields, and that our ability to forecast the (more distant) future of human society will always remain fairly modest.

2.3 Laws, empirical uniformities, and inductivism – A second highly relevant concomitant of the evolution of the sciences since the late eighteenth century has been a rather drastic revision of our view of the nature of scientific laws – the basic principles or axioms underlying any scientific theory. It used to be believed, and is still being believed by many, that such laws or principles represent summary statements, as it were, of what actually happens in reality. In other words, they are statements about the

regularities or uniformities that may characterize the observable world. As a corollary, such laws or principles are to be found by a meticulous observation and measurement of the real world. Thus, according to this conception, Newton's laws of motion were nothing but a summary description of the actual observed behavior of all moving bodies, a generalization and idealization of the inevitably limited number of Newton's own observations and measurements.

Naturally, too, inasmuch as no, or too few, empirical uniformities or regularities can be found in the observable world, no scientific laws can be discovered either. And, indeed, in such cases scientific inquiry properly so called is basically impossible. As a matter of fact, many, in particular many historians, do tend to draw precisely this conclusion with respect to the field of human behavior and social life. For in this field observable uniformities are indeed few and far between. Here, even a cursory glance at the facts tends to reveal that, but for a few uninformative trivialities, everything is, indeed, unique, and that no reliable, exceptionless empirical generalizations seem to be possible.

That this state of affairs should preclude the scientific study of human, social, or historical reality is not true, however. In fact, all this merely means that the notion of science and of its laws or principles at issue here is utterly false to begin with.

For even in the case of such elementary phenomena as moving bodies, perfect uniformity is the exception rather than the rule. Think, for instance, of the actual movements of such things as the planets as compared to those of falling stones, leaves, or feathers. Even in this comparatively simple case it is extremely doubtful whether any amount of meticulous, accurate quantitative measurement would ever reveal reliable patterns in the behavior of moving things generally. And it is absolutely out of the question that Newton could have distilled his famous laws in a quasi-mechanical or statistical manner from such observations or measurements.

This applies even more strongly to the far from elementary, and generally highly irregular things with which the sciences have come to concern themselves since the late eighteenth century. For instance, by no flight of fancy could we regard the first law of thermodynamics, viz., that the total amount of energy in a closed system such as the Universe as a whole presumably is, is constant, as a generalization of empirical uniformities. Similarly, the basic principle of Darwin's theory of evolution, to wit, the combination of variability with natural selection, cannot be conceived, nor could it have been discovered, as a mere generalization of observed facts. And that such a conception is totally

inadequate to explain the theory of relativity or modern quantum physics almost goes without saying. In the field of behavioral inquiry, the same goes for the important assumption that the likelihood of any behavioral option being adopted is somehow proportional to its 'utility' or 'value': no amount of observation or measurement would ever yield this principle.[5]

Accordingly, the business of science can no longer be conceived to be the discovery of empirical uniformities or generalizations, nor can the existence of such uniformities be regarded as a precondition for scientific inquiry in the first place. Instead, science seeks to discover (by creative intellectual effort controlled by observation rather than by mindless measurements and statistics) the laws, principles, or mechanisms which determine how the state or condition of things or systems is being transformed into another such state or condition. It does not so much describe empirical reality as tell us what, given the initial state of some thing or system, to expect with regard to its state at the next moment. In other words, science is concerned less with the visible *appearance* of reality than with its underlying *structure*.[6]

This implies that the predictions or explanations which science has to offer or, to put it a bit differently, the visible effects of the working of its laws, principles, or mechanisms[7], is always determined in part by the initial state or condition of the system or thing being studied. As a consequence, when such initial states or conditions differ, the very same laws or mechanisms will inevitably produce different observable results. And the result may well be that in the succession of the observable states of some given system, for instance a human society, which describes its historical development over any length of time, no empirical regularities or uniformities at all will appear.

But it also means that the effects of the events, disturbances, shocks, or challenges to which such a system is being subjected, too, will be dependent on the system's initial state or condition. For example, whether increasing oppression or poverty will lead to revolution will be highly dependent on the current state and structure of the society concerned. In a way, dependent on the state of the system concerned, the very same causes will produce different results. To the degree that this is indeed the case, mere statistical inquiry, or the observation of any number, however large, of historical revolutions, will fail to reveal any meaningful and reliable general conclusion regarding the relationship between the two phenomena. As a matter of fact, such situations turn out to be the rule rather than the exception in the study of human behavior and of social, economic, or political life. It is, accordingly, hardly surprising

that statistical or historical research has so far largely failed to bring to light any significant empirical generalizations, nor has it yielded much insight into how precisely things hang together in the human or social universe.

2.4 Do things have causes? – The purpose of science is quite commonly taken to be the discovery of the 'causes' of things, especially among social or behavioral scientists, while, for very good reasons, physicists but rarely use the notion at all nowadays. Something, say x, is conceived to be the 'cause' of something else, if the occurrence of x leads to that of y, and if, conversely, the occurrence of y also means that x had occurred. In other words, the term stands for 'necessary and sufficient condition' – at any rate, in the most rigorous conception of the causality relation.

Yet, actual research into the causes of things human and social has so far been singularly unsuccessful. Thus, we are at present as far from understanding what causes human behavior, cooperation, trade, aid, violence, or war, or even such events as the First and Second World Wars, or the Cold War, as ever before. The basic reason for this state of affairs is that the notion of causality itself is singularly unsuitable for dealing with any but the most simple or elementary relationships.[8] Specifically, it utterly fails to do justice to the fact that real social phenomena invariably turn out to form dynamic complexes of a greater or smaller number of different elements or factors that influence each other *mutually* in many direct as well as indirect ways. As a consequence, what any single one of them does or does not do, or how it reacts to such stimuli or disturbances to which it may be subjected, is, in principle, determined by the state of the complex or system as a whole, i.e., by the state or behavior of *all* the other elements or factors.

This applies even to something as seemingly elementary as individual human behavior – even, that is, when, for the sake of simplicity, one ignores the individual's social environment, i.e., the influence of other individuals. Thus, one may assume such behavior to be a function of the individual's expectations and values. Yet, such expectations or values themselves do not simply come out of the blue, but result from the individual's own efforts, specifically: from its information processing behavior, as a function of, indeed, its (preexisting) expectations and values. In other words, purely individual behavior, too, represents a typically dynamical system in its own right.[9]

Similarly, in any form of interaction or intercourse, whether in that of trade or cooperation, or in that of violent conflict, between two individuals, what any one of them does or does not do is obviously

governed by its expectations as to what the other will do or not do. But, equally obviously, this also applies to the conduct of the other party. As a result, the actual nature or form of what will happen *between* them is determined by an inextricably interwoven set of expectations that mutually determine each other – another example of an inherently dynamical system which, incidentally, can be fruitfully studied only by means of mathematical tools.[10]

Thus, too, one might be inclined to assume that enmity or conflict between people or systems generally would raise the chances of violent fights breaking out between them; and, conversely, that the likelihood of their cooperating peacefully were somehow proportional to the degree of friendship existing between them. Yet, further inquiry will also bring to light that such enmity or friendship between people is itself to no small extent determined by the very probability of violence or cooperation between them, a probability which turns out to be less a matter of their own wishes, predilections, or inclinations, than of the prevailing conditions of the situation, system, or society in which they find themselves.

In all these and many similar cases in which things determine or influence each other *mutually*, there is obviously very little sense indeed in speaking of their 'causes'. As a consequence, too, and reinforcing a point made in the previous Subsection, we will in general not be able to predict what will happen in the future from the mere observation of what happened in the past. In a way, it all depends (on the current state and structure of the systems concerned): whether an external threat will or will not stimulate internal unity or integration in a political system; whether oppression or deprivation will or will not lead to revolution; whether power shifts in a political system will or will not lead to violence or war; whether failure or environmental challenges and threats will or will not induce an individual to acquire more relevant information, i.e., to revise and adapt its preexisting insights and values – and so on and so forth.

It also follows that what historical inquiry brings to light with respect to any specific case, system, epoch, or society, may not without further ado be applied to other cases, systems, epochs, or societies, nor be straightforwardly extrapolated to the future, or used as a lesson for present behavior and policy. For example, there seems to be fairly general agreement that the French and British policies of appeasement with respect to Nazi Germany have significantly contributed to the outbreak of the Second World War. Yet, this does surely not mean that giving in to an increasingly strong, and therefore often rather aggressive, power will

invariably lead to war. Indeed, people as well as nations *must* find ways of accommodating to shifts in their relations of strength or power, and appeasing the upstart may well be the sensible thing to do, i.e., bow to the inevitable, and to avoid a costly and useless violent test of strength.[11] Apparently, if history is to teach us any lessons at all, we must look for them at a much deeper level than that of simple observable relationships.[12]

The fact that social, political, or economic phenomena generally represent larger or smaller systems or complexes of interacting elements or factors also implies the need for a *dynamic*, if you wish: *historical*, approach to them. That is to say, at any given moment the state, behavior, or condition of such systems is always in part determined by their state, behavior, or condition at the previous moment, and so on. As a consequence, the current behavior or responses of such systems as human individuals, national or international societies, or the current shape of social events or phenomena generally, cannot be understood apart from their previous history. In brief, such systems or phenomena are inherently *historical*, to be understood only in terms of change or evolution, of transformation or development. We must, in other words, learn to ask, *not* for causes or origins, but how the state of a system (or, for that matter, the shape of an event or process) is being transformed under the influence of environmental stimuli or perturbations and its own internal dynamism as a function of its structure – something which, incidentally, will generally not be expressible in the form of the straightforward hypotheses which contemporary behavioral scientists tend to be so fond of testing.

2.5 By way of a summary and preliminary methodological conclusions –The previous discussion has made it abundantly clear that social systems, things, events, or processes are highly complex things indeed, far more complex, at any rate, and, as a consequence, far less tractable, than they usually seem to be taken for in current sociological, political, or, for that matter, economic research. As a consequence, and as intimated already, their study calls for a rather different conception of the scientific enterprise, and a rather different research methodology than seems to be common nowadays. We have come a long way indeed since the times when the models and ideals of classical mechanics reigned supreme – now all but dead in the physical sciences, but, one suspects, not yet so in the field of social or behavioral inquiry.

Thus, the recognition that it cannot be the business of science to discover empirical uniformities or regularities, which, inasmuch as they are non-trivial, will be exceedingly few and far between in the first place, if they are to be found at all, also implies the final blow to any *inductivist*

research program.[13] By the same token, emphasizing the deeper, and not immediately observable, structure of things as that which governs their transition from one state, form, or shape into another, inevitably makes the behavioral or social sciences both more abstract and more theoretical. After all, to the degree that we move away from straightforward observable relationships, the role of theory becomes both more important and visible.

Obviously, such theory must be such as to do justice to the fact that social reality invariably turns out to be made up of larger or smaller complexes of interacting things, elements, or factors. That is, it must be what is commonly called *systems theory*, that is, one in which things are being studied in terms of their relationships with, in principle: all, the other things making up the system in question or, which comes to the same thing, one in which the state of every single system element or component is being considered as a function of that of the state of the system as a whole.[14] Inevitably, too, such theory must be inherently *dynamic*. In other words, its central problem must be, not the 'causes' or 'origins' of things, but their change, transformation, or evolution through time, as a function both of external disturbances or pressures, and of their internal dynamics. Yet, it has also appeared that, due to the inherently probabilistic nature of the things with which the behavioral scientist must be concerned, we must also reckon with a sharp reduction in the measure of *predictability* attainable according as the time period studied lengthens.

As mentioned before, both the system states, the transformation of which we will have to explain or predict, and the system structure which governs such transformation, will typically be made up of a larger or smaller number of different factors, variables, or functions. There is but one language rich and powerful enough to be able to deal effectively with such complexity, viz., that of mathematics. This, in conjunction with the increasing measure of rigor and precision called for by advancing insight and research, means in fact that social or behavioral theory must needs be or become *mathematical*.[15]

Surely, theory meant to tell us something about observable reality must be *testable*, specifically, *falsifiable*. Of course, this does *not* mean, as some would have it, that every theoretical proposition or notion should thus be directly and immediately testable. In fact, probably the larger part of any developed scientific theory will consist of typically 'theoretical constructs, lacking any immediately empirical correlates, and testable only in a very indirect or roundabout manner, usually involving a great deal of further (often future) theoretical and technical work. Yet, such constructs

are needed and virtually unavoidable as stepping stones, as it were, on the long way between observables and observables, and to the degree that they do indeed help us to travel it in a controlled and unambiguous way, they are in fact testable and falsifiable, too. Indeed, the prejudice of 'primitive Popperism', with its insistence that each and every theoretical notion, assumption, or conclusion should be immediately testable, and in fact be so tes*ted*, before any further development is to take place, is a perfect recipe for insuring that no theoretical or scientific development will take place at all.

However, the systemic and dynamic complexity of things social or behavioral greatly complicates the job of testing or falsifying theory. Specifically, it greatly limits, to say the least, the value and relevance of the testing of single hypotheses cast in terms of straightforwardly observable relationships (for instance: 'shifts in a system's power distribution will (not) lead to violence') which tends to dominate so much of contemporary behavioral science. It does not mean, however, that theory, in particular systems theory, thereby should become *un*testable or *un*falsifiable. Instead, it merely means that we need a somewhat more sophisticated approach to such testing or falsification. After all, a systems theory, too, predicts certain state vectors or probability distributions, cast in terms of observables, from other such configurations of observables. And although such relationships cannot in general be phrased in terms of simple, 'linear' hypotheses, representing, rather, whole sets or systems of such hypotheses, what the theory tells us about them can in principle surely be compared with, so: tested against, observable reality. In a way, all this boils down to taking seriously the general epistemological or philosophical insight that one cannot test single hypotheses or ideas, but only whole *theories*.[16]

In such testing, indeed, in the very development of theory itself, the *computer* is bound to assume an increasingly central role, not merely as a (statistical) calculator, but as an indispensable research instrument.[17] Without it, it would be virtually impossible to reliably execute the staggering load of calculations, or operations generally, involved in the analysis of even very small social or behavioral systems. For instance, the study of even the most drastically (and unrealistically!) simplified case of interaction (i.e., between just two systems or individuals each one of which having but two basic options, to support or to injure each other or themselves) must already take place in 8-dimensional hyperspace. As a consequence, it involves 8x8 transformation matrices consisting, that is, of 64, in general fairly complex, functional relationships.[18] The study of the evolution of such a system, or of the behavior of the model describing

it[19], over any period of time naturally involves the iteration of the operations or calculations involved for a number of times. That this could be done, and reliably done, just by means of pencil and paper is out of the question. Accordingly, computer simulation is practically the only way in which we can see how our theories or models behave over time, whether they yield empirically plausible results or predictions, whether they lead or do not lead to stable solutions, whether, as a result of all sorts of hidden inconsistencies, they will explode or jam, or how sensitive they are to changes in the values of parameters and variables – all of which is essential to further theoretical or scientific development, of course.[20] This is the more so as there are strong reasons to expect that the actual or simulated evolution of the kinds of systems with which we are to concern ourselves will confront us with all sorts of strange and disturbing phenomena. Their occurrence can as yet not be reliably predicted from a knowledge of the relevant functions or fields alone, but can be discovered and investigated only by means of the computer – an issue to which we will now turn our attention.

3. Hypercomplexity and chaos

3.1 Once again: the issue of predictability – The previous argument did contain a definite note of caution, and an injunction to modesty, as far as the long-term predictability of things social and human is concerned. But it did not yet deny the possibility of such predictability in principle. Nor did it doubt the related assumption that behavioral or social processes were *regular*, in the sense that, once set in motion by some environmental disturbance, at moment t_o, they would produce a definite, and in principle knowable or predictable, outcome at every next moment $t_o + i$, as a starting point for the next process round or stage, until, finally, a stable state would be reached. In other words, it was still taken for granted that, should we know a social or behavioral system's initial state at t_o, the disturbance to which it was being subjected at that time, and its structure, and supposing that no further environmental disturbances should take place, the state of the system at every subsequent moment, $t_o + i$, would then be fully, though stochastically determined. This assumption of regularity, then, would in principle allow us to chart the future course of any social or behavioral system for an indefinite period of time – even though the probabilities concerned would very soon become vanishingly small, while the degree of uncertainty involved would rise commensurately, of course.

In brief, human behavior and social, political, or economic live have turned out to be far more complex and elusive matters than would appear from the vast majority of current research efforts in the field. This is bad enough, of course. Yet, we could at least feel safe in assuming them to be regular in the sense described above. However, there is reason to fear that things are even worse than this, and that we must seriously doubt even this assumption of regularity, and, conversely, that we must accept the possibility that social or behavioral processes are to a significant extent *inherently unpredictable*.

Surely, we meet with quite a lot of unpredictable, unfathomable human conduct around us. And time and again we let ourselves be surprised by all sorts of events and processes in the economy, the polity, or in society generally – witness, as a most recent example, the case of the (East) European revolution. Thus far, however, we could ascribe this to the quite evident paucity of our insights, theories and models. But now, it would seem, we must reckon with the strong possibility, indeed: probability, that such unpredictability is not simply something remediable by improving our scientific theories, but that it inheres in the very structure of human social life.

Basically, this insight derives from relatively recent developments in mathematics and in the physical sciences, specifically in (nonequilibrium) thermodynamics, chemistry, fluid dynamics, and meteorology, involving the discovery and investigation of such things as *fractals*, *bifurcations*, *chaos*, and *turbulence*.[21] Their relevance to the behavioral and social sciences does not, of course, reside in the substance of what is being discovered in the various physical disciplines, but in the formal structure of what underlies these phenomena, and which is essentially the same as what governs social or behavioral processes, viz., the fact that the several functions describing the state transitions of the things or systems involved are *non-linear*. It is this which appears to produce the irregularity, chaos, or unpredictability exhibited in the long-term behavior of so many physical systems. Yet, as we will see presently, such non-linearity is equally characteristic of most functions or fields in social science. Accordingly, we may be virtually sure that we, too, will meet with chaotic phenomena in the evolution of behavior or social life through time. And, as a consequence, events or developments like those which occurred last year in Eastern Europe, rather than exemplifying our limited understanding, may, in all their unpredictability, very well be representative of the kinds of things we should expect to happen in social or political life.

In order to see more clearly what is at issue here, we will first briefly discuss the notion of non-linearity in relation to the closely related one of feedback relationships.

3.2. Feedback and non-linearity – Feedback relations are relatively well understood in the social sciences. Put in a most general form, they occur when something, say x, affects or leads to something else, say y, which, in its turn, and possibly via a chain of intermediaries, say {z}, again affects the occurrence, magnitude, or shape of x. The thermostat which regulates the temperature of a room by putting the heater on when the temperature drops below a certain level, and putting it off when the room temperature exceeds a certain level, is perhaps *the* model of a device involving feedback. But human behavior and social life, too, abound in examples of quite essential feedback relationships, both positive and negative.

Thus in a relationship of (successful) mutual deterrence between two parties, say A and B, what A does has the effect of making B desist from using violence against it, A, which, in its turn, bridles A's motivation to use violence against B, and *vice versa*. In a process of escalation, on the other hand, A's raising the level of threat against B, meant basically to reduce B's inclination to use violence against A or to make it more amenable to A's own wishes, has precisely the opposite effect. That is, it will induce B to step up *its* military efforts, too, which, in its turn, makes A all the more strongly inclined to raise its threat level in order to neutralize B's enhanced military posture – and so on, until the two are actually at each other's throats.

Similarly, an individual's information processing efforts, i.e., its thought and perception, may in effect raise the level of information which it possesses. However, as the effectiveness of such efforts in actually producing information is in fact partially determined by the individual's preexisting level of information, such a gain in information will make subsequent efforts at acquiring information even more successful and, therefore, more likely, *et cetera*. In precisely the same way, a higher level of scientific or theoretical development implies both the definition of a greater number of fruitful and well-defined research problems, and the availability of a larger stock of tools for their solution. As a consequence, it renders further progress better feasible as well as more probable – a state of affairs which both explains the tremendously rapid development of the natural sciences since the nineteenth century, and the exceedingly slow pace of the evolution of the social or behavioral sciences to the present day.

And, at an entirely different level, a social system's, or a society's, level of integration refers to its capacity to smoothly and quickly solve the problems which it comes to face, or to effectively respond to the disturbances or shocks to which it is being subjected. By the same token, however, any increase in this level of integration or capacity, even though

it might come about in an initially entirely fortuitous manner, thereby also raises the likelihood of the system integrating still further. For one thing, such an increase in capacity also enhances its ability to profit, as it were, from the problems or disturbances which it has to face, and to use them so as to strengthen the system's density and homogeneity, as well as the position of its leadership or government – something which underlies both the rapid growth and strengthening of the modern state, and the slow progress made so far in international, specifically in European, integration.

All of the above examples of social or behavioral feedback relations also exemplify another crucially important feature, to wit, non-linearity. Briefly, a relationship between two factors or variables is called linear when an increase in one of them leads just to a proportional increase or decrease in the other. Graphically, such relationships can be represented by straight lines. However, many, if not most, relationships underlying nature are non-linear, that is, change in the magnitude of one factor or variable produces a more (or less) than proportional change in the magnitude of the other. Such relationships appear as curved lines in a graphical or geometric representation.

To express all this in a more transparant form, let us suppose, then, that some (scalar) magnitude y is a function of a scalar magnitude x, i.e.,

(1) $$y = f(x)$$

When this function is *linear*, we shall find that

(2) $$\frac{dy}{dx} = c, \text{ a constant, and } \frac{dy}{dt} = c \cdot \frac{dx}{dt}$$

When, on the other hand, the function f is *non-linear*, the above derivatives are themselves functions of x, so

(3) $$\frac{dy}{dx} = g(x), \text{ and } \frac{dy}{dt} = g(x) \cdot \frac{dx}{dt}$$

And this is indeed precisely the situation which we encountered in the above examples of feedback relations[22]: the acquisition of additional information as some function of the individual's current level of information; the likelihood of further scientific progress as a function of the level of theoretical development already attained; and a system's integration as determined in part by its preexisting capacity or level of integration.[23] Another, and even more familiar, example of a non-linear relationship in behavioral or social inquiry would be Gossen's famous

law, telling us that an individual's valuation of an additional amount of money (or, for that matter, of power) is inversely proportional to the amount of money (or power) which the individual already possesses: an extra dollar will mean less to a rich than to a poor individual. Similarly, the well-known, and quite general 'law of deminishing returns' implies the non-linearity of all sorts of production functions in a wide range of human activities. And even the seemingly elementary relationship between behavioral probabilities and function or, rather, field[24]:

(4) $$p(k) = \frac{e^{u(k)}}{\sum_{k} e^{u(k)}}$$

in which p(k) and u(k) refer to the probability and utility or value of the k-th (out of K) behavioral option, respectively.

We may take it, then, that social or behavioral systems, too, are governed by all sorts of non-linear (feedback) relationships. In other words, they are not merely (very) complex, but, as I shall call it, *hypercomplex*.[25] This term serves to express that, mathematically speaking, they are usually located in multi-dimensional (hyper)space, and that they essentially involve both feedback and non-linear relationships. The methodological as well as practical consequences of such hypercomplexity are quite serious.

3.3 The consequences of hypercomplexity: the impossibility of reductionism – In every field, science always aims at explaining or predicting things from *other* things, and seeks to establish a definite, unambiguous relationship between the occurrence of something, y, and the occurrence of something else, x, so that the observed occurrence of the latter, x, allows us to conclude that, therefore, y, too, must occur, or at any rate do so with a certain probability. Preferably, too, the things, x, *from* which we explain or predict other things are more tractable, elementary, simple, or easy to observe and measure than those, y, we thus explain or predict from them. After all, it would seem to make little sense to try and explain the unproblematical from the problematical![26] By the same token, what one may call a *'reductionist'* conception of scientific inquiry is the natural thing to expect. We shall naturally wish to explain y, not by y itself, but by something else, x. For instance, we shall wish to explain intercourse and interaction, violence, war, trade, or cooperation, between individuals or entire social systems or societies from such things as relations of power or

interdependence between them, but which, in their turn, are independent of behavior or interaction.[27]

Conversely, we generally feel very ill at ease when things are explained from themselves, as it were, or when, as in feedback relations, we meet with 'chicken-and-egg' problems, in which, that is, y is indeed explained by x, but in which x, in its turn, appears also to be determined by y itself. We even tend not to accept such relationships as entirely proper, and to regard them at most as provisional or second-best explanations only. Indeed, it would seem to represent one of the chief intellectual obstacles standing in the way of a truly systemic view of human behavior and social life, an obstacle, too, which many find virtually impossible to overcome.

Yet, more even than the prevalence of all sorts of feedback relationships, it is the fact that so much of human behavior and of social, political, or economic affairs is governed by non-linear functions, fields, or relations which makes any reductionist research program into a chimera. For, as we have already seen, non-linearity implies that the extent to which some magnitude, say y, varies with something else, say x, so also: the degree to which y changes as a consequence of change in x, is always, and irreducibly so, determined by the current state or magnitude of y itself.[28] In a way, then, y is indeed explained by itself. Thus, by way of a particularly clear and relevant example using the behavioral function described by (4), it can easily be seen that we must have

$$(5)\quad \frac{\partial p(k)}{\partial u(k)} = p(k)\cdot\{1 - p(k)\} \quad \text{and} \quad \frac{\partial p(k)}{\partial u(k)} = - p(k)\cdot p(k)$$

and

$$\frac{dp(k)}{dt} = \sum_k \frac{\partial p(k)}{\partial u(k)} \cdot \frac{du(k)}{dt}$$

This means, in fact, that how an individual will respond to such value shifts as may be produced by events in its environment or by the actions of others, and how its behavior will evolve through time, will always be in part governed by its current behavior or, rather, behavioral state. In brief, how an indivudual *will* behave or respond is in large part, and irreducibly so, determined by what it *was* already doing or not doing. By implication, too, what the state of any social system, its (collective) behavior, as well as the nature and shape of interaction within it, *will* be, is irreducibly determined to a significant extent by what that state initially *was*. In other words, the explanation or prediction of human behavior and social life cannot be based on non-behavioral or non-social things alone, but must always involve current behavior or the current state of the system

concerned: behavior and interaction can only be explained or predicted from behavior and interaction...[29] All this also implies that the *structure* of behavior or of interaction which, as we have seen, governs the several state transitions of a behavioral or social system generally, will also be partly determined by, and therefore change with, that system's initial state.

Obviously, all this also emphasizes the need for a more explicitly mathematical orientation in behavioral and social research. Surely, and as is illustrated by the examples of a few extremely basic non-linear relationships given in Section *3.2*, awareness, in some cases even: the discovery, of the existence and implications of such relationships does not always require mathematical analysis. Yet, it will also be evident that their precise definition and analysis definitely does necessitate the use of mathematical tools. Conversely, when empirical research is *not* based on such mathematical models as do justice to those non-linearities which are actually to be found in things human and social, its results will at the very least be bound to surprise us. More often than not, we will be absolutely unable to make head or tail of its outcomes, which is bad enough in itself, but, worse still, it will also lead subsequent inquiry astray.

3.4 The consequences of hypercomplexity: chaos – Behavioral or social systems, or non-linear systems generally, then, are highly, and irreducibly, dependent on their initial states or conditions. As a consequence, they tend to be highly *irregular*, in the sense that their behavior over any more or less extended period of time tends to exhibit all sorts of highly disturbing irregularities and unpredictabilities – even, that is, when they are left alone by their environment, and they are not being subjected to (additional) external impulses, shocks, challenges, or perturbations. As intimated already, the discovery of such irregularities, or chaotic phenomena, represents a major, but relatively recent achievement in mathematics, physics, chemistry, and meteorology, the fruit of attempts to investigate the long-term, dynamic behavior of non-linear systems. Apparently, when one knows how such systems, probably the vast majority of natural, and, presumably, of behavioral, social, political, or economic systems as well, respond to given (environmental) stimuli, or how their state or condition is being transformed from one moment to the next, one is still very far from understanding their evolution over any longer stretch of time!

To see in general terms what non-linearity implies for the long-term evolution of a system, specifically: how strongly dependent such behavior is on the system's initial state, is not particularly hard. Let us for

the sake of simplicity assume that the state of the system at moment n is described by a simple scalar magnitude x_n, and that, in the absence of any (further) environmental disturbances, the transformation of the system's state at n into that at n + 1 is determined by some scalar function f, so that

(6)
$$x_1 = f(x_0) = f^{\langle 1 \rangle}(x_0)$$
$$x_2 = f(x_1) = f\{f(x_0)\} = f^{\langle 2 \rangle}(x_0)$$
$$x_3 = f(x_2) = f\{f\{f(x_0)\}\} = f^{\langle 3 \rangle}(x_0)$$

and in general

$$x_n = f(x_{n-1}) = f^{\langle n \rangle}(x_0)$$

in which $f^{\langle n \rangle}(x_o)$ represents what is called[30] an *iterated function system*, describing the behavior of a system over a certain period of time.

However, dealing with non-linear relationships, we must also assume that the way in which x_n varies with x_{n-1}, i.e., the sensitivity of successor system states to their predecessors, is itself soms function, say g, of the predecessor state. So

(7)
$$\frac{\partial x_1}{\partial x_0} = g(x_0)$$
$$\frac{\partial x_2}{\partial x_1} = g(x_1) = g\{f^{\langle 1 \rangle}(x_0)\}$$
$$\frac{\partial x_3}{\partial x_2} = g(x_2) = g\{f^{\langle 2 \rangle}(x_0)\}$$

and in general

$$\frac{\partial x_n}{\partial x_{n-1}} = g(x_{n-1}) = g\{f^{\langle n-1 \rangle}(x_0)\}$$

And for the sensitivity of the system's several (successor) states on its *initial* state or condition, we easily get, applying the chain rule and a few obvious notational conventions,

(8)
$$\frac{\partial x_1}{\partial x_0} = g(x_0)$$
$$\frac{\partial x_2}{\partial x_0} = g(x_1)\cdot g(x_0) = g\{f^{\langle 1 \rangle}(x_0)\}\cdot g(x_0) = g\{f^{\langle 1 \rangle}(x_0)\}\cdot g\{f^{\langle 0 \rangle}(x_0)\}$$
$$\frac{\partial x_3}{\partial x_0} = g(x_2)\cdot g(x_1)\cdot g(x_0) = g\{f^{\langle 2 \rangle}(x_0)\}\cdot g\{f^{\langle 1 \rangle}(x_0)\}\cdot g\{f^{\langle 0 \rangle}(x_0)\}$$

and in general

$$\frac{\partial x_n}{\partial x_0} = \prod_{n=0}^{n-1} g\{x_n\} = \prod_{n=0}^{n-1} g\{f^{\langle n \rangle}(x_0)\} = \prod_{n=0}^{n-1} h^{\langle n \rangle}(x_0)$$

This renders it perfectly clear, then, that the final result of an n-step iteration of a non-linear function, or, which comes to the same thing, the state or behavior of a system after evolving for a period n, must be quite strongly dependent on the function system's initial value, or the system's initial state. In itself, this may well sound innocuous enough. It is not, however. For it also means that extremely small variations in a system's initial state will make a very big difference indeed. This is what, in meteorology, is called the *butterfly effect*: some Japanese butterfly flapping its wings might, in principle, materially effect the weather on the other side of the globe.

In the field of human behavior and social life, too, we must apparently be prepared for very small variations or disturbances making disproportionately large differences in such things as the development or maturing of individuals, the working of the economy, the evolution of a society's culture, its legal system, and its political organization, and in matters of war and peace among nations.[31] This also means that in practice the actual evolution of no two systems, be they human individuals, societies, or entire historical epochs, will ever be the same. For, even though they might be practically identical[32] at any given moment, in the course of time they will surely be subjected to somewhat different experiences or disturbances, minute or seemingly insignificant though they may seem to us. And such differences will tend to become larger and larger as time goes by, so that, after a certain (sometimes surprisingly brief) time has elapsed, they will have grown into quite dissimilar things in which no one will recognize any common origins or ancestry.[33]

All this also has quite serious implications for (our conception of) empirical behavioral or social research. For one thing, it strongly emphasizes the futility of looking for observable regularities or uniformities in this field. In a way, and as historians tend to be so fond of saying, everything *is* unique.[34] For another, it implies that the outcomes of empirical research will be extremely sensitive to such seemingly insignificant variations in our data as are produced by inevitable measurement errors and rounding, not to speak of the unreliability and fuzziness of most of the data which we have to use in the study of real systems – an obviously rather disturbing conclusion!

However, the behavior of many non-linear iterated function systems, so: that of many natural as well as, in all probability, behavioral ones, is also highly *irregular*, in the sense that the paths which they actually follow seem to be without rhyme or reason. That is, these paths often exhibit large and apparently arbitrary variations; they may fork or bifurcate at any number of points; highly erratic paths may alternate with perfectly regular ones; and they may or they may not end up eventually in some

'attractor', i.e., some region in 'phase space' where the system settles down either to a particular stable form or to some more or less complex (fractal) pattern of continual and more or less periodic variation or oscillation.[35] Apparently, such chaotic behavior depends on the values of the variables and parameters describing the system's initial state, though in ways that seem as yet to be but very imperfectly understood.

One can easily convince oneself of the existence of such bizarre behavior even in seemingly very simple cases by iterating the rather elementary quadratic function

(9) $$x_n = \tau \cdot x_{n-1} \cdot \{1 - x_{n-1}\}$$

on a computer or calculator, for two values of the parameter τ (4 and 3.839), while choosing x randomly between 0 and 1.[36] For the parameter value 4 one shall find that for some initial values of x the outcomes repeat themselves, but that in most cases they wander aimlessly about the unit interval. When one chooses the parameter value $\tau = 3{,}839$ instead, one shall find that, for any initial value of x within the unit interval, its iterates will eventually settle down to a repeating cycle of but three numbers, to wit, .149888..., .489172..., and .959299...[37]

What seems to be fairly clear is that chaos in, or the inherent unpredictability of, all sorts of systems is a consequence of, or, rather, closely connected with, the non-linearity of the functions or relationships defining the their state transitions, and the consequent strong dependence on initial conditions of their subsequent evolution or behavior.[38] And it is precisely this relatively 'formal' condition which, because it turns out to also govern social or behavioral systems, justifies the expectation that the evolution of these systems, too, must be subject to chaos.

Fortunately, however, unpredictability appears not to be total. For it is now becoming clear, too, that most of such hypercomplex or chaotic systems are also characterized by the existence of so-called *attractors*, that is, definite states or regions in phase space into which, from a certain 'point' onwards[39], the systems concerned are being sucked as it were. Such attractors may, but need not, imply the end of the system's evolution, i.e., the end of all change in the system's state. In fact, in many cases they turn out to be characterized by continuing motion or change, though of a recurrent, more or less periodic form. Nor does it mean that, once a system is trapped by its attractor, it could never again escape or being pushed out of it by external impulses. Barring such impulses, however, the system's attractor may be regarded as a more or less stable state or, rather, pattern of motion in which the system may stay and survive for any length of time.[40]

Roughly, then, attractors describe the states or conditions in which systems can actually work or function, and assume a more or less definite shape – which also tells us why knowing them is so eminently important. For example, it might well be that the course of some revolutionary process of change in the political or institutional structure of a particular nation, or the process of national or international integration, were inherently chaotic. Yet, knowledge of the precise nature of the kind of institutions, provisions, or solutions which, given the general conditions of the systems concerned, would actually prove to work more or less stably, or towards which the systems would be eventually drawn anyway, would obviously be of the greatest importance to all involved. Thus, it would do much to keep them from pursuing fanciful or unrealistic ideas, ideals, or goals; fighting for what cannot be realized anyway; and engaging in, usually extremely costly, errors and futile societal experiments.

3.5 But is social life chaotic? – An honest answer to the question heading this Subsection should in all strictness be: We do not really know as yet.

For whether or not the actual evolutions of social systems or societies, or whether or not actual social, political, or economic processes really exhibit chaos or unpredictability, can surely not be concluded from mere empirical, specifically: statistical, research or from the detection of observable irregularities or variations. After all, we have seen that the occurrence of observable irregularities or variations should be expected to be the rule rather than the exception for reasons that have nothing at all to do with the *inherent* unpredictabilities with which we are here concerned. In fact, the *only* practically feasible method by which we could get at least a plausible idea as to the dynamic behavior of social or behavioral systems, and thereby discover the existence of chaos is that of *computer simulation*. As emphasized at an earlier occasion, however, this method calls for a comparatively very highly developed, in particular: mathematical, theory on how social or behavioral systems respond to environmental stimuli, and on what precisely underlies their transition from one state to another.[41] So far, however, simulation experiments meeting this condition seem not to have been done in our field. Accordingly, we cannot as yet be absolutely sure that things human, social, political, or economic do indeed involve chaos.

Yet, there definitely is a strong likelihood that they do in fact. Thus, both human behavior and social life generally *are* governed by all sorts of strongly non-linear relationships. It is these that form the source of chaotic behavior in all sorts of naturel systems. So it would be rather

peculiar indeed, in fact: utterly unlikely, should they *not* do so in social or behavioral systems. And if this should be accepted, the fact that such things as the recent European upheaval, economic depressions, international wars, revolutions, mob behavior, scares and panics, and the conduct of human individuals so very often seem to be without any rhyme or reason, to occur and evolve so erratically, to be governed to such a large extent by seemingly insignificant accidents, and to be so highly unpredictable generally, would all appear in a new light. For, rather than as remediable defects of our present theories or insights, they would have to be accepted as the natural and inevitable concomitants of human behavior and social life.

And *that* all the social phenomena or processes mentioned here (and a great many others besides) do indeed involve non-linearities can be easily seen even with the naked eye, without, that is, any mathematics. Thus, to take but this one example, one of the basic relationships underlying the recent European upheaval is that once people begin to suspect that the government which oppressed them so far is growing weak, divided, or less determined to go to any length to maintain its own position and to physically crush any opposition to it, their inclination to actually oppose and fight it will increase commensurately. After all, such opposition or fighting will thereby be judged to become less risky or hazardous, and more likely to bear fruit. Incidentally, it is this which makes one suspect that any attempt to make a Communist regime (or, for that matter, any other totalitarian dictatorship) more humane and tolerant cannot but be the first step towards the total disappearance of such a regime. We clearly meet here with a non-linear, strongly self-reinforcing mechanism.

This is the more so, as it also works in the reverse direction, as it were. For the government's determination to use all its available forces to crush any opposition, too, will inevitably grow weaker according as such a course of action is expected to become more costly and less certain of success, so: as the opposition grows more powerful, and as the revolution gathers momentum. And while dissension and conflict within the ruling group might well have set this process in motion in the first place, such dissension and conflict, hence a further weakening of the government, will surely make their appearance or grow more intensive, according as the revolution takes up steam – if only because there will always be some among the ruling group who will want to profit from the process, i.e., strengthen their own position, by allying themselves with oppositional groups or by fostering further unrest in order to embarrass their own competitors.[42] Accordingly, we meet here also with a strongly self-reinforcing mechanism which will, in its turn, interact with that which

governs the actions of the rebels, and will surely fire *their* fervor, strengthen *their* determination, and attract more support for the revolutionary cause generally.

In all, then, it would seem that our inability to foresee the sudden and remarkably peaceful breakup of the Eastern European Communist regimes, and practically also that of the Soviet Union's empire in that region, does not so much derive from our, or the experts', stupidity, laziness, or lack of imagination, as from the inherently chaotic nature of such events as well as, more generally, of things human and social.[43]

Yet, social processes or the evolution of social, political, or economic systems would not seem to be totally unpredictable either. Thus, there are very deep reasons for the expectation that, as far as its institutional structure is concerned, the evolution of a modern, specifically: industrial or industrializing, society will inevitably move in the direction of a more democratic system of government, and that, conversely, autocratic or dictatorial patterns of rule will find it progressively more difficult to maintain themselves in such conditions.[44]

Very briefly, industrialization involves the evolution of a more highly differentiated and homogeneous social structure, characterized by the proliferation of interests, the development of all sorts of crosscutting interests, loyalties, and alliances, as well as a considerably enhanced social and geographic mobility, and a commensurate enlargement of the scope of social action of individuals and groups. In such conditions more democratic arrangements become both more feasible and necessary, while, conversely, the systematic oppression and exclusion from political participation of the large numbers of inherently important and powerful groups that are characteristic of any industrialized society, becomes increasingly difficult, hazardous, costly, and impractical. Moreover, there is ample reason to believe that a productive, which also means: an innovative and adaptable, industrial economy *cannot* be effectively run by a centralized, more or less totalitarian bureaucracy, so that any attempt to do so would eventually lead to a loss of competitiveness of the economy concerned, and, as a consequence, of the nation's power and international status.

We would seem to meet here, then, with an example of an attractor in an otherwise chaotic or unpredictable process of evolution[45]: democracy as a kind of sink in which the evolution of an industrial society must eventually 'end'. And this aspect of the matter, too, would seem to be illustrated by the recent East European events. However, it is also implied by the supposedly chaotic nature the process that, inevitable though (more) democracy may be[46], we will be unable to predict either when

precisely, or via which routes or methods this will be realized. Nor is it to be excluded that the road towards this 'end', or towards a stably working institutional structure generally, will be marked by violence, by the emergence of different totalitarian movements, as well as by temporary (though not necessarily brief) relapses into more autocratic models of government.

4. Does social science still have a future?

The previous discussion might well raise grave doubts as to the use or meaningfulness, indeed, the very possibility in the first place, of doing or studying social or behavioral science. Would not the existence of chaos, and of an apparently irreducible and significant measure of unpredictability in human social life imply the utter futility of its scientific study?

To answer this question straightaway: it definitely does not.

For, first of all, it merely reinforces the argument for a rather different conception and methodology of social or behavioral inquiry than seems to be prevalent today. Briefly, and as has been discussed before, it renders it ever more necessary to conceive such inquiry in a rather more abstract or fundamental fashion than seems to be common, to wit, as regarding the structure of things, events, or systems rather than theit outward, immediately visible or observable manifestations. It strongly emphasizes the need for a more explicitly theoretical as well as mathematical orientation in behavioral or social research.[47] It makes the adoption of a systems approach to things human and social imperative, indeed inevitable.[48] It implies the indispensability of the computer as a basic research tool for testing and developing our theories and insights. And it makes the testing of isolated empirical hypotheses even less relevant and meaningful.

Beyond all this, which basically concerns the *how* of behavioral inquiry, however, the recognition of the (probably) chaotic and highly unpredictable nature of things human and social, also necessitates a reappraisal of our scientific ambitions or goals. For, surely, it means that we can no longer let ourselves be guided by the ideal of perfect (if probabilistic) predictability or by the ambition to forecast all of the human universe's future course of evolution. Even as regards this issue, however, the picture turns out to be far less bleak than it might initially seem to be.

To begin with, we should bear in mind that the purpose of science is basically to *enhance* the transparency and coherence of the world as we

know it, that is, to *reduce* the level of uncertainty in it, or to *raise* the measure of information it holds.[49] Conversely, it can certainly *not* be to destroy all uncertainty utterly, or, which comes to the same thing, to produce anything like 'full information' – a notion of which it is impossible to make sense of in the first place. For one thing, the world as we know or perceive it, which is the only one about which we can speak at all, is itself already shaped by the very theories which we use to order it. For another, the further development of any theory invariably leads to the definition or discovery of more problems than it solved.[50]

There is nothing in the previous analysis of the nature of social or behavioral systems which really would stand in the way of realizing this basic goal of all scientific inquiry, which is 'merely' to produce more, not 'complete' information. Thus, it would in principle be perfectly feasible to determine the *ranges* within which various social processes or forms of human behavior vary erratically and randomly. Such insight would be enormously important, both from a purely scientific and from a practical point of view. As already intimated, this would also apply to the determination und understanding of the *attractors* of social or behavioral processes, i.e., the more or less stable states or configurations towards which they are being drawn eventually, as well as to knowledge of what upsets or destabilizes such states or configurations – all of which would again seem to be perfectly feasible. And, of course, further inquiry might well bring to light deep structures in, and underlying the unpredictabilities which now baffle us so much.

It will be evident that to realize all this calls for a not insignificant, above all methodological, reorientation of the behavioral or social research effort, and quite a lot of strenuous intellectual labor. But, then, who could ever expect human behavior and social life to be easy matters? And who would ever wish to squander his or her intellectual energy and capabilities on meaningless trivia?

Notes

1. It may not be amiss to emphasize here that the primacy of theory in all scientific research, and in our perception of the world in the first place, derives from the very nature of our knowledge or insight generally. That is, it is a matter of *epistemological* argument. In this essay, however, I will be concerned less with epistemology than with the methodological implications of what, as a consequence of advanced theoretical inquiry, we are nowadays finding out about the very nature of social or behavioral systems themselves, the subject matter of our science.

2. See in particular *De Vree 1990*.

3. In this essay the terms 'behavioral' and 'social science', meant to cover all the disciplines studying the human or social universe, from psychology to political science, will be taken to refer to what is essentially the same thing. All those disciplines are basically concerned with inquiry into what underlies (more or less complex, interacting configurations or systems of) human behavior. One can neither understand the human individual without taking into account its social environment, i.e., its interaction with others or its position in the social system or society of which it is part, nor study social, political, or economic life in ignorance of the forces and mechanisms governing individual behavior. And advanced inquiry into these matters brings to light that, as far as theoretical principles and basic methodology are concerned, the several social or behavioral disciplines do not really differ in any significant sense of that word. That is, they all share the same basis of assumptions, and they all meet with basically the same research problems.

4. This also means that behavior cannot be represented by some simple, scalar, property or magnitude, but should always be described in terms of (a vector of) any number of relevant choice probabilities. Thus, we should not simply speak of the probability of behavior, but rather of the probability *distribution* which, at any given moment characterizes an individual's conduct – something which obviously greatly complicates behavioral and, by implication, social or political inquiry.

5. Indeed, when considered in isolation, this last principle can hardly be called an empirical proposition at all. For while we might have an idea as to the empirical meaning of the expression 'behavioral probability' (although further inquiry brings to light that even this represents no small problem), the primitive notion of 'utility' or 'value' has as yet no meaning other than, roughly, 'that which determines behavioral probabilities'. Like the true primitives of any scientific theory (think of the notion of energy in thermodynamics!), this one, too, lacks an independent empirical meaning, and cannot be defined by means of an ordinary explicit definition. Rather, such notions are defined 'implicitly', as this is sometimes being expressed, by the whole *set* of assumptions in which they figure. As a consequence, too, the principle linking behavioral probabilities to utilities, when considered alone (without reference to the other assumptions in which it figures, that is), is just an empty tautology, always true, but therefore also completely uninformative. Basically, we need it in order to be able to map, as yet undefined, but presumably infinitely variable, subjective insights or value judgments on behavioral probabilities which are of course restricted to the closed interval (0,1). Clearly, too, all this also gives additional weight to the point made in the text, viz., that scientific laws cannot be regarded as empirical generalizations.

6. Here and in the rest of this essay the term 'structure' refers to the entire set of relationships (as determined or defined by a particular theory) which determine how the state of a system at some moment, t, is being transformed into another such state at the next moment, t+1, either under the influence of certain environmental stimuli or disturbances, or under that of its own internal

dynamims. The notion should be sharply distinguished, then, from that of 'system' which merely refers to any collection of elements somehow hanging together – although a system's structure forms a kind of system in its own right, of course. In a way, structure describes the internal makeup of a system, usually in the form of a more or less complex transformation matrix.

7. In order to preclude any possible misunderstandings, it should be mentioned that the term 'mechanism' merely refers to some set or system of relationships or functions governing the transition of one thing into another, or one system state into another. It does not, then, imply anything 'mechanical' or 'mechanistic'.

8. One may even suspect that the initial plausibility and appeal of the notion basically derive from a deeply ingrained 'anthropomorphic' approach to life and nature generally. That is to say, the notion reflects less the need to *understand* nature in general, and human behavior or social life on their own terms, so to speak, as the urge to *assign responsibilities* for what actually occurs, to mete out blame and praise, and to identify those things or agencies by means of which we can effectively intervene in our natural or social environment, alleviating distress, righting wrongs, remedying misery, punishing or eliminating what harms us, and praising, reinforcing, or stimulating what benefits us. All this may well be necessary or inevitable. Yet, it is in principle entirely different from explaining or understanding reality.

9. It will be clear, too, that the inherently dynamic nature of individual behavior greatly detracts from any intuitive appeal which 'methodological individualism' may have. For apparently the individual is anything but the straightforward, hard and fast 'atom' of social life for which we might initially be inclined to take it; and basing social (or, for that matter, political or economic) inquiry on the principles of individual behavior surely offers no escape from systems theory.

10. So far, the only well-known method to do justice to the fact that interaction is a matter of sets of interrelated expectations is that of *game theory*. Its usefulness, however, is sharply limited by the fact that it is a prescriptive rather than explanatory theory; that its scope is restricted to relatively simple cases; and that it tends not to do justice to the dynamical nature of interaction, i.e., to its evolution through time.

11. This example also illustrates the crucial relevance of *information* in the study and explanation of war and violence. For it is precisely such information which allows the parties involved to assess what is or is not inevitable, feasible, or worthwhile – information, however, which in practice, especially in international systems, is all too often lacking. And it will be the more so according as the system as a whole is more opaque, in particular in the sense of lacking any clear and definite power *im*balances or *in*equalities, or when it is subject to large-scale change, so that its members can no longer make head or tail of their mutual relations of power and interest. In its turn, this again illustrates the importance of a social or political system's degree of *order* or *organization* (a typically systemic notion, incidentally) as an important determinant of the nature of intercourse in such a system. In fact, at a deeper level of analysis, both measures, information and

degree of organization or order, represent but different interpretations of the originally thermodynamic notion of information. For a non-technical and easily readable discussion of in particular this last point, see Jeremy Campbell: *Grammatical Man*, Simon and Schuster, New York 1982.

12. That level is, of course, that of the *structure* of systems or things generally, rather than that of immediately observable events or statistical relationships. In this sense, and as mentioned before, (social) science becomes both more abstract, in the sense of being further removed from observable reality, and more complex in that the structure of a system will be typically defined in terms of a (matrix of a) larger or smaller number of different relationships or functions, determine the state transitions of a number of observable magnitudes, and produce quite different (observable) results depending upon the initial state of the system concerned. Conversely, all this also implies that, at any rate: in principle, no amount of testing such hypotheses as are cast in terms of straightforward observables will produce much reliable and applicable or generalizable insight into the working of social reality.

13. Of course, inductivism is already an impossibility for purely epistemological reasons alone. Apparently, however, many working behavioral scientists find it hard or inconvenient to take epistemology as seriously as it should be taken.

14. To forestall possible misunderstandings, this does *not* imply that the construction of such a theory could not start with, or be based upon, certain assumptions about individual human behavior, as in the program of 'methodological individualism' (and recognizing that such behavior, too, forms a system in its own right!). In fact, the distinction between 'individualism' and 'holism' (with which systems theory is often identified), the occasion for bitter fights and polemics between warring academic factions, is rather less than useful. It should be added, too, that for a theory to be a systems theory it is not sufficient that its subject matter be some sort of system. Thus, much of what goes by the name of 'systems theory' in the social sciences, while surely concerned with social, political, or economic systems, is no true systems theory in the above sense of the word at all.

15. It is often thought that the use of mathematics were a matter of mere choice or taste. It is not. As mentioned in the text, mathematics provides us with the tools, unavailable in our natural language, to effectively deal with the complexity of things. Thus, it is impossible to discuss such things as system states, system structure, and their transformation, which typically represent vector or matrix variables as well as various operations on them, without the use of (non-)linear algebra and calculus. Even more generally, we speak mathematics without knowing it, in the sense that many of the centrally important notions which we use, and are bound to use, in scientific or even everyday discourse (for instance: 'number', 'magnitude', 'distance', 'likelihood', 'relation', 'proportionality', 'change', 'speed', 'velocity' – and a great number of other common notions besides) are of an inherently mathematical nature. They are so, not in the sense that they were invented by mathematicians, but because it is the proper subject of

mathematics to investigate and lay down their precise nature, their scope and limitations, the ways in which we may use them properly, i.e., consistently, what we may and may not do with or to them, as well as what their use does and does not commit us to. To the degree that it becomes necessary to become aware of all this, i.e., usually not in ordinary discourse, in literature, journalism, or the writing of history, but definitely so in evolving scientific inquiry, we are virtually *forced* to employ the language of mathematics.

16. Ultimately, this derives from the fact that things, for instance hypotheses, assumptions, or concepts, cannot have a meaning of their own, in isolation, independently, that is, of other things. Rather, what anything means resides in the whole network of relationships which connects it to a greater or smaller number of other things – to which the same applies, of course. In science, representing, among other things, an effort to tightly control and render transparent the meaning of the notions or concepts we use, this network, which in ordinary discourse is usually quite fuzzy and indeterminate, is replaced by some explicit theory.

17. I know this sounds very faddish and trendy indeed. Yet, the truth of the matter is that for the more advanced forms of inquiry into the kinds of systems with which we are to concern ourselves, the computer *is* a godsend. For an easily accessible discussion of precisely this issue, see in particular *Pagels 1989*.

18. This also means, incidentally that geometric intuition and graphical representation can be of but very little help in the study of such systems or phenomena, which must therefore proceed in a purely analytic fashion only.

19. There is in principle no difference between inquiry into *real systems*, and *simulation*. In the former case the computer is just being fed real data regarding real social or behavioral systems; in the latter we feed the computer more or less artificially simplified data concerning generally more restrictively defined, and therefore more manageable systems. It can be easily seen that real systems will usually be rather large and exceedingly complex, so that, as a rule, inquiry into them will call for very large computers indeed, comparable to those used for meteorological forecasts – always assuming, that is, that the relevant data will in fact be available and sufficiently reliable. Naturally, we shall wish to consider doing that kind of costly research only after we have convinced ourselves that the models or theories we use are sufficiently powerful and reliable. And this is precisely what simulation is meant to establish.

20. Obviously, computer modelling or simulation also reinforces the need for a more explicitly theoretical (and mathematical) orientation in social or behavioral science. After all, computers are relatively stupid things, meaning that what you get out of them cannot be better than the theoretical models you feed them. It is precisely this paucity of theory which has so far stood in the way of a convincingly succesful use of the computer in our field.

21. Although some of the relevant (mathematical) discoveries were already made by *Poincaré* at the end of the nineteenth century, it is only since about the middle of the present century that the great practical as well as theoretical

importance of this field of inquiry is gradually, and increasingly, being recognized in the several branches of mathematics, physics, chemistry, biology, and even medicine. Very briefly, mathematics contributed the discovery and analysis of the highly irregular behavior of certain classes of non-linear 'iterated function systems', and, in the work of *Mandelbrot* in particular, insight into, as well as the tools to describe, the surprising geometric shapes or 'fractal' structures, produced by such systems in a wide range of different fields. Thermodynamics, particularly in the work of *Prigogine* and *Haken*, led to the recognition of the chaotic nature of various chemical and physical processes far from thermodynamic equilibrium, as well as, rather paradoxically, to that of the importance of precisely such processes for the production and maintenance of highly ordered structures. And in meteorology as well as in fluid dynamics it was found how extremely sensitive the processes or systems involved were to even very slight changes in initial conditions. At the end of this essay I have included some of the, by now vast, literature on the subject. For a very accessible introduction, not requiring any mathematical or physical knowledge, one may wish to consult *Gleick 1987*.

22. Which, however, does *not* imply that feedback relations should always involve non-linear functions.

23. It will be clear that, in actual social analysis, the situation is considerably more complex than the above may suggest. Specifically, the vast majority of magnitudes or variables with which we have to deal in such analysis will typically be vectors rather than scalars; functions will have to be replaced by 'vector fields'; and the several derivatives figuring in the above examples will assume the form of more or less complex vectors and (Jacobian) matrices of (partial) derivatives. Yet, for the purpose of illustrating the problems raised by non-linearities, scalar functions will do.

24. See *De Vree 1990, vol. 1, ch. 8**. Briefly, this 'behavioral function' *must* have this normalized exponential form because (*a*) as all probabilities, behavioral probabilities, too, must be additive, sum to unity, be nonnegative, and not exceed unity; whereas (*b*) subjectively estimated, expected utilities or values may assume any positive as well as negative value; while (*c*) both the absolutely certain, $p(k) = 1$, and the absolutely impossible option, $p(k) = 0$, implying, that is, the absence of choice, so that we cannot speak any more of behavior in the first place, must be treated as marginal cases, i.e., they should be defined as limiting cases only, specifically: for $u(k)$ approaching plus and minus infinity, respectively.

25. In much of the relevant literature the term 'chaotic systems' is being used instead. I prefer the term 'hypercomplex', because, although such systems do lead to all sorts of 'chaotic' phenomena, they are themselves surely not chaotic in any possible sense of that word, still less so, as most of the systems thus being studied in the physical sciences are of a relatively simple, essentially deterministic nature, in contrast to the inherently stochastic or probabilistic systems with which social or behavioral scientists are concerned.

26. We should be well aware, however, of the fact that things are 'tractable', 'simple', 'elementary', 'unproblematical', and 'easy' to observe or measure only

to the degree that they do already have a recognized place in more or less established and familiar 'theories'. In other words, these qualities are not inherent in those things themselves. In reality, nothing at all is inherently 'simple', 'unproblematical', etc. The intuition that we explain or predict what is complex and problematical from what is elementary and unproblematical or evident can therefore only mean that new theory or insight is always built or developed from existing theories or insights – which represents both a true and inevitable implication of the very nature of knowledge itself. As a matter of fact, too, the rather common prejudice that the primitive notions as well as the axioms or assumptions underlying a scientific theory should be inherently clear and 'self-evident' is belied by any more advanced scientific theory. Thus, to mention but two important examples, neither the idea that the total amount of energy in a closed system is constant (the first law of thermodynamics), nor the notion that there is no privileged place in the physical Universe (one of the basic ideas underlying relativistic physics) can be called inherently clear or self-evident in any sense of those expressions whatsoever.

27. Of course, there is in principle no end to the process of explanation, nor, as a consequence, are there any inherent limits set to the reductionist ambition. Thus, one might well aim at explaining things human and social from purely natural or material forces and mechanisms alone, thus reducing behavioral or social science to a mere branch of physics or chemistry. It is this kind of ambition to which the name of 'reductionism' has become particularly closely attached, an ambition, however, which nowadays seems to be shared by very few scientists indeed. Yet, the basic idea of reductionism, though in a usually very much milder form, would definitely seem to form part of our more or less intuitive conception of scientific inquiry generally.

28. True, in the case of quadratic functions, for instance, at least the second derivative will be a constant (more generally: the nth derivative of and nth-degree function will be a constant). But apart from the issue of the explanatory relevance of such higher-order derivatives, the more important relationships underlying human behavior and social life (as well as, incidentally, much of nature as a whole) tend to involve various exponential and logarithmic functions, no nth order derivatives of which will in principle ever reduce to a mere constant.

29. At a somewhat deeper level, it even appears that such a basic relationship as that of interdependence which one tends to conceive in terms of more or less 'objective' relations of power and of distance between systems, is already to a significant extent shaped by the current state of interaction between those systems. Again: in the explanation of current behavior or interaction, one cannot escape from previous behavior or interaction, and in predicting the future one cannot escape from the past.

30. See *Barnsley 1988*.

31. Thus, relatively small disturbances in an international system, such as, for instance, the murder of Archduke Franz Ferdinand and his consort in 1914 in the case of the First World War, relatively insignificant though such an event might

have been in itself, might well set off dramatic and devastating processes of escalation. Similarly, economic depressions might be initiated by relatively insignificant shocks or perturbations, such as may well have occurred in the case of the sudden rises in oil prices in the early 'seventies which were imposed by OPEC, even though, in money terms, the share of oil in the Western economies was relatively modest. In many social, political, or economic systems, the problem at issue here is considerably aggravated because such systems (think, for instance, of international systems) seem to be inherently unstable in the sense that they lack the capacity for correcting, dampening, or, in general, processing the shocks or disturbances to which they are inevitably subjected in an orderly and peaceful manner – something which, at any rate: many, nations are much better at doing.

32. Even this expression should be used very cautiously. For 'practically identical' means that such differences as inevitably exist between systems either are deemed irrelevant by us, or fall below our threshold of detection. But what we are gradually finding out these days is precisely that such differences may count nonetheless, and that they will tend to be magnified in the course of time.

33. Indeed, this fact underlies one of the measures of the chaotic nature of a particular path or process, to wit, the *Lyapunov exponent*, which measures the extent to which small differences in a system's initial state are being magnified in the course of time. It will also be clear that to the degree that a system, as a result of non-linearities in its structure, exhibits chaotic motion or behavior generally, knowledge of its initial conditions becomes less and less relevant in the course of time. In a way, information is being lost along the system's trajectory. This consideration is precisely what underlies another important measure of chaotic behavior, viz., the *Kolmogorov entropy*, which turns out to be intimately related to the *Lyapunov exponent*, as well as, presumably, to the *Hausdorff dimension* (or *Hausdorff-Besicovich dimension*, the fractal, usually non-integer, dimension of the system's attractor. See, for instance, *Schuster 1988*, p. 24 ff, 110 ff, and 122 ff.

34. Whether they always know what precisely they are saying thereby, or why they are saying it, is quite a different matter. Taking it fully literally would at any rate render even their own trade absolutely futile, indeed: impossible. And the conclusion which they often like to draw from the supposed uniqueness of things, to wit, that behavioral or social science were inherently impossible, is definitely false to begin with. For, as has been stressed at several previous occasions in this essay, it merely means that we should conceive our science in a more abstract fashion, and locate it at a deeper level of inquiry that that of the study of observable uniformities.

35. *Fractals* are among the latest fundamental discoveries in mathematics and the natural sciences in their continuing endeavour to come to grips with the seeming irregularity exhibited by such things as clouds, dust particles, land masses, and the distribution of islands over a particular sea or lake. They regard such things as non-rectifiable, non-differentiable curves which, while they may enclose a definite area, yet lack any definite length; and surfaces enclosed by a definite perimeter, yet lacking a definite area. One of their most characteristic

features, sometimes even taken to define them in the first place, is *self-similarity*, i.e., the property that the exhibit the same basic form at any scale. That the 'attractors' of iterated function systems will tend to exhibit fractal structure may be rendered intuitively plausible by recognizing that such systems involve the repeated execution of an operation or set of operations on given initial conditions, which will frequently result in typically self-similar structures.

36. This function, precisely because it is so deceptively simple, is one of the favorites in the literature on chaos. See, for instance, *Devaney 1986*, p. 2ff. It should be especially noted that this simple function system, as well as many other such systems to be found in the literature, still describes mere *deterministic* state transitions, not marred, that is, by randomness and 'noise'.

37. It would seem, however, that even in this second case unpredictability lurks in the background, that the perfect regularity which we seem to see here, is merely hidden from our view as a result of roundoff errors, and that, at any rate: for some initial values of x, it will again become visible according as the accuracy of our calculations is being raised. Apparently, then, the phenomena which we are discussing here may sometimes also lead us to conclude to order or predictability where none is to be found in reality!

38. Yet, even with respect to this point, some caution is in order. For there are a number of non-linear function systems that yield sequences of values which merely converge to a definite limit, for instance: $x_n = \mathrm{Sin}\{x_{n-1}\}$ which tends to zero, while others, for instance: $x_n = \mathrm{Exp}\{x_{n-1}\}$, just 'explode' into infinity. At present it even seems impossible to say beforehand which function systems will and which will not exhibit chaos or unpredictability.

39. As soon, that is, as the path followed by the system in question enters the *basin of attraction* of its attractor.

40. Apart from the existence of attractors as regions of relative stability in the otherwise bizarre and seemingly aimless wanderings of hypercomplex systems, it is not to be excluded that we will eventually even discover certain deep structures or patterns in these wanderings themselves. After all, unpredictability is also a function of the state of our insight, i.e., of the level of development of our scientific theories. What seems to be unpredictable or bizarre *now*, might well turn out to exhibit a perfectly regular structure at a deeper level of inquiry which merely remains hidden from our present view because we have not delved deep enough as yet. In fact, the argument, earlier in this essay, about the need to conceive social or behavioral science in a rather more abstract way, concentrating upon the investigation of structures rather that on a search for observable uniformities, and which are hardly to be expected in the first place, was concerned precisely with this point.

41. Insight into the mechanisms underlying the responses or state transitions of systems in principle allows us to predict how a system will behave, or what the form and nature of social life within it will be, at moment $t+1$ from its state at t. Such insight is an obviously essential precondition for being able to chart the course or evolution of a system over any longer period of time. Yet, it does nog

suffice to discover the kinds of anomalies and irregularities which, even in the absence of any (further) environmental disturbances, might occur in the course of time as a result of the non-linear nature of the relationships involved. For as neither their precise form, nor the moment of their occurrence can be straightforwardly predicted from these relationships themselves, the only way to discover and study them is the experimental one.

42. It should be added that the analysis of such events is complicated still further by the necessity to also take into account interactions, and non-linear relationships across different societal levels, for instance those between the national and the international sphere. Thus, in the example under discussion here, any weakening of the Soviet Union's resolve to do its utmost to prop up the several national Communist governments within its ambit, will again stimulate domestic opposition against them, but, at one remove, also render it more hazardous and difficult (so: less likely) for the Soviet Union to effectively intervene in the process at a later stage, should it decide that things are going too far, etc., etc.

43. In this essay we are concerned first and foremost with broadly methodological issues. Yet, it may not be amiss to mention that the (recognition of the) existence of chaos in social, political, or economic life must also have grave consequences of a more practical, political, or even ideological nature. It means that the uncertainty in social life will be and remain even greater than we suspected – and such uncertainty or lack of information is among the prime determinants of the nature and form of intercourse in social life, of violence or war as well as of peaceful cooperation, trade, and business enterprise or investment. It means that, at any societal level whatsoever, we must be prepared for the likelihood that our policies and decisions, rational, sensible, just, or well-intentioned though they may be in themselves, will have all sorts of unexpected, unintended, and usually unpleasant, consequences. And what of our capacity for steering, controlling, or regulating social life, and for shaping society according to our ideals, norms, and predilections?

44. See on this issue in particular *De Vree 1990*, vol 3, chs. 40 and 41. In this connection a system is called *more democratic* according as *a*. a greater number and variety of societal groups and interests are allowed to compete for positions of, roughly, public responsibility and influence; and *b*. the degree to which public policies and decisions (including, of course, such decisions as allocate public positions) are made by means of voting and elections is higher. Conversely, a system is *more autocratic* according as it scores lower on these two criteria. Clearly, too, this definition replaces a rather common dichotomy, and a dichotomous distinction between 'good' and 'bad' regimes, by a completely neutral and inherently quantitative measure.

45. The existence of such attractors is sometimes taken as a constituent element in the definition of chaos as a technical term.

46. Granted, of course, that the several East European countries, including the Soviet Union, will not be reduced to preindustrial societies.

47. As far as the role of theory is concerned, the vast majority of contemporary

behavioral or social scientists seem to agree that meaningful empirical inquiry must indeed be based on a theory, or even: that things do not have any meaning at all outside of the context of such a theory. And virtually every monograph or dissertation in our field does start out by describing what is purported to be the 'theoretical base' on which the work rests. Far more often than not, though, this 'theoretical base' proves to be nothing more than a mere set of very loosely connected hunches or hypotheses or, even worse, a structure of definitions, i.e. just words and terminological conventions.

48. In order to forestall rather common misunderstandings, it should be added that in itself the term 'systems theory' means very little indeed. Specifically, it does not refer to any definite, substantive kind of theory at all, in the sense in which expressions like 'the theory of relativity' or 'the theory of biological evolution' refer to particular empirical theories. Rather, the term 'systems theory' merely serves to emphasize a methodological issue, to wit, the explicit recognition of the fact that things hang together, are made up of still other things that thus hang together, and should therefore be studied as such, or, conversely, that there is very little sense in studying things in isolation. This, however, is so elementary, indeed: trite, that it would scarcely merit a special name. And that we still tend to use the term merely testifies to the fact that we still find it hard to actually take such commonplaces quite seriously.

49. It is in this, too, that the eminent practical usefulness of scientific inquiry resides. For raising the level of information which we possess also turns out to entail a commensurate increase in the effectiveness or efficiency of our behavior, i.e., in our capacity to use (so also: produce) material resources, our ability to avoid errors, and in that to attain the goals we set ourselves, as well as, it should be added, in the realism with which we set those goals in the first place. This is evident enough in the case of the information produced by the physical sciences. It also implies that further scientific progress will be more likely according as our theories have already grown better, containing, that is, more information – something which is equally easily visible in the historical development of, in particular, the physical sciences. But, as has already been hinted at, such increasing information is also of eminent practical significance in the sphere of human social life, specifically: in improving the conditions for peaceful cooperation, trade, and business enterprise, and in lowering the likelihood of violence and warfare. It remains to be added that the supreme relevance of information in these spheres ultimately derives from something which turns out to underlie nature as a whole, to wit, that the amount of usable energy contained in a system, so: the amount of 'work' which it is able to do, is proportional to the amount of information it contains, i.e., the level of its internal order or organization.

50. In view of all this scientific inquiry should be conceived in an inherently dynamical fashion as the process by which we raise the level of information in our experiences or observations, recognizing full well that the latter are themselves shaped by such inquiry. In a way, science aims at defining or shaping experience so that we can make sense of it. This is being done by the invention or further

development of theory or theories. If any good, these do indeed thus raise the information level in our current experiences, i.e., they solve the problems, overcome the inconsistencies, fill the gaps, and straighten out the ambiguities in our current (rather: previous) picture of the world. But they inevitably also define new experiences or observations, and lay bare all sorts of new problems, inconsistencies, and so on. In that respect, they should always be treated as no more than programs for further research, as stepping stones towards new and better theories. Accordingly, the fact that a scientific theory does raise any number of as yet unsolved problems, far from representing the defect for which, particularly in the social sciences, it is usually (mis)taken, is in fact a measure of its scientific fruitfulness.

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Note: Works marked by an asterisk generally call for a comparatively high level of mathematical sophistication and interest, and often for a somewhat more than elementary knowledge of physics.