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Erodynamics and the Dischaotic Personality

Ralph H. Abraham

Dedicated to Kurt Lewin (1890-1947)
and
Gregory Bateson (1904-1980)

The binary dichotomy of chaos/dischaos is used in place of that of disorder/order in modeling the psyche in the style of Kurt Lewin. Application is made to several ideas of Gregory Bateson.

HISTORICAL INTRODUCTION

The new field of erodynamics consists of applications of the mathematical theories of dynamics, chaos, and bifurcations to models in the social sciences, including economics. Here we give a capsule history of the field. Complex dynamical systems theory provides a new modeling strategy for social systems, which are usually too complex to model without a theory that allows chaos and bifurcation. These new models contribute to the hermeneutical circle for evolving social structures, in which mathematical help in understanding may be very welcome. Even the simplest social systems, such as two persons or two nations, tax our intuitive cognitive strategies. Dynamical models may be used as navigational aids for cooperation or conflict resolution in many situations in which good will prevails, yet does not suffice.

An early dynamical model for social systems, the first we know of, is the (1837) Verhulst model for population growth. Later, in the context of the Great War, came Lanchester's (1914) model for war, and Richardson's (1919) model for the arms race. Next came dynamical models for economic systems, with Keynes, Schumpeter, and von Neumann in the 1930s. Rashevsky, the founder of mathematical biology and editor of Richardson's papers, invented mathematical sociology during World War II. This sequence accelerated after World War II with the syntheses of general systems theory and cybernetics. In the mathematical branch of these movements, systems dynamics, we have the extensive development of models for factories, cities, nations, the world monetary system, and many other complex systems. The work of Jay Forrester was central to this growth. The independent development of dynamical systems theory after Poincaré remained aloof from social applications until recently, and now a reunion of these two branches of mathematics is underway. In the Poincaré lineage came the development of applied singularity theory by René Thom, its extensive application to social systems (as catastrophe theory) by Christopher Zeeman, and new dynamical models for economic systems by Radnor, Smale, and Chichilnisky in the 1970s. Since then, chaos theory has discovered systems with complex structure, and systems dynamics has discovered chaos.

THE PIONEERS

Here are some milestones in the evolution of erodynamics.

Lanchester, 1914

Frederick William Lanchester (1868-1946) was an English engineer. A creative genius interested in economics, physics, military strategy, automobiles, and airplanes, he was of one of the first to grasp the military advantage of aircraft. In this context, he conceived a dynamical model for armed conflict, in which numerical strength, firepower, strategy, and attitude were counted (Lanchester, 1914).

Richardson, 1919

Lewis Frye Richardson (1881-1953) was an English physicist, meteorologist, and Quaker. A conscientious objector in the World War I, he served as an ambulance driver on the frontlines in France, and saw a great deal of death and suffering. He decided to devote his life to the elimination of war. He developed a linear model for the arms race between two nations, in which a spiral of increasing armaments in each nation resulted from mathematical laws. He felt that the individual nations caught in this kind of dynamic were innocent victims of an out-of-control global system. He submitted a paper on this model to a journal, fully confident that another war could be averted. However, the paper was rejected, and the second World War began. After this rejection Richardson continued his work, trying to justify the model on the basis of actual armament statistics. In these efforts, he founded the field of politicometrics. Richardson's life work was published posthumously in 1960.

Von Neumann, 1932

The word *economics* is derived from the Greek *oikos nomos*, meaning the management of a household. This is also the source of oikonomia, the Christian doctrine of the economy of salvation. In the last century, economics became an important social science. Because economics is naturally equipped with numerical data, it was one of the first of the social sciences to receive a mathematical treatment. In 1932 John von Neumann (1903-1957) created one of the first dynamical models for an economic system, giving rise to a whole industry of mathematical analyses, computer simulations, and data collection (econometrics) (see Goodwin, 1991, Chap. 3).

Bateson, 1935

Gregory Bateson (1904-1980) adapted the Richardson arms race model to the process of the division of a culture into subcultures, analogous to differentiation in biological systems. He called this universal dynamical process for the development of a schism a Richardsonian process of schismogenesis (Bateson, 1972, p. 68). In fact, schismogenesis, a social form of bifurcation, was one of Bateson's main themes (Bateson, 1972, pp. 61, 107). Later he would apply it to schizophrenia (see "The Double Bind" below).

Lewin, 1936

Kurt Lewin (1890-1947) was influenced by the hermeneutics of Dilthey, with whom he had contact in Berlin, and Wertheimer, who had developed a *field* concept in Gestalt psychology as early as 1923. This was extensively developed by Lewin. His *life space* is a sort of psychological field, extending over a group of animals (Lewin, 1951/1975). He modeled social psychological objects by shapes within the life space, or field. He also introduced concepts of dynamics and bifurcations in these shapes, under the name *topological psychology* (Lewin, 1936). The rigorous development of Lewin's ideas had to await complex dynamical systems theory, or chaos theory, in the 1960s and 1970s.

Rashevsky, 1939

Nicholas Rashevsky (1895-1964) escaped from the Russian revolution to become the indefatigable pioneer of mathematical biology at the University of Chicago (Karreman, 1990). He published an early erodynamics paper (1939) and a book (1947) applying the methods of mathematical biology to sociology. He edited the writings of Lewis Frye Richardson, the founder of erodynamics, for posthumous publication in 1960. In *Looking at History through Mathematics* (Rashevsky, 1968), he offers steps toward a mathematical model for Arnold Toynbee's theory of history. A tentative prevision of catastrophe theory is included to explain revolutions:

> Whenever we have threshold phenomena, whether in physical, biological, or social systems, the configuration of the system at the moment when the threshold is reached becomes unstable and the slightest, even infinitesimal, displacement of the configuration in a proper direction leads eventually to a finite change in the configuration of the system. Therefore, a change in the behavior of a single individual, no matter how small, may precipitate in an unstable social configuration, a process that leads to a finite, sometimes radical, change. (Rashevsky, 1968, p. 119)

An explicit recognition of the hermeneutic circle is presented in the Preface of this book, as part of an extensive defense of mathematical modeling.

Jung, 1952

Carl G. Jung (1875-1961) came late in his life to some fractal awakening, expressed in his book *Answer to Job* (1952). This presents an astonishingly bold psychoanalysis of the god Yahweh, in which good and evil are combined in a fractal binary. Further, his concept of *enantiodromia* (oscillation) admits a Lewinian model (Abraham, Abraham, & Shaw, 1990, pp. III-11 ff.).

Thom, 1972

In the 1960s René Thom developed catastrophe theory; he published the theory in 1972, along with a number of ideas for its application in the sciences, linguistics, philosophy, and so on. The final chapter of his work sets out the modern formulation of erodynamics in the context of proposed applications to sociology and psychology.

Zeeman, 1976

In the 1970s Carlos Isnard and Christopher Zeeman replaced the linear model of Lewis Richardson and Gregory Bateson with a nonlinear model, the cusp catastrophe of Thom's theory. They applied their model to the original arms race context of Richardson's work, showing how the model fit a situation of schismogenesis, in which the voting population of a democratic nation split into hawks and doves. Zeeman also adapted the cusp to model anorexia nervosa, an emotional disease in which phases of gluttony and fasting alternate (Postle, 1980; Zeeman, 1977).

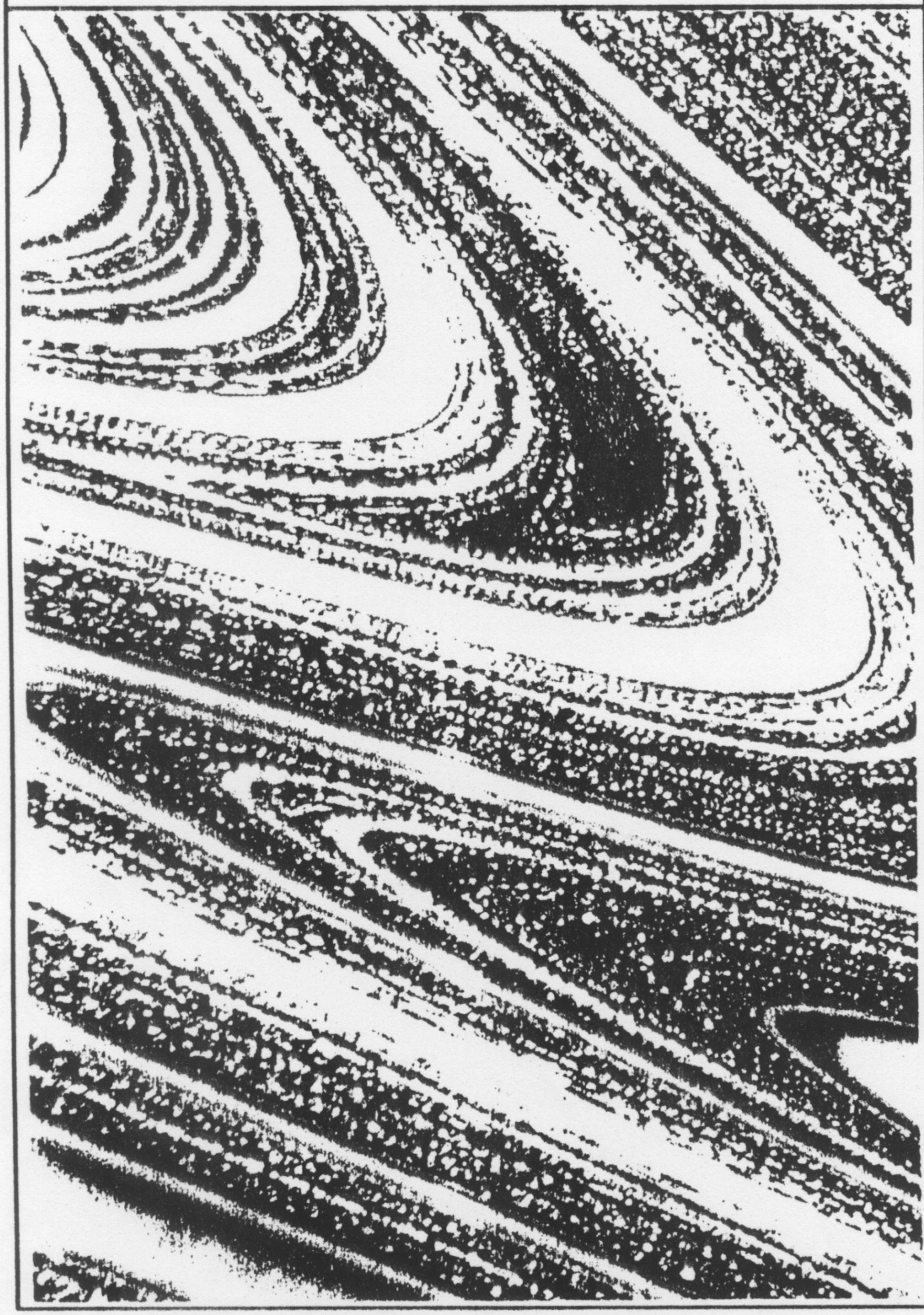
Kushelman-Kadyrov, 1985

Mark Kushelman (under the pseudonym Kadyrov), a mathematician and systems' scientist then in Moscow, put together two of these cusp models into a double-cusp model for two nations engaged in an arms race, completing the nonlinear version of Richardson's original model. It provides a map, in the two-dimensional space of sensitivities of each nation to armaments of the other, showing regions of different behaviors, such as hawks and hawks, hawks and doves, doves and hawks, and doves and doves. Surprisingly, in the north-west and south-east sectors of this map, Kushelman found oscillating behavior. This might be significant in situations of codependence or addictive behavior (Abraham, Mayer-Kress, Keith, & Koebbe, 1991). A slightly different double cusp map was used by Callahan and Sashin (1987) in the treatment of anorexia nervosa and affect-response. Some other nonlinear adaptations of Richardson's model for the arms race have been studied by Saperstein and Mayer-Kress (1988), who found chaotic behavior in their model.

Haraway, 1985

In *Manifesto for Cyborgs*, Donna Haraway (1985) analyzes the cyborg, an integral being who is part human, part machine. Without explicit reference to fractal geometry, Haraway's vision is essentially fractal. She describes three critical cases of the fractal deconstruction of a binary: human/animal, animal-human/machine, and physical/nonphysical. She extends these examples to a long list of fractured identities: self/other, mind/body, culture/nature, male/female, and so on, of political significance. This pathfinding analysis leads the way to a fractal method for the deconstruction of all binaries as well as to the reconstruction of self-images (and scientific categories) as fractal identities. Thus, she introduced fractal geometry into anthropology, beginning a transformation ongoing today. Since 1985, there has been an erodynamic explosion. (See also Eglash, 1992.)

Figure 11.1: Fractal Separatrix
Formed by coupled oscillators, and seen in Poincaré section.
(Grebogi, Ott, Varosi, & Yorke, "Fractal Basin Boundary 2," displayed at an exhibit at the Fine Arts Museum of Long Island, April 1-June 24, 1990.)



DISCHAOS: DYNAMICAL MODELS

The fractal concept introduced into anthropology by Haraway and subsequent works by Wagner, McWhinney, and Strathern are epitomized by the idea of the sandy beach. We begin the description of our model by recalling this static concept, then extending it to the dynamical model of Lewin, Thom, and Zeeman as the fractal separatrix or basin boundary (Fig. 11.1). Finally we will use the model to introduce the concept of the dischaotic personality.

The Sandy Beach

In Benoit Mandelbrot's classic text, the second chapter is titled, "How long is the coast of Britain?" We will describe the sandy beach in the two-dimensional context of a map. Thus, the ocean and the land are mostly two-dimensional. Before fractal geometry, the map showed the boundary between the ocean and the land as a smooth curve, a one-dimensional coast. But now, thanks to Mandelbrot (he gives credit to Richardson), we may zoom in on the coast and see that it has very small islands, even pebbles, in a densely packed structure. Zooming in again, we see grains of sand on the beach, and in the ocean close to the beach. All this is the coast: It has a fractal dimension. Land penetrates into the ocean in a frothy structure of sand; ocean penetrates into the land in a frothy structure of water in the wet sand. Not only is the coast a fractal, with a dimension more than one but less than two, but it is a fractal region: the coastal zone. The ocean and land are not divided by the coast in a binary fashion; they interpenetrate in a fractal geometry. The fractals of chaos theory—attractors, separatrices, and bifurcations—are all of the sandy beach variety.

Fractal Separatrices

We now make a jump to the dynamical model of Lewin (1936), who imagined the life space or psychological field of a person as the state space of a (continuous) dynamical system. The observable behaviors in this model are the attractors, and the significant regions of life space, then, are the basins of attraction of these attractors. Further, the separatrices (the boundaries of these basins) are crucial to the Lewinian view of psychology (Abraham, Abraham, & Shaw, 1990). In many important examples, these separatrices are fractal (Kennedy & Yorke, 1991; Ueda, 1992). This means that the sandy beach concept applies to the boundary between two different behavioral regions. This will be our basic model in this chapter. We should point out, however, that the improvement of the Lewinian model due to Thom and Zeeman is more complex: the attractor-basin portrait in the state space (life space of Lewin) is replaced by the response diagram, in the product of the state space and the control space of a dynamical scheme (morphogenetic field of Thom).

The Dischaotic Personality

We now assume a Lewinian dynamical model for the self or life space of an individual. Different aspects of the personality, depending critically on the individual, are represented in this model by groups of basins of attraction. These may be slowly changing in time under the effects of learning, adaptation, stimuli, and so on. Now that chaos theory and fractal geometry have emerged, we expect that fractal boundaries of these psychological regions are the rule, rather than the exception. Following the lead of chaos theoretic models in medical physiology, we may expect that chaotic attractors and fractal separatrices are important for health. Specifically, we may suggest that thick fractal separatrices in the psyche have an integrating effect. For under the effect of random or chaotic stimuli, the trajectory of the Lewinian model jumps about in small discontinuities, landing in different basins because of the fractal boundaries. This has the effect of integrating the different behaviors of the different attractors into a strongly associated or mixed personality. On the other hand, when the boundaries have become (perhaps in a pathological situation) too ordered, or *dischaotic*, or if the fractal dimension is too small, there would be a tendency to manifest one attractor for some time, until an exceptional stimulus pushes the trajectory over the edge into the basin of another aspect of the self and there is a dramatic change in behavior. Posing *dischaos/chaos* as a binary dichotomy instead of *order/disorder*, we may call this situation *personality dischaos*, rather than the more patriarchal *personality disorder*.

BATESONIAN APPLICATION

In a number of papers, Bateson anticipated the fractal and chaotic models of the psyche. Here, we consider three examples.

Logical Types

First, consider Bateson's work on logical types and communication theory (Bateson, 1972, p. 177). Each type may be viewed, in the Lewinian model, as a region of life space, a union of basins of several attractors, which enjoys some isolation from other similar regions. A message is interpreted by each category, unless it contains an identifier, or address, specifying one category as its intended destination.

Paradoxes

Next, consider Bateson's analysis of paradox, in which the meaning of a message in one category denies its meaning in another category, and vice versa. He likened this situation to a door buzzer, one of the first models of a negative feedback oscillator (Bateson, 1979, p. 65). The exemplary paradox (which is closely related to the double bind, see below) is the liars paradox ("this sentence is false"), which has recently been shown to generate a chaotic attractor in truth space (Mar & Grim, 1991). We may regard paradox as a fundamentally chaotic process.

The Double Bind

In 1952, with coworker Jay Haley at Stanford University, Bateson developed the double-bind theory of schizophrenia based on his theory of logical types, multiple levels of learning, paradoxes, and communications theory (Bateson, 1972, p. 201). The basic idea of this theory is a cycle involving two people, the dominator and the victim, in which a signal from the dominator is interpreted by the victim on two levels, and each interpretation contradicts the other. See Eglash (1992, chap. 4) for a relevant characterization of mental states in terms of fractal dimension.

In all these examples, an aspect of the individual psyche is divided into multiple levels, a normal structure. But in the pathological situation, a dynamical communication loop is set up between them, like a door buzzer: a disabling oscillation (or chaotic attractor). In our model of the normal psyche based on a dynamical system with fractally intertwined basins (the levels), a small amount of communications noise would be sufficient to stabilize the oscillation. But in a dischaotic psyche, however, the basins are separated by a clean boundary, rather than a sandy beach. Thus, in this model, dischaos is a precondition for schismogenesis, and thus, unwanted oscillations. In this picture a useful property of the psyche might be the *Wada property*: Each point on the boundary of one basin is on the boundary of all (Kennedy & Yorke, 1991). This is known to occur in the dynamical system for the forced damped pendulum. If a psyche has the Wada property, then environmental noise can effect a synthesis of all the levels into a unique self. Alternatively, periodic forcing (turning the pages of a book, for example) may suffice to restore chaos.

CONCLUSION

These examples should suffice to give an idea what chaos theory can do for the evolution of Lewinian and Batesonian models for the individual or the group psyche. This is as far as a mathematician can go; the next steps are up to the psychologists. By learning a modicum of the mathematical theory of chaotic dynamical systems and their bifurcations, one can develop new theories of dischaotic personality, and therapies too, that can spontaneously pop up. It may be, for example, that electric shocks might be replaced by computer-generated foot massage as a treatment for depression.

In future work we may use the fractal boundary model to suggest some therapies for multiple personality dischaos (MPD), bipolar personality dischaos (BPD), and other dischaos phenomena. These would utilize *forces of chaos*, such as chaotic music or exposure to nature, perhaps in a workshop setting. Further, we might try to identify some of the *forces of order*, cultural causes, or concomitants of dischaotic personality such as: urbanization, organized religion, patriarchy, monotheism, the Bible, monogamy, marriage, nuclear families, and childrearing practices.

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