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1-1-1998

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Published version. *Discrete Dynamics in Nature and Society*, Vol. 2, No. 2 (1998): 147-151. DOI. © 1998 Hindawi Publishing Corporation. This is an open access article distributed under the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Book Review

A Review of Chaos, Catastrophe, and Human Affairs: Applications of Nonlinear Dynamics to Work, Organizations, and Social Evolution by Stephen J. Guastello (Mahwah, NJ: Lawrence Erlbaum Associates, 1995, ISBN 0-8058-1634-8, pp. x + 439, author and subject indexes, \$89.95).

The Guastello–Abraham Correspondence.

Dear Steve,

What a pleasure to finally get a chance to look over your marvelous book. Despite your claim that its topics “apart from the core mathematical theories, are centered around my own work on catastrophe and chaos theory applications to human problems in industry since 1980”, it would seem to me to be useful to a much broader basin of interests in psychological and social sciences. Did you expect it to have a more general audience, or be principally of interest to those in organizational psychology? Were you concerned with issues of audience specificity?

While I am just beginning my reading, I must say I love your balance of formal concepts with informal discourse, and your interrogative style with its pleasant sense of humor. You gently but firmly state that your subject is mathematical, but digestible. Most readers should be comfortable with your providing a serious treatment that should nonetheless be tractable to serious professional psychologists and students.

In your opening chapter, enchantingly entitled “An Invitation to Chaos”, I thought you did several things superbly, stating the nature of nonlinearity, basic tenets of nonlinear dynamical

systems (NDS) theory, the nature of general systems theory, the nature of modeling and testing, the field of industrial psychology, and the range of areas in organizational psychology to which NDS applies.

Among the things I liked most was your treatment of predictability and dimensionality, and your inclusion of bifurcation, stability, and self-organization among the most important foundation ideas. The one idea that I thought could have received more emphasis in this opening chapter is that a system is comprised of interacting components whose patterns of interaction over time is what we study (Goerner, 1994; Masters, 1991). This metaprocess is so obvious that we often forget to highlight it. Obviously not only does NDS revolve around this concept, but it is also the foundation of the relevance of NDS for I/O. This interactive causality, as you later nicely develop, is reflected in systems of differential equations. I like your rapid shift from nonlinearity as curved lines to its real meaning in dynamics as these differential equations, that is, the nonlinearity as dealing with temporal features of the system.

Beautiful job!

Fred

Dear Fred,

About the audience, I imagined that people from a range of social sciences would be interested, although I/O psychologists would be near the center of the interest group because so many of the applications pertained to topics in the I/O and ergonomics area. I also wanted to push the boundaries of I/O psychology; for that matter several disciplinary boundaries could be melted or reshaped.

About “interacting components” – I did list it as point #6 on p. 3. The nature of causality as an interaction between an autonomous nonlinear process and control variables unfolds as the book progresses. I wanted to keep the primary focus on the substance of the applications. For someone who hadn’t thought of the nature of causality issue before, the type of interaction that is really taking place should become apparent by the time the end of the book is reached. At least I would hope so.

Have a great weekend on the river.

Steve

Dear Steve,

I can see your point. The sophistication you bring to I/O (Industrial/Organizational) is not only that of dynamics, but of the liberalization of basic concepts in psychology that dynamics motivates, and your synthesis of general psychology, dynamics, and I/O. Your coverage of basic dynamics (Chapter 2), modeling and testing nonlinearity (the very sane synthesis of traditional and nonlinear statistics of Chapter 3), and the synthesis of broad psychological concepts (Chapter 4 on decision-making and cognitive process; and of motivation and conflict (Chapter 5) are general even though Chapter 5 starts developing the I/O applications. These make your book important even for those of us who are not principally I/O. Your book should succeed in sophisticating the I/O audience. But I think it should be on the bookshelf of every serious student of psychology and social science as well.

More things that I especially loved. I liked your discussions of stability, bifurcation, and dimen-

sionality. Also, when you mentioned “sensitivity to initial conditions” in chaotic attractors, you point out that some of us find the emphasis overdone; some of us like to use the complimentary phrase “insensitivity to initial conditions” (Abarbanel *et al.*, 1993), although most people use “attractor invariants” to point to the stable properties of chaotic attractors (Ott *et al.*, 1994). Some authors like to emphasize that there is not just one Lyapunov exponent, but a spectrum for each attractor; chaos is the result of convergent and divergent forces, so taking ranges and ratios of Lyapunov exponents becomes important in characterizing a chaotic attractor.

A personal anecdote involves my initial assumptions about the meaning of the ‘insensitivity’ phrase before I learned what it really meant. I had assumed it meant trajectories that led to different attractors, but Paul Rapp set me straight that its usual meaning was about divergence within chaotic attractors. However, I discovered that my own interpretation, while uninformed, was exonerated through its inclusion by Ruelle (footnote 5, Chapter 8, 1991). The concept of separate basins is also suggested by the alternative phrase, “butterfly effect”.

Your own work in catastrophe theory on deriving nonlinear difference equations from data is especially important, as is your emphasis on classes and multiplicity of models. I also liked your discussion of the difficulties of traditional statistics (regression, reliability, and validity) in the face of the nonlinearity and nonstationarity of the real (nonlinear) world. I liked your acceptance of traditional statistics despite their limitations, because we too, in the nonlinear world, have to deal with appraising the different sources of influence within a system, much like traditional components of variance and other multivariate techniques, including assessing the degree of influence from high-dimensional unidentifiable sources (error/noise).

Your next three chapters (6, Stress and Human Performance; 7, Accidents and Risk Analysis; 8, Stress-Related Illness) of course justify your claim to an I/O audience, but at the same time should have appeal to other areas of human activity. Risk

and accidents are a part of everyday life, stress and illness are obviously also of interest to everyone. There is much to be learned even here by the general reader.

The next chapter (9), *The Evolution of Human Systems*, while oriented to organizational issues of game theory, spatio-temporal dynamics (urban development), population dynamics and workforce productivity, and chaoeconomics, also opens nicely with general concepts of evolution, ecology, and social Darwinism. I like the emphasis on cooperativity especially, a favorite subject of many (Combs, 1992; Choi, 1997).

As for the river, while only a few chaos-oriented friends joined in this exploration of the Missisquoi National Wildlife Refuge, in addition to proving a satisfying experience of quiet enjoyment of the beauty of nature, it provided an unsettling example of Lotka–Volterra dynamics. There proved to be an alarming biodisplacement of Great Blue Herons in their rookery by Cormorants. The change over the past two years is dramatic, and I wonder if the population dynamic is influenced by human meddling or by natural bird interactions. Choi's forthcoming article in your journal should be applied along with your Chapter 9.

Fred

Dear Fred,

You do reflect back what I was trying accomplish in CCHA; I'm glad I wasn't the only one who thought he saw what he thought he saw.

The Vermont river delta and lake sound beautiful. Remember (how could one possibly forget?), that the crest of every wave breaks at a 120 degree angle.

Steve

Dear Steve,

There were no waves on that beautiful morning, except for those made by my kayak during an occasional sprint near the end of the 6 hour paddle.

Since you imply going into the final quarter of the book, Chapters 10–12, will be like cresting a wave, I am indeed fastening the seat belt in my kayak and measuring the 120 degree angle to test your wave-bifurcation theory.

Chapter 10 on Innovation, Creativity, and Complexity is a favorite subject of mine as you know, although I have not been particularly concerned with creativity in the business setting, but more in personal domains. Yours emphasizes the evaluation of creativity, which is an important topic when trying to objectify creativity, which is necessary in research and evaluating business success; I remain in the more comfortable and less rigorous world of metaphor. But, like you, I too start my chapter with definitions. You like Simonton's for its NDS nature: "Creative solutions 'reduce mental entropy, by joining configurations together into more comprehensive hierarchical formation,' and the human intellect is programmed to self-organize its cognitions and emotions accordingly."

Your coverage of traditional viewpoints in creativity, i.e., Guilford's divergent and convergent cognition are especially relevant as those are exactly the ingredients of a chaotic attractor, which metaphorically at least, seems to characterize a lot of the creative processes implied by other traditional approaches as well (personality features, motivation and style, group dynamics in brainstorming, organizational theory, and an especially interesting aspect, social and cultural aspects of creativity). The application of elementary catastrophe theory, enhanced by your own considerable work in that area, points heavily toward the importance of the concept of bifurcation in creativity (witness my own definition: "Creativity is self-organizational bifurcation to novel attractors of being.")

Using elementary catastrophes to model such complex problems means essentially reducing the state space to one dimension, while leaving the parameter space to be multidimensional, and that is fine to approach and depict the problems, but I look forward to the expansion of the state space (cognitive/behavioral/motivational) to more easily

include chaotic attractors. Your own descriptions of the mushroom catastrophe suggest such multidimensionality, but of course it would be complicated. Perhaps a depiction of the basic model as an elementary catastrophe, and then sub-portions of the parameter space with multidimensionality of the psychological state space expanded would be of value. I look forward to such research. You set the stage nicely. I also liked your discussion of creative problem solving in groups because your stress on chaos causing creativity is a favorite idea not only of Gardner (1993), but again of mine. I further go on to say that there are optimal levels of mid-dimensional chaos that set the stage for creative bifurcations, although Gardner and I are talking of the individual rather than the group situation. I also found myself wondering if the analysis of the electronic bulletin board system data involved any of the threads on the Chaopsyc listserver of the Society for Nonlinear Dynamics in Psychology and the Life Science in which I participated. This is an exciting and well-done chapter!

Organizational Development, Chapter 11, concerns bifurcations in organizations. It is an area of intense transformation by NDS as you note. Not being familiar with this area, I will not attempt to detail it as much, but will summarize for potential readers, and you can comment on any important features I miss. You discuss the traditional approaches, especially those motivated by Lewin (1951), which as a field theorist, are rather system-oriented by nature already (bifurcations: unfreezing, change, and refreezing). Again I want to stress the importance of your book to all readers in psychological and social theory. Not only are organizational changes characteristic of all social processes, but the action research inaugurated by Lewin previews the later developments going on today in making more realistic the interaction between research and society, breaking down traditional concepts of isolated research. Witness Murphy and Abraham's chapter (1995) on feminist psychology on the relationship between NDS and feminist psychology. In the liberalizing of Lewin's

concepts with the unfolding of modern NDS, you and Michaels do a great service in pointing out that chaotic attractors before and after bifurcations represent stability. Thus organizations go through bifurcation sequences of stability, instability, and stability, and that furthermore, this is a self-organizational process.

The discussion of "Can organizational culture be changed?" is especially critical and interesting. This and the discussion of evolutionary versus revolutionary change again remind us of the generalizability of NDS beyond the world of organizational development. The specific examples of research on "Chaos in the production lines" and "Creative problem solving in an interdisciplinary team" provide beacons of clarity in research for others to follow as our field becomes increasingly research oriented. We all owe you a debt of gratitude for collecting so much information in one volume.

Chaos, Revolution, and War, Chapter 12, are the ultimate concern of psycho-social scientists, and the ultimate expansion of the important consideration of dynamical theorists. There is even a society dedicated to this attempt, GERG, formed by Laszlo (1993). It has interested me because as a lover of the nonlinear approach-avoidance model, I like to think that model should be used in this arena. One great importance of your chapter is in reviewing the many different approaches being made in NDS to this problem. So far, these many efforts have been largely isolated from each other, despite the emphasis on the metalanguage of NDS as a force to increase communication among social scientists (Gilgen, 1995; Tryon, 1995).

It is interesting to observe that of the many who used the term chaos in international affairs before it had any technical mathematical meaning, Woodcock (1974) later became a major mathematical theorist of the Zeeman catastrophe school. I recently met him at a WESS gathering in the DC area where he is now living, and discovered these earlier interests of his as well. Your perspective on revolutions, war, internal national security, and political cooperation and the specific models of them were helpful to me, as were your extensions to

world economics and ecology (Meadows *et al.*, 1972, a NDS effort and another product of Laszlo's unbounding energy in directing NDS to tackle world-wide critical issues with his Club of Rome). Raising the issue of the onset of world government is a great concluding issue, and it raises the question of individual liberties, cultural diversity, conformity and diversity, and concludes very aptly with a discussion of an end to war:

"And where there is chaos, there is hope."

And at the end of your summary in the epilogue:

"Perhaps the theories, models, and experiments that have been drawn together here will joggle a few useful thoughts in that direction."

"THE BEGINNING" (instead of "The End".)

I like your dedication to the promise of social change for the improvement of humanity, and look forward to the coming bifurcations that reveal the trajectories of its unfolding.

Nice job. You are both helping sophisticate the field and motivating change in science and society.

Chaoharmonically, Fred

Dear Fred,

At the point where you mention the derivation of the polynomial regression equations for the catastrophe model, please add, that the chapter also includes statistical models for capturing the Lyapunov exponent and dimension, which is a test for chaos. We can now separate the chaos from the noise.

Steve

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