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# Commentary on Paradigms and Key Word Index for *NDPLS* Articles 1997-2006

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***Abstract:*** *Although a paradigm shift in the sense of a postmodern worldview might be taking shape in society at large, the core concepts of nonlinear science date back a century, and are only tangentially influenced by other intellectual developments. Relative to contemporary science it offers new concepts concerning events that transpire over time, new hypotheses, new methods for answering new questions, some efficient answers, and a new perspective for understanding what we do not know in addition to knowing how we know what we know. Paradoxically, nonlinear science can be viewed as a narrow specialty within a specific discipline and as a general systems theory that identifies common themes that underlie phenomena found in a wide range of disciplines and specialties. The key word index illustrates the breadth of concepts and applications found in NDPLS, and some pathways for continued growth of the field.*

**Key Words:** nonlinear dynamics, psychology, biology, economics, simulation, paradigm

The *NDPLS* Editorial Board and I hope that the topics concerning paradigms that we have assembled on the occasion of our 10th anniversary issue provided a thought-provoking experience at the very least. I am enclosing a few remarks that are based on what our colleagues have written with the intention of identifying any subtle implications for editorial directions.

## A DIFFERENT RIVER

Dynamicists often say to each other that, "You can't step into the same river twice." If any paradigm shifts are taking place today, it would

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be very unlikely that they would be the same as those that were produced during the Renaissance. Rather we can probably expect a new kind of science, as Wolfram (2002) might have phrased it, or a new kind of something else.

During the last major shift in worldview, science – in the most general sense of an approach to gathering knowledge about the world – broke off from other fundamentally different ways of thinking and from the surrounding social institutions, which were under relatively monopolistic control. Psychology was the first of the social sciences to separate from philosophy when Wundt established the first psychological laboratory in 1879. Early psychological theory was built on philosophical develop-ments that seemed relevant at the time, and it too developed paradigms within – structuralism, functionalism, behaviorism, psychoanalysis, and a distinctive theory of mental measurement. These paradigms of psycho-logical thinking were all distinct at first, but they later combined in various ways to liberate new approaches for the study of phenomena that were always of interest.

All the sciences differentiated into specialties and subspecialties during the last century, as did other non-science institutions. Political parties in many countries are more fragmented than they are in the U.S., where, barring rare circumstances, over 90% of the presidential votes are cast for a candidate from one of the two major political parties (a duopoly). Henwood (1994) reported that about 86% of adults in a national survey in the U.S. self-identified as either Catholic (26%) or any of 39 varieties of "Christian" or "Protestant" (60%). In light of the level of splintering in political and religious thinking and the paradoxical level of homogeneity involved, it would thus follow that coalitions would form to enhance political and social influence.

To make things more interesting, the non-science portions of society use many more products of science today than there ever were available during the Renaissance. The forces of anti-science 500 years ago could probably remain smug in knowing that science had not cured any of their ancestors of the black plague, alleviated their migraine headaches, driven them to work with combustion engines, blasted their favorite madrigals over the radio, or cleaned their flush toilets with antibacterial agents. In other words, the basis of anyone's complaints in a contemporary war of worldviews has to involve different and more specific targets while preserving the convenience afforded by other potential targets.

By the 1950s we saw the first vestiges of general systems theory – scientific principles that transcend the given disciplinary boundaries

(Bausch, 2001). In this regard nonlinear dynamical systems (NDS) theory was just another example (Guastello, 1995), although as time wore on, the depth and breath of its concepts made it a distinctive example that continues to thrive. In any case, if there are any paradigm shifts of Renaissance proportions taking place, it would appear that it might be in the form of post-modern thinking itself and not NDS specifically. Anything that could be said today about Renaissance thought is done with the benefit of several hundred years of elapsed time. Anything that could be said today about contemporary transitions in thinking must be made with the qualification that the transitions are probably not finished yet.

## WHAT ABOUT NDS?

It seems reasonable to make a case that NDS is a paradigm of science, within the boundaries of science, if it is not also a paradigm of a larger world view. First, we should not become overly preoccupied with its principles of system connectedness at the expense of forgetting the basics – attractors, bifurcations, chaos, fractals, self-organization, catastrophes, and so on. These concepts have given us new ways to explore and reflect upon how events change over time. It is fundamental that we now know that there are many possible patterns of change, that we have a language to describe them, and we have methodologies to isolate and identify them. Before basic NDS, change was understood in the social sciences as only one amorphous entity – change.

It is also historically important, in my opinion, that two of our most central concepts, chaos and fractals, originated about a century ago when aviation was in its infancy and the very first papers on rocket science, not to mention the Theory of Relativity, were being published and discussed. In our travels we picked up nonlinear topology, information and entropy concepts, catastrophes, and self-organization; by the mid-1980s had begun to see *formal* connections among all these systems phenomena. Given the time horizon involved, it is doubtful that post-modern philosophy can claim with a straight face any more credit for the scientific developments than perhaps generating a little more interest than what would have been the case otherwise. It is also doubtful that any philosophical genre could claim more credit than any other genre for having discovered creativity itself.

For the majority of contributions of NDS to a theory about *something* there are examples of a pre-NDS theory that could have handled the time, emergence, and probably other issues, better than they did. In other cases, there was no pre-NDS theory at all. Paradoxically, we

have a broad-range general systems theory and the risk of being misperceived as a random collection of odd-ball studies by readers who are only exposed to a few of the NDS studies that show up in particular mainstream journals. Those who have had a chance to follow the NDS contributions through an entire discipline such as psychology, neuroscience, *or* economics might come away with the idea that NDS is a one more reasonable subspecialty of a particular discipline. A different picture comes into focus, however, if we change *or* to *and* in the previous sentence.

The paper about coordination (Guastello & Bond, 2007) in this issue underscores the point that neither its specific hypotheses nor the more basic premise that different forms of coordination exist proceeded from conventional thinking on coordination in work groups. In other words, we have new concepts, theories about phenomena, and specialized means of testing them. The methodology is indeed developing, somewhat in response to the types of applications that substantive researchers are now bringing forward (Elliott & Kiel, 2004; Gregson & Guastello, 2005; Guastello & Gregson, 2006). In studies where it has been possible to compare the accuracy of nonlinear and linear models, and the nonlinear model was adopted as the conclusion, the average ratio of variance accounted for was 2:1 in favor of the nonlinear model (Guastello, 1995, 2002). This is obviously a utilitarian criterion of success, and it should not be interpreted as the only criterion; understanding phenomena matters also.

NDS ideas are worldwide in their origin and distribution. Although Gleick (1987) and Waldrop (1992) highlight the important role played by the Santa Fe Institute, there were many points of origin for NDS contributions in Europe, Russia, and elsewhere in the US and Canada. NDS continues to be a worldwide effort and not merely a local phenomenon. This journal has subscribers in over 30 countries at the time of this writing.

The complexity aspects of NDS tell us a great deal about what we do not know about a situation and why. For that reason, simulation techniques have evolved that allow the researchers to study complex phenomena and gauge the range of possible system outcomes on the basis of what-if scenarios. Like other types of expert systems, they are subject to limitations of internal and external validity. In the category of internal validity: Are their rule structures based on knowledge about a system that has actually been verified empirically, or are they all guesswork? Are the numeric values for the critical parameters similar to those that occur in the real world? In the broader spectrum of expert

systems and artificial life, there are some viable strategies for experimental design that could answer these questions (Guastello, 2006; Guastello & Rieke, 1994; Nolfi & Floreano, 2000). This may be a good time for someone to examine progress on these matters.

A central goal of the new kind of science, according to Wolfram (2002), was to identify some simple programmable logic structures that can produce a complex array of outcomes. Indeed some of those functions were found along with applications for them. The idea behind these logic structures is not radically removed from the principle of deterministic chaos – seemingly random events are actually ordered and describable by simple deterministic functions, and small differences in initial conditions can have can a great impact on the system's behavior.

Chaos brings us to another paradox. On the one hand there has been considerable rationale to support a hypothesis of chaos in one situation or another. On the other hand, there have been some difficulties in actually finding it. It is very possible that the practical manifestations of chaos that could be evident in biological or social science data are going to deviate somewhat from the ideal forms of chaos that are generated from numerical runs from mathematically-defined attractors. The case for developing methods that can finesse non-Gaussian noise and transient instabilities has already been made (Gregson & Guastello, 2005) along with progress on these matters. Progress has also been made toward putting an end to the Myth of the Million Data Points, which says, in essence, that we need a phenomenal number of data points to be able to test any hypotheses about dynamics. Nonetheless, we should be prepared to see the myth persist wherever it is convenient for some entity to ignore nonlinear science on the grounds that it is somehow impossible to test in the real world. It is not impossible.

## ETHICS

The ethical concerns that were raised by Fleener and Merritt (2007) concerning the misappropriation of science or its methodology have not yet involved, to my knowledge, any issues that are unique to nonlinear science. There is nothing in the public forum to suggest that our standards and procedures for scientific quality assurance should be any different from what they are now.

Most nonlinear scientists probably anticipate that our scientific works will have a positive impact on social welfare and not a negative one. Misappropriation and confusion by others is not unthinkable, however, and philosophers are exploring the possible scenarios (DeRisio & Orsucci, 2004). There will probably be more than two sides to any

issue of public importance. Some corporations would want to preserve their current markets and products, while other corporations would like to divert some of the cash flow to their own services and products. Then there is the medical-insurance complex who would like to reduce various kinds of risks as much as possible, and the informed citizens who would like to make their own choices and not be told what to do by government or industry any more than necessary. The perception of risk is relative to a culture and to the full scope of large and small problems that the culture needs to worry about (Douglas & Wildavsky, 1982). And yes, corporations are part of the complex of social institutions that did not exist in any meaningful numbers 500 years ago.

## KEY WORD INDEX

After some quick time travel to the Renaissance and into thinkable and unthinkable futures, we return to the concrete present tense. This index of key words was compiled as an aid to our readers and authors. It provides a concise list of the topics that we have covered thus far. Since the last iteration of the index (Guastello & Gunderson, 2004), many new index terms have appeared, and many have become more dense with entries. Hopefully, this index will add some clarity to the understanding of our paradoxical nature as a general systems theory and a specialty topic. One can only connect the proverbial dots to see how far the field has expanded and the regions of expected new growth.

The index was compiled from key words that were supplied by the authors. The lexicon was then condensed to ignore singular versus plural forms of the same word and few other trivial differences. In a few cases, the index words were restated or reorganized into first-level and second-level index terms. The most notable example was the re-organization of the topics that are currently listed under the first-level heading of *affect*. Articles that were associated with some key words were combined with articles that were associated synonyms that were more commonly used. Entries for each key word are formatted as [journal volume]:[page range]. Multiple articles for a key word are separated by a comma and listed in chronological order of their publication.

Thus we now present the index of the first ten years of *NDPLS'* publication. The book reviews dating back to 1997 have also been indexed in this edition using the key words already available to the greatest extent possible. Future editions of this index will appear on the journal's web site, www.societyforchaostheory.org/ndpls/; select Indexes and Citations from the menu.

## KEY WORD: V:PP

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