

*Dedicated to the development of  
nonlinear science worldwide  
since 1991*

**Abstracts to the  
2nd International Nonlinear  
Science Conference,  
Heraklion, Crete, Greece**

**2006**



## Messages from the SCTPLS President and the INSC Conference Chair\*

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Welcome to the 2<sup>nd</sup> International Nonlinear Sciences Conference. This conference has been organized by the Society for Chaos Theory in Psychology and Life Sciences in conjunction with the Società Italiana Caos e Complessità. The event reflects a commitment on the part of our organizations to facilitate international collaboration and to encourage the cultivation of scientific partnerships across the globe. We are able to offer you a rich and varied program, covering a wide range of scholarly disciplines including theoretical as well as applied approaches. It attests to the international character of our scholarly community that we have presenters from many countries to share their work in nonlinear dynamics, including scholars from the U.S., Eastern and Western Europe as well as Asia. We hope that this conference will become part of a long-standing tradition of international scholarly exchange, which surely will strengthen our nonlinear dynamical systems community, and the impact of our work, in the long run.



*Matthijs Koopmans, Ed. D.*

President

Society for Chaos Theory and Life Sciences

<http://www.societyforchaostheory.org>

Dear Conference Participants,

I would like to extend a warm welcome to the 2<sup>nd</sup> International Nonlinear Sciences Conference of 2006 on behalf of the scientific and conference committees. This year we are gathering at the Foundation for Research & Technology (Forth) in Hellas, Heraklion, Crete, Greece. As a *place* to gather **-FORTH-** affords participants the opportunity to experience a scholarly self-organized and emergent environment. As a *destination*, it is the world scientific canvas for the 2<sup>nd</sup> INSC of 2006. We trust that you will find the conference presentations insightful and energizing. Nonlinear sciences play an important role in the development of models and applications at all levels of educational and clinical practice. Thus, it is our hope, that you enjoy the conference and find the scholarly exchanges and our wonderful venue inspiring.



*Ivelisse Lazzarini, OTD, PhD*

Chair, 2<sup>nd</sup> INSC 2006

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## KEYNOTE SPEAKERS

(Abstracts Appear at the End of This Document)

***Peter M. Allen, PhD***

Professor of Evolutionary Complex Systems  
Head of Complex Systems Management Centre  
Cranfield University, School of Management  
Cranfield, England

***\*Complexity: the Challenge of a co-evolving  
Epistemology and Ontology\****

***Tassos Bountis, PhD***

Professor of Mathematics  
Center for Research and Applications of Nonlinear Systems  
University of Patras, Greece

***\*The New Science of Complexity: Promises and  
Challenges for the 21st Century\****

***Stephen J. Guastello, PhD***

Professor of Psychology  
Editor in Chief of the journal, *Nonlinear Dynamics, Psychology, and Life Sciences*  
Marquette University, Milwaukee, USA

***\*Leadership Emergence in Coordination-Intensive,  
Creative Problem Solving, and Production Groups\****

***Wolfgang Tschacher, PhD***

Professor of Clinical Psychology  
Universitätsklinik für Sozial- und Gemeindepsychiatrie  
University of Bern, Germany

***\*Self-Organization of Cognition\****

# ABSTRACTS

## Phase Portrait of Cell Membrane Passive Depolarization

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Shall a persistent blockage of the ionic pumps bring the cell membrane voltage to zero? This apparently trivial question of basic cellular Biology stirred up an intriguing problem of nonlinear dynamics. A 3-ion model based on continuity and charge conservation, suggests that the membrane voltage actually approaches negative values, meaning that chemical equilibrium is never reached. As such, at least in theory, repolarization always should be possible independently of how close the voltage is to its asymptotic value. For a typical isolated cell electrochemical equilibrium is reached through an inversion of the  $\text{Na}^+$  concentration gradient. For an inactive cell this inversion occurs hours after the blockage of the pumps. With data for the squid nerve cell and the cat spinal neuron, the inversion occurs from 32 hours (squid) to 8 hours (cat) past the blockage of the pumps. Thereafter all Nernst potentials run negative, and so does the membrane voltage. The asymptotic values of the ionic concentrations vary with the type of cell but are independent of the electrical parameters of the membrane. In the 3D space of the ionic concentrations the depolarization process reveals an intriguing, non-intuitive topological structure: i) trajectories starting from points lying on a plane run on the same plane, and end at the same fixed point; ii) for each plane there is a unique fixed point, which acts as a global attractor for all trajectories in the plane; iii) all trajectories in a plane merge, on their way to equilibrium, into a common escape route, which is to be interpreted as an infinitely dense set of trajectories; iv) as a result of time-reversal symmetry, backward trajectories initiating in the escape route land at unpredictable points, either in the upper or in the lower half of the plane. This last feature is particularly interesting as it reveals the system's potentially high sensitivity to initial conditions, which would affect repolarization near equilibrium: the later the repolarization the more uncertain the return to the same initial conditions. If passive depolarization involves many cells in close proximity to each other, like in a neuronal module, the external ionic concentrations vary in time to an extent, which depends on the volume fraction. When a suitable correction factor is entered in the model, the  $\text{Na}^+$  inversion times reduce considerably.

Thus, for a volume fraction of 25%, the inversion times reduce by 60-70%, with asymptotic values of membrane voltage being more negative. Unlike the case of an isolated cell, trajectories are no longer planar. Near equilibrium, however, the phase portrait still shows an escape route, but now 3D trajectories also merge in the common tract, which increases the degree of irreversibility accompanying near-equilibrium repolarization.

## Nonlinear Dynamics and Belief Systems

*Arahovitis, Ioannis*

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Ben Goertzel in [2] discusses the possibility of considering a particular human belief system as an attractor of a "cognitive equation of motion" discussed in [3] and he poses the question: if one is to declare that belief systems are attractors, one must specify: attractors of what dynamical system? In the sequel we are proposed to find attractors for some particular human belief systems, by searching for their appropriate dynamical system. The resulting dynamical systems are nonlinear ODE systems or IFS treated with the Random Iteration Algorithm of [1] and describing people having phalocratic beliefs, people always acting under a "square logic" (no EQ) people evolving optimistically or pessimistically, as well as a conspiratorial belief system and another one describing the social phenomenon of vendetta. The present note aims, for educational reasons, at the approaching of Psychology to Nonlinear Dynamics and the Mathematics of Chaos and Fractals.

## Evolution of Utility Theory for Heterogeneous Interaction and Coordination in Terms of Discrete Choice Models

*Aruka, Yuji*

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Social interaction and coordination between heterogeneous agents is a process of mutual

interdependent communication for better or worse. Utility of each agent is always affected not only by his own specific attribute and other behaviors but also by subgroup of characteristics to which each belongs. In such an environment, the neoclassical utility theory does not work. There may be found a certain prospect to correct the concept of utility. We, on one hand, describe an adoption of discrete choice model under uncertainty and sequential choice. On the other hand, we suggest an adoption of master equation as the method of socio-dynamics. In this paper, we are interested in an attempt to integrate both a utility based prediction and socio-dynamics by means of discrete choice model and master equation approach. This way of integration could successfully depict a complex evolving dynamics of human nature and societies. The multinomial logit model is now quite popular in the field of traffic or transport problems. In the context of socio-dynamics pioneered by Weidlich, Helbing (1995) in particular, favored to replace the transition rates in their socio-dynamical master equation with the multinomial logit type utility. This approach may remarkably improve our applied skills of economics to develop socio-dynamics in Schumpeterian context.

**The Necessity for Incorporating Nonlinear Teaching Practices and New Technologies in the Lab Environment: A Critical Approach on Recent Studies**  
*Athanasopoulos, Evangelos*  
School of Pedagogical and Technical Education  
Greek Open University

The purpose of this paper is to examine the hypothesis that nonlinear integration of new interactive multimedia and the use of the internet in the lab environment improve in depth student comprehension and motivation. Nonlinearity is one of the basic traits of interactive multimedia and all hypermedia-learning environments such as web-based hypermedia environments accessed via the internet. The traditional approach in educational laboratories follows highly structured and predetermined teaching sequences, in other words “linear instruction” which consists of presenting skills, formulas, techniques and other details, one by one, in a sequential and orderly “single-path” progression leading to a conclusion. The traditional approach was fostered mainly for two purposes. Firstly, teachers tend to teach what they can teach, not necessarily what they think it would be useful to teach. This is what Osborne calls technological determinism “that which we do teach is limited by that which we can teach” (Osborne, 1990, pp. 193). Second, for control purposes, to be able to control larger groups of students in the lab with less wasted materials within the specified time constraints. Research has shown that

these approaches do not meet learners’ expectations considering the variety of abilities, interests and cognitive styles. They do not enhance students’ comprehension and motivation and they do not promote social interaction among peers. Nonlinear instruction on the other hand, is a gestalt in which learners initially comprehend the whole, rather than the parts. Once viewers grasp the whole, they are able to identify details and relationships among the parts. The learners are challenged to see relationships, to discriminate important ideas from less essential ones, to sequence and organize facts, to make comparisons, and to draw logical conclusions based upon sound inductive and deductive reasoning (Khalifa, 1993). Nonlinear teaching originates from recent advances of nonlinear science and its application to cognitive psychology. Learning is viewed as a nonlinear and self-organized process that is dynamic in nature rather than linear one such as preset and predetermined algorithmic procedure. Several studies (Khalifa, 1993; Novak, 2003) have shown encouraging results, when applying nonlinear instructions to traditional non-lab oriented classes. Today, a growing number of educators and researchers alike believe that interactive multimedia and the internet combined with nonlinear instruction elevate self-confidence and social skills especially when combined with cooperative learning practices. Scientific discovery on the other hand is based on nonlinear research and teamwork that is challenging and requires in depth comprehension on many levels. In a similar fashion, students must be stimulated and allowed to think creatively in groups in order to discover science, and learn to take into account the relationship of the parts to the whole. Although much more research still needs to be done on the critical and practical frameworks regarding the integration of nonlinear interactive multimedia and the use of the internet in the lab environment, sufficient evidence exists in relevant training environments that can be highlighted and contextualized accordingly.

**Abnormal Release of Dangerous Gases and Vapors in LNG Plants in Qatar**  
*Badr, Osama, Al-Jamal, Basim and Marafi, Abdel-Hamid*  
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Qatar, one of the Gulf States, possesses one of the world’s largest non-associated gas fields. LNG plants, thus, represent a major source of the national income. The main objective of this paper is to study the environmental impact due to abnormal releases of toxic and flammable gases and vapors within such plants. Hazardous zones due to toxicity, flammability, and

thermal radiation from subsequent fires are being considered. Software based on EPA-developed dispersion models was utilized to estimate the size and location of the toxic and flammable clouds at different elapsed times from the start of the accident. The growth and decay of the formed dangerous zones with respect to time were also obtained showing them in downwind, crosswind, and vertical directions. The paper considers three case studies. The first case involved the formation of an LNG pool due to a rupture in the delivery system containing a pipe connecting the production line to the storage tank. The second case considered a full depressurization of the plant; a situation in which the entire flow of incoming sour gas is flared. The third case considered the abnormal situation of flaring of acid gas (H<sub>2</sub>S-rich). For the first case study, non-linear mathematical models were developed to evaluate the transient LNG pool size and temperature as well as evaporation rate. For such a case the rupture of a pipe downstream of the production line, produced toxic and flammable zones with maximum size of 2310 m and 755 m in the downwind direction and 45 m and 18 m in the vertical direction, respectively. The rupture of a storage tank, on the other hand, produced an extremely hazardous situation with toxic and flammable zones with maximum size of 38 km and 16 km in the downwind direction and 35 m and 20 m in the vertical direction, respectively. If such LNG pools catch fire, zones with thermal radiation levels exceeding the allowable values of 5.05 kW/m<sup>2</sup> extended to 1300m from the fire edge. Fire fighting people with proper clothing that stand up to 31.5 kW/m<sup>2</sup> can not come closer than 700 m from the fire edge. For the second case study of full depressurization of the incoming sour gas, flaring of the gas forms a flammable zone extending to 200 m. If ignited, this may create a shock wave hitting the LNG plant facility. For the third case study of abnormal acid gas release, ignited and unignited flares produced both toxic and or flammable zones that depend on the stack height. The results mentioned earlier were imported automatically to the Qatar GIS system in order to show the important landmarks affected by the accident.

### **Quasi-Diffusion Model of Population Community**

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By methods of qualitative theory of ODE and theory bifurcations [2, 8, 10, 11 et. al.] we analyze the model dynamics of the community consisting of “predator-prey” and “prey” systems interacted by prey inter-migrations; we suppose that Allee effect is incorporated in each prey population. We show that the model

community persists with parameter values for which any “separate” population system can go to extinction. We investigate the dynamics of coexistence, in particular, showed that the model community can either exist in steady state or with oscillations, or get to extinction dependently on initial densities.

### **Spike Propagation as Traveling Waves in the FitzHugh Model with Cross-Diffusion**

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We utilize a modified version of the Fitzhugh-Nagumo equations to model the spatial propagation of neuron firing assuming that this propagation is (at least, partially) caused by the cross-diffusion connection between the potential and recovery variables. We analyze parametric conditions of arising and spread a neuron firing along a nerve- space, specially, revealing the dependence between cross-diffusion coefficient  $D$  and velocity of its propagation  $C$ . A neuron firing corresponds to a traveling wave solution (impulse) in frame of the model. We studied the wave system of the cross-diffusion model and explored its bifurcation diagram. We have shown that the cross-diffusion model possesses a large set of traveling wave solutions; besides giving rise to the typical fast traveling wave solution exhibited in the diffusion Fitzhugh-Nagumo equations, it also gives rise to a slow traveling wave solution. The domains of existence of the fast and slow waves in the parametric space ( $D, C$ ) are separated by a parabolic boundary,  $D=KC^2$ . After the intersection of this boundary, due to very large of the cross-diffusion coefficient or too small speed, a normal propagation of the nerve impulse is impossible and some violations are inevitable: nerve impulses propagate with decreasing amplitude or as damping oscillations. It means that if the speed of transmission of a signal along the axon is reduced, then the normal neuron firing propagation in the form of a traveling spike is impossible. The increase of the cross-diffusion coefficient beyond the normal value implied the same result.



### **Evolving robot's behavior by using CNNs**

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This paper deals with a new kind of robotic control, based on Chua's nonlinear circuit called Cellular Neural Networks (CNNs). A CNN is a net of coupled circuits, connected in a grid structure, which inherits its features and properties from the well known Artificial Neural Network and Cellular Automata. It has been demonstrated that CNNs are able of universal computation, many cognitive processes such as pattern recognition, features extraction, image processing, and mathematical simulations of nonlinear equations such as Navier-Stokes equations, reaction-diffusion equations, and so on. Using an approach like Evolutionary Robotics, we evolved, instead of Neural Networks, CNNs by using Genetic Algorithms (GAs), for controlling the behavior of a hexapod robot in a simulated environment. We developed a Java3D software in which it is possible to run real physics simulations of virtual worlds, populated by robots that can be easily created with this program. A module for evolving the robot's behavior by GAs has been developed. Furthermore, many advanced sensors and actuators complete the evolution of the robot's behavior. The evolved behavior of our robots is very similar to that of real insects, and we analyzed the pathways these agents perform in the simulated environment.

### **Neural Sensitisation and Progression of Affective Disorders Modelled by Nonlinear Feedback Systems with Noise.**

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Karlheinz Huber, Martin T. Huber**  
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Electrophysiological recordings from hypothalamic neurons have elucidated that neuronal responses to a given stimulus can drastically change in the presence of another stimulus. Similar effects are known from systemic functions including autonomous progression e.g. in addition or mood disorders. For a better understanding of the underlying mechanisms we have used a generalized modelling approach which can be seen as a combination of diverse nonlinear, positive and negative feedback loops with different activation levels and time delays. This model can be adapted to neural as well as systemic dynamics and exhibit a manifold of bifurcations between different dynamic states, including clearly chaotic regimes. We can demonstrate general principles of mutual sensitisation, e.g. modifications of

tuning curves which can account for neural or systems' sensitisation by the broadening or shifts of the range of responsiveness, and even can lead to an inversion of the response (see <http://arxiv.org/abs/q-bio.NC/0509028>). We will emphasize on functionally relevant consequences of cooperative effects between noise and nonlinear dynamics which especially can be seen near the thresholds of the subsystems and at the bifurcations to chaos (see Braun et al, FNL 4, L207-L217, 2004). Additionally, we will give examples of specific functions which, at the neuronal level, shall focus on highly nonlinear alcohol effects (Wollweber et al. *J Thermal Biol* 29, 345-350, 2004) and, at the systemic level, on autonomous progression of affective disorders (e.g. Huber et al. *Neuropsychopharmacology*, 28: S13-S20, 2003). Supported by the European Union through the Network of Excellence BioSim, Contract No. LSHB-CT-2004-005137

### **Chaotic Footloose Capital**

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The Footloose Capital (FC) model is the analytically most tractable variant of the influential Core-Periphery model (Krugman, 1991, JPE). The FC model involves two regions, each with a monopolistically competitive manufacturing sector and a perfectly competitive agricultural sector. There are two factors of production. Labor is used in both sectors. Capital is used only in manufacturing. Workers are immobile between regions but instantaneously mobile between sectors within a region. A key feature of the FC model is that physical capital is mobile between regions but capital owners are completely immobile and they spend all their earnings in the region in which they live. The repatriation of capital earnings accounts for the greater analytical tractability of the FC model. Since production changes brought about by the movement of capital are not accompanied by expenditure switching, the demand-linked circular causality that features in the Core-Periphery model does not arise. Furthermore, since costs-of-living are irrelevant to the production location decisions of capitalists, the cost-linked circular causality of the Core-Periphery model is eliminated. Currie and Kubin (JEBO, forthcoming) shows that reformulating the standard continuous-time symmetric Core-Periphery (CP) model

in discrete time has profound implications for its dynamical behavior. In this paper, we reformulate the FC model in discrete time. We explore not only the complex dynamical behavior for the case of symmetric regions, where each region has the same number of workers and where the owners of half the capital are located in each region, but also the dynamical implications of regional asymmetries.

**Analysis of Physiologic Time Series: Fractal, Complexity and Time Irreversibility Measures**

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Physiologic processes are regulated by control mechanisms that operate on multiple time scales. The time series generated by these processes are nonlinear, non-stationary and non-equilibrium in nature. However, conventional tools for the analysis of physiologic time series, such as analysis of means, standard deviations and other features of histograms, along with Fourier power spectrum analysis, assume linearity, stationarity, and equilibrium-like conditions. Consequently, these techniques do not fully characterize the dynamics of physiologic systems. In recent years, we have developed several new algorithms aimed at quantifying different properties of complex physiologic fluctuations. Here, we discuss the detrended fluctuation analysis, the multiscale entropy and the multiscale time irreversibility methods. Detrended fluctuation analysis characterizes the fractal properties of non-stationary signals. The multiscale entropy and time irreversibility methods quantify the degree of irregularity and the degree of time irreversibility of a time series over multiple scales, respectively. These methods were applied to the analysis of time series generated by several physiologic systems of healthy subjects and patients with different types of pathology. In this talk, I discuss applications of the three complementary methods to the characterization of heart rate dynamics of healthy subjects, patients with heart failure and subjects with atrial fibrillation, under free-running conditions. The results consistently indicate that (i) the output of healthy dynamics, which have highest functionality and adaptability, are the most complex and time irreversible and, that (ii) aging and disease lead to the degradation of the overall system's complexity. Finally, we discuss the implications of our results for modeling the cardiac dynamics and the limitations of these methods.

**Title Stabilization of chaotic dynamic in micro-economical model of competing firms**

*Davidich, Maria and Loskutov, Aleksandr*

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We propose a method, which allows realizing the stabilization of chaotic dynamic in a simple micro-economical model of competing firms. Our model consists of two firms competing on the same market of goods. The firms perform active and asymmetric investment strategies, i.e. their temporary investments depend on their relative positions on the market. Under certain parameter values the given model exhibits the properties of dynamical chaos that consists of continuous power spectrum and positiveness of Lyapunov exponents. We show that by means of weak external direct parametric excitations it is possible to suppress chaos and stabilize the prescribed periodical orbits. As control parameters we choose such values that describe the investment values of both firms. With economical point of view this means, that we may realize a quite simple control and present a way of increasing profit.

**Walking Straight and Walking Crooked: Mythic Apperceptions of Complexity**

*De Chiantis, Cheryl, Ph.D.*

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Hephaistos, the divine blacksmith, is the Greek god of technology (in Greek, *techne*). As the mythic emblem of *techne*, Hephaistos represents the branch of knowledge that the Greeks described as quantifiable, replicable and linear. Plato introduced the metaphor of those who walk with an unimpaired, straight gait to represent the linearity of classical logic that still confers legitimacy upon ideas in Western culture. Yet, Hephaistos, the only Olympian god who was said to be a cripple walks in a crooked, irregular gait. Close examination of his myth and related Mediterranean myths of technology reveals that Hephaistos also possesses the quality the Greeks called *metis*. This includes the traits of resourcefulness, subtlety and deceptiveness, and the situational characteristics of transience, ambiguity, and resistance to precise measurement or exact description. The quality of *metis* is only possessed by certain mythic figures, particularly those associated with metallurgy and knowledge of the forge. Myths remain alive because they emanate from unconscious apperceptions of human

and natural systems. This paper will examine the image of the god whose very gait may be said to resemble irregular periodicity traced around a strange attractor. Thus, the ancient god Hephaistos may be seen to present an archetypal image of both mythic knowing as a human cognitive mode, and its applications to understanding and describing complexity and chaos.

### **A Systems-Based Approach to Management**

*Draman, Rexford*

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It has been said that organizations function perfectly. They are structured and organized (italics added for emphasis) just right to get the results they get. Like any system, its outputs (both volume and variety) are determined by its inputs, structure, and processes. If we accept this as truth, and we also recognize that most, if not all, organizations continually face the struggle to attain some level of sustainable success, then the logical conclusion one can draw is that they (organizations) need to change either their structure and / or organization if they desire to achieve some form of sustainable success. Using this as a starting point, I have synthesized the following new systems-based business model from the wide variety of systemic tools and practices currently available. This model more realistically reflects the world, as we understand it today, which is not the Newtonian world that existed when today's business practices were established. Given the known issues with the traditional business practices, I chose to start over with a clean slate and use what we know about a living system (processes, resources, information, and goal) as a framework. I then translated the requisite conditions for a living system, into what reflects the necessary conditions for a living (sustainable) business system (functions & activities, inputs, organizational knowledge, and goal). From this perspective, profit is recognized as the results of the system's effectiveness and therefore not its goal. With a model defined, the next step involved identifying an initial set of systems-based business tools to be included in the model. Among these, I have included the Theory of Constraints for overseeing the value-adding processes, Requisite Organization for assisting in the people side, 2nd generation knowledge management for the flow of information, along with a variety of thinking and problem-solving tools and practices. As in all well-working systems, each of these components must have the ability and desire to coordinate their actions and subordinate their efforts to the overall goal of the organization. The final segment will be an overview review of the current progress I am

having implementing this model in a construction-based start-up. This will also include a brief discussion relative to the sequencing of activities for any organization wanting to implement this model.

### **Knightian Uncertainty and Poverty Trap in a Model of Economic Growth**

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At the early stage of development, the degree of uncertainty in the economy is extremely large. The purpose of this paper is to explore how Knightian uncertainty affects dynamic properties in a model of economic growth. The decision-making theory in the analysis is that of expected utility under a non-additive probability measure, that is, the Choquet expected utility model of preference. We apply this decision theory to an overlapping-generations model where producers face uncertainty in their technologies. When the producers have aversion to uncertainty, output becomes rigid for some measurable range of real interest rate. In the dynamic equilibrium, the existence of the output rigidity makes multiple equilibria more likely outcome under log utility and Cobb-Douglas production functions. We show that even if aversion to uncertainty is small, poverty trap can arise for a wide range of parameter values. In particular, we show that when two parameters have different degree of uncertainty, the dynamic equilibrium may have endogenous cycles. The introduction of the Choquet expected utility model of preference in an economic growth model therefore induces complicated non-linear dynamic path that classical growth models do not have.

### **Nonlinearity, Complexity, Engagement Learning, and the Role of the Arts in Human Development**

*Gardiner, Martin F.*

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This paper reviews and discusses recent evidence (1, 2) that arts learning, and especially arts skill learning, can affect human learning and development more broadly – cognitively and socially. I am developing theory to address certain features of these data that are still not fully understood. Connections between arts and broader learning seem worth investigating for at least two reasons. One is the more general new information on human learning they may provide. The other is the possibility that such connections from arts to broader learning may well be an essential part of the human

meaning of the arts. This follows, I propose, from the inherent complexities of the world which we help to form and in which we live. To survive in such a world we must integrate accumulating factual knowledge into a larger developing and redeveloping complex fabric of brain processing by which we engage with the world. This fabric of Engagement Learning and how it develops will be the principal focus of my talk. From the viewpoint of Engagement Learning, human development of spoken and then written language, of mathematics and science, enlarge and enrich our opportunities to develop our engagement, and so too, I argue, do the arts. What we learn from the arts can complement and reinforce, but also supplements what we can learn from other sources. Historically, I argue, arts have often had an important influence on how we have developed our individual and social means of living together. The arts can provide complexities of form and experience as high as available from other experience. We require such levels of complexity to prepare ourselves to engage richly with our developing world. Such considerations may help to explain why humanity has included the arts in essentially every human culture, and also the further human potential that they still hold.

#### **Clinical time Series Analysis-Only a Prognostic Tool?**

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Time series analysis of clinical data has been used in several medical areas. Most established is Heart Rate Variation (HRV) analysis. The heart rhythm changes showing complex nonlinear patterns that depend on the clinical conditions of the patient. Typical algorithms use time domain, frequency domain, fractal analysis or measures of entropy. In cardiology, different linear and nonlinear HRV-measures have been used for risk stratification of sudden cardiac death. HRV seems to be feasible at bedside to distinguish between groups at risk and not at risk, but there is a lack of interventional studies basing on HRV risk stratification. In intensive care first studies show encouraging results using HRV for risk stratification of sepsis, respectively multi-organ failure. Other areas of interest include prediction of stroke outcome. Nonlinear time series analysis has been used in broad areas. Approximate entropy or similar algorithms have been use in psychiatric, endocrinological, and neurophysiological studies. Up to now there exist only few interventional studies. Possible approaches will be discussed. Preliminary results of a study with palliative patients will be shown.

#### **Modeling the Complexity of Pain – Possibilities and Problems**

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Our understanding about pain and pain mechanisms has increased impressively in the last two decades. We have learned regarding the onset of nociceptive signals in the periphery and on pain transmission in the dorsal horn, processes mediated by innumerable substances and receptors at these locations. In this review, our objective is to discuss the possibilities and limitations of the complex systems approach for both research and treatment of pain. Three general approaches to complex systems will be presented, including examples: the “top-down” approach, the “hidden signals” approach and the “bottom-up” approach. Examples include classical models of the behaviour of the NMDA-receptor, the analysis of nonlinear signals of neurons in the dorsal horn and own biopsychological models on the interarction of pain pathophysiology and treatment.

#### **The Sign of the Lyapunov Exponent is Insufficient to Describe Synchronization of Coupled Chaotic Systems**

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As discussed elsewhere [Pyragas, Phys. Rev. E54, RA508 (1996)], the threshold of weak and strong synchronization in coupled chaotic systems depends on the signs of the Lyapunov exponents. Using this terminology, we have demonstrated the occurrence of weak and strong synchronization in a coupled chaotic Gaussian map. Recently it has been shown that these criteria may vary from one coupled chaotic system to another [Vieira, et al. (1997)]. In this presentation we demonstrate that in the case of zero or negative Lyapunov exponents, these exponents alone may be insufficient to differentiate among various types of chaotic synchronization. In such cases the various synchronization behaviors depend upon the eigenvalues of a system obtained by subtracting two chaotic systems.

#### **A Self-Transcending Constructional Logic for Emergence**

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In this paper, I carry through on my proposal for formalizing emergence in complex systems according to the idea of self-transcending constructions (Goldstein, 2005, 2004, 2003, 2002, and 2001). The formalism offers both a generalization of and a template for understanding emergence in whatever context it may occur whether mathematically, computationally, physically, or social-scientifically. I will offer a mathematical representation of the formalism, then where this representation falls within modern mathematics and logic, and next how it both flirts with yet avoids a full embrace of self-referential paradoxes. More specifically, I will layout the unique kind of logic required for the formalism of self-transcending constructions in order for them to aid in our understanding of emergence. I will describe this logic of self-transcending constructions according to the following five features of which it must partake: 1. A logic that allows for a simultaneous continuity with and transcendence of that from which emergents emerge, in other words, what I've been calling a logic of following and negating; 2. A logic that accordingly flirts with paradox, i.e., approaches paradox closely enough to partake of its dynamism yet steers clear enough of the self-enclosing nature of this same dynamism; 3. A logic that is constructional in nature but may include processes such as self-organization and similar supposedly spontaneous processes; 4. A logic that confounds previously separate categories characterizing antecedent or lower level components from which emergents are constructed; 5. A logic that, although it may allow for the utilization of abstraction, induction, and synthesis, nevertheless constructionally surpasses what can be generated by these three modalities.

### **Semantic Evaluations of Silhouettes with Different Fractal Dimension**

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The reported studies investigate the relationship between the fractal dimension of artificial landscape silhouettes and a number of established perceived dimensions. Naturalness predicts environmental preference and nature is suggested to be restorative because it is fascinating but effortless to attend to. The organized complexity in fractals could explain why attending to such patterns is fascinating but effortless. Artificial landscape silhouettes were created by filling in the space under fractal lines generated with a computer using a Fast Fourier Transform technique. The lines had fractal dimensions, 1.14, 1.32, 1.52 and 1.70, respectively. Subjects rated the silhouettes for naturalness and for 6 selected sub-scales from the 3 dimensions pleasantness, unity and complexity of the Semantic Environment Description scale. Results show a decrease in pleasantness and naturalness with increasing fractal dimension. The same relationship was found in a previous experiment using simple outlines. Contrary, complexity shows a positive linear relationship with increased fractal dimension. The perception of the silhouettes as a unified figure is the weakest for the outline with D 1.52 indicating that both the lower and higher dimensions are more easily recognizable as a whole with a dominating character. There appears to be a difference between artificial and extracted real silhouettes, for which preference and naturalness seem to peak at a fractal dimension of 1.3. A second part of this study, from which data is currently being analyzed, involves EEG responses to the same artificial silhouettes. The research is supported by the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning.

### **Individual and collective action competence in decentralized organizations: A frame of reference in progress and some empirical illustrations**

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A case study of a decentralized and competitive bank in Sweden is in progress. The organization is guided by a company culture characterized by a "humanistic" belief in the capability of employees, trying to generate a sustainable "win-win" situation taking into account both the demands of the organization and the employees. Decentralized work systems are based on the assumption that external regulation of work can be replaced by internal regulation of work both on an individual and a collective level. However, sustainable work systems also seem to require the capability and possibility of

individuals and organizations to develop higher complexity levels of internal work regulation, i.e. higher action competence. This way of reasoning lead to some overriding issues concerning our case, namely whether such internally regulated action competence is at hand, whether this competence can develop towards higher complexity and what change mechanisms are involved in such processes aims and framework. The paper takes departure in theories of Complex adaptive systems (CAS) when reasoning about the development of schemata and competence individually and collectively. CAS develops by the process of collecting information about the environment and the consequences of acting in it in an internal and an external phase. The internal phase of development is understood as strive to be an integral part of an aggregate (social integration) and to follow the legitimate schemata of this meta-individual. The external phase is the strive towards of self-assertion (autonomy). The overriding aim of the paper is to tentatively outline how such ways of reasoning in theories of CAS can be related to similar ways of reasoning in action theory and adult development theory (Hagstrøm & Hanson, 2003) and about the holon concept (Koestler, 1978), in order to broaden our understanding of individual and collective change mechanisms towards higher complexity levels. A collective is understood as a holon of aggregated individuals with a gestalt of its own, e.g. partly joint values (Backstrøm, 2004). Furthermore, our ambition is to elucidate our ways of reasoning with empirical illustrations from our case study.

### **Making Sense of Complexity and Chaos as Applied to Executive Coaching: A Case Study**

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The Edge of Chaos refers to the critical point of a system, where a small change could either set the system into chaotic behavior or secure the system into a set behavior. The system can be seen as dynamically unstable to some perturbations, yet stable to others. Most living systems are understood to operate within in this region (Lucas, 1999). It is this region, which Marion (1999) believed could be best understood through Complexity Theory. In executive coaching, working at the “edge of chaos” can be powerful. It is a high leverage point where maximum change can occur with minimal effort. Many times executives come to or are referred for coaching because they are either “stuck” and appear unable to change or are out of control, in a state

of internal or external chaos, having trouble adapting, developing, growing or changing. It can be through an effective coaching relationship that these individuals get back into balance with their systems and as a result achieve greater bottom-line results for every aspect of their internal system and external environment. Using an “edge of chaos” perspective, the coach can use effective questioning and other resources to encourage the executive to allow creativity and efficiency to emerge naturally within organizations rather than imposing their own solutions on employees. Complexity Theory can best be applied in executive coaching by guiding the executive to a renewed perspective of his role as a leader by redefining working relationships as non-linear and containing feedback loops, realizing that complex challenges in organizations are best dealt with by understanding their history, treating them as naturally open system, with fluid boundaries and dynamically interwoven within a network of other complex sub-systems. Apart from the coaching relationship it, Goodman (2002) suggests that there is a more important relationship that will have an even more profound and lasting impact on the individual being coached is the executive’s own internal relationship with the self. The effective coach needs to provide a safe and trusting environment and relationship for the executive to explore, learn and embrace change. It is the coaching relationship that often provides the leverage needed by the executive to create change internally and facilitates the development of self-empowerment in the form of self-correcting and self-generative thinking, beliefs, and behavior. In this research, a case study is presented of the development of a coaching relationship between a consulting psychologist and an executive presenting himself as being in conflict and crisis within his organization. The application of chaos and complexity theory to the process of intervention and executive coaching is thoroughly presented. Results of the intervention and follow-up are presented by the consulting psychologist/coach.

### **Signal-energy-metric Approach to Chaotic Phenomena: Theory and Simulations**

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A new approach to problems of nonlinear system analysis, synthesis and design, including generation of

different classes of deterministic, chaotic, pseudo-chaotic and hyper-chaotic signals is presented. The proposed method insists on a new abstract formulation of the energy conservation principle, based on the idea of introducing a proper state-space metric as measure of total energy, accumulated in the state space of a system representation. Instability and/or unwanted chaos are often considered as the most important phenomena, which should be investigated before any other aspect of reality will be attacked. Two typical situations should be distinguished in causal systems theory. The first one arises if the energy function of a given system is known in mathematical form and can be explicitly used to describe the time evolution of internal system energy. In such situations some form of the energy non-increasing test can bring useful information about the system state evolution. Unfortunately, in most real-world situations some form of energy conservation law is known to play a crucial role, but any mathematical expression for the system energy is not available. One standard way to overcome this difficulty is to make some additional restrictive assumptions, such as linearity and time-invariance, and try to use explicit knowledge of the solution of differential or difference equations describing state trajectories of the system, combined with computer simulations, laboratory experiments, and with sophisticated mathematical methods such as, for instance, the bifurcation analysis. The fundamental idea is illustrated by examples.

### **Values and Complexity in Leadership and Organizations**

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Humans are psychologically and socially complicated, complex, and often confusing. Complexity and Chaos theory has offered a general model with which to help make sense of that human complexity. Much of the application of Complexity Theory to human organizations has necessarily begun in making analogies from mathematical concepts to apparently relevant concepts and dynamics. This paper continues with that practice, suggesting that organizational values are concepts that describe the landscape of an organization, which in turn forms a basin of attraction and holds various types of attractors. Values theory, in particular the structure of 125 values appearing in developmental and increasingly dynamic stages, has been described by Brian Hall. This work shows not only how organizational values depend on increasingly dynamic underlying values, but also indicates the changes that increasing complexity requires in terms of leadership

behavior. This examination has particular utility at three levels of observation. At the level of the individual one can understand and manage development, as well as prepare for complex and dynamic organizational situations in an informed manner. At the group level, it is possible to predict what sorts of values and skills will support high level values that attend complexity, like collaboration. And at the organizational level, as an aid to strategic planning and development.

### **Comparing Linear to Nonlinear Models: Plant Manager's Energy Innovation Outlook**

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One focal point of concern, policy and a new research will involve identifying individual and organizational facilitative and obstructive factors within the context of energy innovation diffusion in the US and other countries. This interdisciplinary intersection of people, technology and change is one of serious consequence and has broad implications that span national security, energy infrastructure, the economy, organizational change, education and the environment. This study investigates facilities and plant managers' energy innovation information seeking and energy adoption evolution. The participants are managers who use more electrical energy than all other groups in the world and are among the top users of natural gas and oil in the United States. The research calls upon the Theory of Planned Behavior, the Diffusion of Innovations and nonlinear dynamics in a study of adoption patterns for 13 energy-related innovations. Cusp catastrophe models were compared to a counterpart multiple linear regression to examine and characterize data. Data was also tested for power law distributions. Findings reveal the group as a whole may resist change. Organizational resistance emerged as a controlling variable that split the group into two directions while attitudes were asymmetric. Of the 13 innovations, some exhibit very strong cusp catastrophe distributions while support for multiple linear regressions and the power law were found.

### **Fractal Dimensions and the Lyapunov Exponents in the Philippine Foreign Exchange Market**

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We report the results of a 58-year study on a new nonlinear model in analyzing the Philippine peso-USD rate using chaos theory, which was applied on the raw data consisting of 1946-2004 (58 -year period, a total of 15,153 observations) PHP-USD exchange rate time series and daily volume trading data from 1988-2004. The chaos techniques call for the calculation of the correlation dimension as an estimate of fractal dimension and the calculation of the largest positive Lyapunov exponent as evidence that the time series is sensitive to initial conditions. A fractal structure and sensitivity to initial conditions are the basic features of chaos. Aside from the basic chaos tests, we also subjected the time series to the following chaos-related tests: probability distribution, polynomial fit, power spectrum, dominant frequencies, capacity dimensions, correlation function, correlation matrix, phase-space plots, return maps, and Poincare movie. Chaos analysis shows that the trading volume data registered a correlation dimension between 2 and 3, hence the presence of a fractal dimension, approximately between 2.941 and 3.840. This means that the volume trading time series has a fractal attractor. A positive Lyapunov exponent was also found for the volume trading data which is 0.114. The same findings were found for the PHP-USD time series with positive Lyapunov exponent found to be 0.010. The findings declared the existence of chaos in the Philippine foreign exchange market. An important objective of this study was to describe the behavior of the Philippine foreign exchange market by examining whether it conforms to chaos theory, a nonlinear, dynamical model. It examines the presence of a fractal structure through the correlation dimension, and the largest positive Lyapunov exponent, which are the characteristics of chaos. Finally, it tries to develop a chaos-based forecasting model to predict future movements of the exchange rate. This study presents the basic concepts of chaos theory as an emerging paradigm to understand a world made up of adaptive, complex and dynamical systems. It also provides a methodology drawn from advanced physics and mathematics that can be applied in the study of how financial markets behave, particularly, in the local currency market. Results of the study showed that the Philippine foreign exchange market's behavior since 1946 and up to 2004 can be described as having a long period of stability (for the fixed exchange rate regime), a moderate degree of volatility (for the floating exchange rate regime) and a period of turbulence and chaotic behavior in the latter period, particularly, during the 1997 Asian financial crisis. Lastly, three dynamical variables (or value drivers) are needed to specify the dynamics of the currency market. The research was partly supported by the Canadian International Development Agency

(CIDA) research grant. This paper is also partly the results of the doctoral dissertation of the researcher for her Doctor of Business Administration (DBA) Degree at the De La Salle University, Taft Avenue, Manila, Philippines in 1998. The data were updated until December 29, 2004.

### **Use of Artificial Neural Networks for Risk Assessment for Work and Organizational Issues**

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The prerequisites for planning and decision-making in risk assessment and management for psychosocial issues at work lie largely in being able to accurately assess, model and predict the risks to individual and organizational health (Karanika, Cox, Griffiths, in press). This study examined (a) the potential of using artificial neural networks to predict the impact of work and organizational issues on health outcomes and (b) the application of such an approach on risk assessment for work and organizational issues. It was a comparative study of a connectionist approach (neural networks) and a statistical approach (multiple linear regressions) in the context risk assessment. The precept of this investigation is that non-linear approaches can offer better models of psychosocial phenomena than linear approaches (see Guastello 2000), especially in relation to modeling complex second-order emergent properties such as risk, and can thus fortify risk estimation. Predictors were: age, gender, organization, social support, work and organizational factors (control-demand, pay and fairness, management, work-home issues, job a role, breaks, colleagues, information). Outcomes included: general well-being, job satisfaction, intention to leave, days of absence. 1003 cases (from 5 organizations) were used for model development and validation. The two approaches are examined both quantitatively (accuracy,  $R^2$ , mean absolute percentage error) and qualitatively (model specifications and weight of predictors). Results suggest that neural networks offer slightly better but comparable models to linear regression. The implications (a) for use of neural networks in psychosocial research and (b) for a methodology of risk assessment for work stress will be discussed.

### **Unpredictability, Chaos and Order in Social Systems**

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Since no one has ever observed an immobile society, the author attests the capability of a social system to surprise us by always changing and maintaining a fort dynamical aspect of continuous movement. In a rather implicit but clear way, the author consider stable positions of the system (fixed-point) as unrealistic regarding the historical aspect in the evolution of human societies. Thus, we shall present a model of opinion dynamics called X-Model, based on the MER Model; it takes under consideration both an agents' internal (intra-individual) regulation structure among different opinions regarding the same social issue and a tendency for social equilibrium. In X-Model, we regulate both the social and intra-individual strive and we try to find in what conditions (parameters setting), equilibrium could be achieved. One of the findings concerning MER Model is that with  $\psi=1$ , the system ends to a periodic equilibrium (if the communication topology is a complete graph). Therefore, if  $\psi=1$  and  $\kappa = 1$  is a pair of values that equilibrates the system then, starting from this finding, there were two possible ways of confronting the problem: a/ these two forces are opposites and, it would be sufficient to be of equal strength for the system to stabilize ( $\psi=\kappa$ ), b/ these two forces are complementary and, then, it would be sufficient to maintain the same sum (according to previous findings, equal to 2) for the system to equilibrate ( $\psi + \kappa=2$ ). Then, we explore this nonlinear model by a series of computer simulations for a variety of parameter values. We examine under what conditions the model exhibits sensitive dependence on initial conditions and, finally, we calculate the Lyapunov Exponents. Our results show that for certain parameter values, the system exhibits final state sensitivity, thus it is chaotic (deterministic and unpredictable). The crucial question is to find out under what conditions the system stabilizes or destabilizes. Our results show that, in certain locations of the parameter space (two-dimensional) the system becomes periodic while in others the system presents a far-from-equilibrium behavior. Social systems, as represented by X-model, can be stable, near equilibrium or far-from-equilibrium. This is a dynamic characteristic that can be deterministically predicted by means of three major factors (two individualistic, bottom-up and one societal, top-down) which interact with each other: a) The strive for social consistency (individualistic-bottom-up approach); B) The strive for the individual consistency (individualistic- bottom-up approach). The social network-communication topology (societal top-down approach).

### **Nonlinear Model of Epidemic Spreading in the Complex Social Network**

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The epidemic spreading in a human society is a complex process, which can be described on the basis of a nonlinear mathematical model. In such an approach complex and hierarchical structure of social network (which has the basic meaning for the spreading of pathogens and can be treated as a complex network), can be taken into account. In our model each individual has one of the four permitted states: susceptible, infected, ill, unsusceptible/dead. This refers to the SEIR model used in epidemiology. The state of an individual, changes in time depending on the previous state and the interactions with other individuals. Probabilities of the transitions between different states are described by a set of parameters (e.g. the average time of the incubation). Their proper values enable to model different epidemics. The description of the interpersonal contacts is based on the experimental observations of the social relations in the community. It includes spatial localization of the individuals, who can belong to different social groups, the effectiveness of different interpersonal interactions and the mobility of the contemporary community. Numerical simulations were performed for different types of epidemics, giving the progress of a spreading process and typical relations (e.g. range of epidemic in time, the epidemic curve). The spreading process has complex and spatially chaotic character, especially in endemic state. We investigate the influence of the preventive vaccinations on the spreading process. In particular, for critical value of preventively vaccinated individuals the percolation threshold is observed and the epidemic is suppressed.

### **Dynamical Perspective of Post-Traumatic Stress Disorder**

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On the basis of descriptions gathered from the published literature in post-traumatic stress disorder (PTSD), chaos theory, and neuropsychology, a model was created with the help of Atlas.ti, a computerized implementation consistent with the Grounded Theory method. The features of chaos theory that enabled the construction of this PTSD model were: (1) bifurcation ties attractors together across various locations in the brain; (2) fractal firing patterns contribute to vertical, functional convergence from the molecular level up to entire

systems; (3) attractor patterns formed in response to new experience and stored as memory are associational in nature, thus connecting neuronal, physiological, and psychological processes. This model suggests four correspondences between PTSD and chaos theory: (2) The periodic attractor concept and the tendency of PTSD victims to repeat traumatic experiences; (2) neuronal chaos and the negative effect that low levels of chaos exert on mental health; (3) sensitivity to initial conditions in chaotic systems and risk factors in PTSD; (4) the idea of chaotic bifurcations and the possibility for taking advantage of this phenomenon to effect positive outcomes as a result of psychological therapy. These relationships suggest that chaos dynamics are active in the brain and body, and represent a useful model for understanding and treating PTSD, whose symptomatology may be endlessly related through a type of devil's polymer. Hence, chaos on the neuronal level may result in physiological responses and emotions associated with PTSD, precipitating thoughts and behaviors manifested psychologically.

### **Creativity as an "Order through Emotions" Process** *Laycraft, Krystyna*

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We analyze the Theory of Dissipative Structure (I. Prigogine, 1984) and the Theory of Positive Disintegration (K. Dabrowski, 1970) as a potential theory for process of creativity. According to Prigogine's theory, dissipative structures are new types of structures originating spontaneously in far-from equilibrium conditions. There are transformations from disorder to order. The characteristic feature of these transformations is change from repetitive and the universal to the specific and unique behavior. When the flow of energy and matter through them increases, they may go through bifurcation points of instabilities and fluctuations, and transform themselves into new structures of increased complexity. This spontaneous emergence of new structures and new forms of behavior, which has become as self-organization, is the basis of the phenomena of creativity. The Theory of Positive Disintegration, developed by K. Dabrowski (1970), is a complex and comprehensive theory of personality development. Positive disintegration process, through loosening and even fragmenting the internal psychic environment, through conflict within the internal environment and with the external environment, is the ground for the birth and development of a higher psychic structure. Dabrowski found a fairly high positive correlation between mental disintegration, nervousness on one hand, and accelerated development and creative abilities on the

other. It seems that a creative man, individual in the process of accelerated mental development must experience states of disequilibrium. Based on these two theories we summarize that: 1. Creativity develops under conditions of emotional fluctuations, tensions, and external as well as internal conflicts. 2. Creativity would be referred to as "self-organizing dissipative structure," an open system that can survive only through a constant exchange of matter/energy and information with its environment. 3. Creativity continuously creates disequilibria and bifurcations, breaks barriers of routine, to liberate from automatic experiences in order to achieve inner autonomy. 4. Creativity can be regarded as a desire to build a new reality through an expanded awareness. 5. Creativity is an important outlet for the increased tension of inner conflicts and defense force against mental illness. The concept of a dissipative structure and the theory of positive disintegration provide a new point of view to the process of creativity as a model "Order through Emotions."

### **How to Describe Dynamic Encounters with Police Officers and Citizens**

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Police officers control citizens' antisocial behavior and this often places them in conflict with citizens. It is important to understand the dynamics in order to be able to promote the police officers' safety during threatening and violent encounters. The purpose of this study was to examine the basic elements of threatening and violent encounters between police officers and citizens and describe the whole process. Methods: 13 police patrol officers were interviewed. Every police officer reported at least two encounters. The stories were tape-recorded and put down in writing. Results: The interviews produced 28 stories about threatening or violent encounters. A kind of universe of actions, which was named the behavioral universe, was formed from all the actions by police officers, during these encounters. Besides the actions, the phases were also roughly named and marked in this behavioral universe. The stories showed that the encounters did not proceed linearly. Instead, many of them calmed down and changed to threatening again because of some trifle. They again calmed down and suddenly changed to threatening once more. Many times during the encounter the police officers had to size up the situation, and make strategic plans and quick decisions. The encounter analyzed in this presentation



began with the following story: " A woman called the emergency phone 112 and told how she had run out of her apartment. Her husband had battered her. He was drunk and was inside the apartment with their four-month-old baby." The emergency center sent a police patrol to the apartment. The encounter was drawn as a line in the behavioral universe. The decision points were marked on the drawing. It was seen that the strategic planning, the decisions and the acts were the basic elements; they could be found by using the story and drawing a flow chart of its events in the behavioral universe. Conclusions: During threatening and violent encounters police officers act as decision makers who size up the situation to recognize which course of action makes sense. The basic elements in this encounter were strategic planning and the decisions the police made. The encounter did not proceed linearly, but it could be drawn in the behavioral universe with the help of the story. While reading the text and looking at its flow-chart of events, actions, and decision points, one could realize the nonlinearity of the encounter. The whole encounter could be seen as a dynamic process containing many independent decision situations. This behavioral universe can be used as a method of analysis, while training safety-promoting practices and it also adds clarity to understanding why people act violently.

### **Models of Ion Channel Density Regulation**

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The dynamics of a neural network depends on density parameters at (at least) two different levels: The subcellular density of ion channels on single neurons, and the density of synapses at a network level. For the Frankenhauser Huxley (FH) neural model the density of sodium and potassium channels determine the behavior of a single neuron when exposed to an external stimulus. The features of the onset of single neuron oscillations vary qualitatively among different regions in the channel density plane. At a network level the density of neurons is reflected in the global connectivity. We study the relation between the two density levels in a network of oscillatory FH-neurons by qualitatively distinguishing between three domains where the mean network activity (1) is spiking, (2) oscillating with enveloped frequencies, and (3) where it shows bursting activity, respectively. The global activity can be shifted between regions by changing, either the density of ion channels at the subcellular level, or the connectivity at the network level, suggesting that different underlying mechanisms can explain similar global phenomena. Finally, we

model a possible effect of anaesthesia by blocking specific inhibitory ion channels.

### **Kinetographic Approach in Neurorehabilitation Research**

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New approach for monitoring and assessment of functional state (FS) of an individual viewed as complex system generating mechanical response to inner and outer perturbation is presented. Kinetographic method is applicable to quantification of rehabilitation process. Methods: Kinetography, clinical observation, neuropsychological assessment. Results: Basic technique used is to measure movement of human body total center of pressure (TCP), or stabilography. The tool worked out is authors updating of stabilography for sitting position. Individual functional condition study is carried out with special platform reinforced in adapted chair. Measuring system gives chance to record small (in rest state) and larger (hyperkinesias or purposeful activity) TCP deviations of sitting individual in relation to platform center. Taking into account the integral nature of TCP movement for numerous biomechanical processes of human body and yet peculiarity of signal analysis used the method was defined as kinetography. FS of any individual as complex system was axiomatically considered in terms of energy, entropy and stability. Data received in healthy volunteers in two conditions (awaking with open and close eyes) revealed set of three descriptors for current FS estimation, and transitional coefficients for FS transformation. Conclusion: Kinetographic data obtained in brain injured patients during and after rehabilitation merely coincide with clinical observations, yet revealing peculiar features of individual process which suit for elaboration of current rehabilitation activities.

### **Nonlinear Model of B-Cell Chronic Lymphocytic Leukemia (CLL)**

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Background and Purpose: B-cell chronic lymphocytic leukemia (B-CLL) is defined as a lymphoproliferative disorder of morphologically mature but immunologically less mature lymphocytes and is characterized by the uncontrolled expansion of a single clone of B-cells. The disease is often accompanied by



immunological abnormalities involving at the same time B, T, and NK cells. The CLL patients can be divided into two groups: those with a slow progressing and those with a fast progressing pathway of the disease, respectively. A search for specific differences in functional activities of both leukemic B-cells and T-cells which might be related to a slow or fast progression rate of the disease is important for the better understanding of the complex CLL pathogenesis. **Material and Methods:** We propose a nonlinear dynamical toy-model to mimic the interaction between the B-cell clone and the developmentally altered or weakened T-cells in CLL. The growth rate of these two active groups of cells is described by two non-linear first-order cubic differential equations with three control parameters and a feedback effect incorporated. Depending on the relation between the control parameters and the initial count of the B-T cells in the peripheral blood, the future behavior of the B-T system can be predicted. **Results:** The quantitative imbalance between T-cells in the peripheral blood was found to play an important role in modulating the CLL clinical evolution. The progressive expansion rate of B-cell clone is found to be related to the total tumor mass (TTM) predictor. The level of T-cells activity in the individual patient becomes an important determinant and a useful prognostic indicator. **Conclusion:** Our nonlinear dynamics toy-model qualitatively describes some of the interesting features of the CLL disease, in particular, the accuracy of the fast and slow pathways.

### **Mixed Duopoly Dynamics with Product Differentiation**

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We extend a nonlinear duopoly model in which demand is isoelastic and production cost is linear by introducing two heterogeneities; heterogeneity in production (i.e., product differentiation) and heterogeneity in strategy (i.e., price-competition and quantity-competition). Profit-maximization yields mound-shaped best reply functions. We demonstrate the analytically as well as numerically principles of the following: (1) in a mixed duopoly market, quantity-competition is dominant over price-competition in a sense that profit of a quantity-setter duopolist is larger than profit for a price-setter duopolist when an equilibrium is stable; (2) chaotic dynamics can be emerge via period-doubling bifurcation when the equilibrium is unstable; (3) for the quantity-setter, a long-run average profit taken along chaotic trajectory can be larger than a profit obtained at a stationary point while for the price-setter, a long-run

average profit becomes negative. The results imply that (1) the chaotic market is preferable for the quantity-setter but harmful for the price-setter; (2) a birth of monopoly out of duopoly is explained endogenously because, sooner or latter, the price-setter leaves the market due to negative profit and then the chaotic duopoly market turns to be a stable monopoly market.

### **Emergence of Core Teams in Open Source Communities**

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Open Source Software (OSS) communities are typically organized into a two tier structure of core and peripheral developers. Yet, little is known about the process through which such structure manifests. Following the theory of leadership emergence (Guastello, 1998) we model the emergence of core teams using the rugged landscape self-organization processes (Kaufman 1993) and the cusp catastrophe (Thom, 1975). The data were collected from two mailing lists from the KDE community for a period of two weeks. Social network analysis was used to quantify (a) the prestige of developers as the order parameter in the cusp catastrophe model, (b) the knowledge sharing activities that developers utilize in their interactions as the asymmetry parameter (b) the coordination challenges of developers as the bifurcation parameter. The results show that when developers utilize a more diverse spectrum of knowledge sharing activities they can become more prestigious and emerge as core team members. When they face few coordination challenges the process tends to be gradual, slow and evolutionary. When they face many coordination challenges the process is sudden and discontinuous. By providing a dynamic account of how structure emerges in OSS communities, this study makes various contributions to the extant literature on open source communities, dynamic systems, and knowledge sharing.



### **Windows to Brain Complexity Using Electroencephalographic (EEG) Signals**

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It is well known that EEG (and MEG) signals are the expression of interaction of a huge amount of neurons

and their interplay. Complexity of the brain expresses the complex interactions during each function and between different functions or self-organization and effect of one unity to others. It quantifies the number of independent variables of a system. The Brain web is a nonlinear system. The model of chaotic EEG dynamics is in accordance to flexibility and rapid reactivities of brain networks. Nevertheless, evidence for chaotic EEG dynamics is controversial and inconclusive. Although Chaos in the Brain is no longer a field of research, the studies using methods derived from nonlinear dynamics (chaos theory), are proper to study normal or pathological EEG and MEG signals. Different EEG frequency bands are known to have differing functional significance and interplay. Thus, the evaluation of the different bands is more informative. The nonlinear methods we use are: D2, Nonlinear cross prediction (CJ. Stam), Prediction using ANN and Synchronization Likelihood a new method evaluating linear and nonlinear synchronization (CJ. Stam). Examples: (A) Deaf people, during reading activate a wider region of cortex expanded to the temporal cortices. At rest, the signals are more complex on the whole cortex explained as an elevated readiness to process the incoming information. (B) Mathematical thinking in normals revealed local (almost invisible) activation during number comparison (parietal sulcus activation) and widespread activation during difficult mathematical thinking. Recently, methods of Graph Theory seem to be promising to study complex phenomena such as the Neural Networks. There are findings supporting the Small-World Networks (SWN) architecture and interplay in Brain during the neuronal activity. Using a software developed by CS. Stam, we evaluated the mathematical thinking and found that the difficult mathematics show the SWN organization for low frequencies i.e. frequencies involved in widespread synchronization. In another study, undereducated individuals showed more SWN organization in most EEG bands during 2 Back WM in relation to higher education. The former group needed more attempt leading to higher organization. At end, schizophrenics during WM showed significantly less SWM in relation to normals. Thus methods derived from two developing fields i.e. chaos theory and graph theory are proper to study functions of the Complex Brain.

**Asymptotic Behavior in a Modified Liu's System**  
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Over the last forty years, several three-dimensional autonomous dynamical systems with chaotic attractors have been studied. The first one was the Lorenz's system

(1963), where cross-products in the second and third equations introduce the nonlinearity necessary for folding trajectories. Other 3D butterfly-shaped chaotic attractors based in cross-products are found by Chen et al. (1999) and Ló et al. (2002). Recently, Liu et al. (2004) have proposed a new nonlinear three-dimensional system, with a cross-product in the second equation and a quadratic term in the third one, exhibiting chaotic dynamics. This paper considers a modified Liu's system, adding a constant in the third equation. The aim is to study the asymptotic behavior of the system depending on the value of this parameter. It is interesting to notice that the behavior is not symmetrical for negative and positive values. We analyze the stability of the equilibrium points and investigate the existence of different kind of bifurcations (pitchfork, Hopf, period doubling bifurcations). In addition, Lyapunov exponents are calculated, confirming the results. Finally, we also present some numerical simulations that allow visualizing the most interesting situations.

**Living Artifacts Need Chaos for Growing-up?**

**Morgavi, Giovanna**

IEIIT- National Research Council

Many research works in robotics and autonomous systems are focused on getting an agent to learn to do some task such as recognizing an object or reaching a specific place. The task can be learned, but in most of these works the robot's task was predefined by the researcher. The next logical step is to project an autonomous robot that can dive in unpredictable environments. That means to investigate how robots that are capable of 'growing up' through experience can be designed. Living systems, starting from a pre-structured set of functions, develop competence to better adapt to the environment all life long. They present multiple levels of organization, with elements at one level interacting and aggregating to create more complex behavior at a higher level. Many recent investigations on the spatio-temporal activity in living being showed the presence of features common to the behavior of self-organizing dynamical systems. Thus a question arises: is this chaos useful for growing up? In this paper we present and discuss that question, and we try to give some indication for a possible answer, with the aim of defining the basic features of a behavioral kernel for growing up artifacts.

**The Space-Time Model of Natural System Conditions Appraisal**

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Traditionally, when appraising the damage to a natural system caused by external influences only geometrical properties of time are taken into account. Physical properties, such as time pace and time density, are never account for. Time pace and time density were theoretically founded and experimentally proved by astrophysicist Kozyrev Nikolai (1971). Based on Nikolai discoveries, the space-time model of appraising ecologic and economical damage to the environment caused by external influences was worked out. In our model, time is considered to be structured according with synergetic views. The model accepts nonlinearity of system's time and allows appraising the rate of influence on different hierarchical levels of the system. This allows the more adequate appraisal of the natural system condition and helps to predict the point of transition of the quantitative changes into qualitative. The universal formula of appraising the damage on any level of the natural system, including the whole planet, is deduced and can be applied in conditions of both single and complex external influence.

### **Simple Nonlinear Models that Produce Latent Emergent Order: Implications for Consciousness**

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According to the theory of Primary Mental Models (Pavloski, 2005a,b) qualities of experience are expressions of global order in a mental space of relations that emerges from certain types of neural interactions. Building on earlier work (Pavloski, 2005b), this paper describes two nonlinear models that have been developed to understand further the properties of such spaces, their relationship to neural activities, and their detection from outside the system. The attractor dynamics of the models are governed by virtual interactions between the relations of activities within clusters of neurons. Every relation is produced by many specific patterns of neural activity, so the global order is latent (i.e., not expressed by state vectors of neural activities). Although latent order depends on interactions of relations, it is determined by the nature of the neural interactions and is therefore a definite global physical property of the system. The first model developed (Pavloski, 2005b) is an adaptation of the Ising model of a ferromagnet. Binary neurons with states  $\pm 1$  combine the outputs of neurons within each cluster multiplicatively rather than additively, as they do in attractor neural network models. The dynamics of the model reduce an energy that depends on alignment of products rather than on alignment of states of elements.

Simulations confirm that global order emerges at a critical noise level, and that this order is not evident in the space defined by neural activities. The model has therefore been termed a virtual Ising model. Two generalizations of this model are reported. First, it is easily generalized to a virtual Hopfield network that produces patterns of products rather than patterns of states of elements. An energy function is derived and minimized when specific patterns of products of activities within clusters are present. Simulations demonstrate that this network stores and retrieves latent patterns of relations just as the Hopfield network stores and retrieves manifest patterns of neural activity. Furthermore, the virtual network shows interference effects among latent patterns, and is influenced by external inputs at the level of the latent patterns. The second model generalizes products to arbitrary relationships between elements comprising clusters. This can be done using feed forward networks with hidden layers. Neural interactions produce virtual interactions between these arbitrary sets of relationships. An energy function is derived and minimized when each cluster expresses a particular relationship. Simulations confirm that global order is produced and is not evident in the state space of neuron activities. In conclusion, both models exploit equivalences of the formal expressions for energy when abstract relational states are substituted for states of neurons. This equivalence shows that the corresponding network demonstrates behavior in a space of relations that corresponds to the behavior of a typical attractor network in the state space of activities of elements. Although the two models presented here are extremely simple, they are useful for studying aspects of the theoretical construct of latent order. Implications for the development of more realistic models and their potential use in the analysis of actual neural data are discussed.

### **Oscillations, Chaos and Noise in Peripheral Sensory Receptors and Neural Networks.**

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Electrophysiological recordings in the central and peripheral nervous system have shown that neurons can generate a fascinating array of different impulse patterns which include regular and irregular single-spike discharges, burst activity and also chaotic dynamics. We have developed computer models of the Hodgkin-Huxley type which, in addition to the spike-generating currents, possess subthreshold currents. The subthreshold currents activate at lower membrane potentials and have slower time-constant which can give

rise to subthreshold oscillations. Our simulations and nonlinear data analysis elucidated that complex interactions between the oscillatory and spike-generating subsystem, with additions of noise, provides the basis for a most flexible pattern generator (Braun et al., *Biosystems* 71: 39-50, 2003; Sosnovtseva et al. *FNL* 4: L521-L533, 2004). The model neuron can be tuned through all types of patterns with physiologically plausible parameter scaling. This goes from pacemaker-like tonic firing via chaos to burst discharges and back to single-spike discharges again, which are riding on subthreshold oscillations. Moreover, the model can easily be adapted to account for specific processes of neural encoding and neuromodulation including experimentally observed sensitisation phenomena in peripheral nociceptors. Our simulations also demonstrate that the internal dynamics of such neurons can have significant impact on the activity patterns and synchronization phenomena in neural networks especially at the transitions between tonic, chaotic and burst activity which are of particular relevance for diverse physiological and pathophysiological processes (Postnova et al. *Biosystems*, in rev.). Supported by the European Union through the Network of Excellence BioSim, Contract No. LSHB-CT-2004-005137

#### **Towards Self-Organizing Economy**

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Self-organizing economy is considered as an alternative to centralized one. The experience of Russian economy is analyzed in the light of synergetics. Over the last two decades Russia has passed a great variety of dynamic states: order, crises, chaos, deep chaos, and edge of chaos. The current state of Russian economy could be described as stability that includes instabilities. The traditional way of economic investigation lies in the searching for the interdependence between main economic indicators (inflation, rate of economic growth, budget deficit, export, import, etc.). In the framework of synergetic approach the transition from one state to another is analyzed as the development of complex adaptive systems. From this point of view the main attention is devoted to determination of control parameters, dominant adaptive strategies, principles of management, and variants of economic development. The strategies that block natural tendency of self-organization are also discussed. Four basic types of management given by Charles Handy (role culture, task culture, power culture, star culture), are added by anarchy culture. The resistance of this type of culture to chaos, to natural ability to change by self-organization is

demonstrated. This research sheds light on the processes of economic development and mechanisms underlying the socio-economic transformations.

#### **Patterns of Nonverbal Interaction in Psychotherapy**

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Synchrony is a universal concept in nonlinear systems science. Synchronization phenomena have been conceptualized as important features of successful psychotherapy dyads. Aims: Various characteristics of nonverbal behavior in dyadic psychotherapies were analyzed in a sample of videotaped psychotherapy sessions in order to explore behavioral synchrony. Inclusion criteria embraced both patients reported quality of the therapeutic bond and multiple ratings by independent observers. Methods: Nonverbal analysis focused on movement patterns of client and therapist during the course of selected sessions. The raw data consisted of video-sequences recorded by two cameras whose signals were joined to a split-screen. This technique yielded a full-length portrait of both subjects. Target areas for motion detection were the subjects head and trunk. Data collection was accomplished by motion energy analysis carried out by a fully automated frame-by-frame examination of the sequences resulting in basic descriptors of each subject's individual movement patterns. Additionally, time series of the temporal flow of motion energy were compared and signs of simultaneous and time-lagged movements were being automatically detected. Results: Findings showed that synchronized nonverbal behavior occurred independently of the quality of the therapeutic bond. Features of synchrony seemed to be nonlinearly associated with patients' interpersonal styles. The comparison of observer ratings and movement patterns showed interesting relationships requiring further investigation. Conclusions: The exploratory analysis of the selected therapy sessions (N=20) indicated that the chosen methodology is a feasible approach to study videotaped psychotherapies

#### **Nonlinear Perceptual Learning Dynamics in Visual Search**

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Perceptual learning is an increase in the ability to extract information from the environment, as a result of experience and practice with stimulation coming from it (Gibson, 1969; Kellman, 2002). From this theoretical definition, it seems possible to assess perceptual learning by tracking motor behaviors involved in visual perception in order to detect changes in the dynamics of the latter during a learning process. **Aims and Framework:** Our main goal is to develop an objective index of perceptual learning dynamics that would be based on head and eye movements and that could be used in virtual reality environments. **Methods and Samples:** A small sample (N=11) of subjects were immersed in virtual reality environments to execute visual search tasks while their eye movements were tracked from a head mounted display combined with an infrared eye-tracking device. Learning level was controlled by varying the amount of time allowed to subjects to get acquainted with virtual environments before visual search was done. Gaze behavior, as it relates to the geometry of the searched virtual objects, was recorded (Duchowski et al., 2003; Renaud et al., 2002, 2003) and correlation dimension analysis was done on the time-series resulting from this recording. **Results:** First, from correlation dimension analyses and surrogate data tests, it appears that gaze behavior dynamics is nonlinear, fractal and distinct from noise. Second, visual search performance (i.e. the number of true detections) is highly correlated with the value of correlation dimensions. Finally, fractal dimensionality in this case seems to be modulated by learning. **Conclusion and implication:** These results point toward the possibility of an objective index of perceptual learning dynamics in visual search that would reflect the nonlinearity of the perceptual invariance extraction process.

#### **Assessment of Embedding Dimension and Sensitivity to Initial Conditions Based on Statistical Tests.**

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Nonlinear forecasting of Time Series can be used to estimate Embedding Dimension (ED) and to assess Sensitivity to Initial Conditions (SIC) (Sugihara and May, 1990). We can make these analyses using Artificial Neural Networks (Rifa-Ros and Viader-Junyen, 2000).

On both cases decision-making is based on the observation of graphs. We have developed a method that allows us to make decisions based on statistical tests. We have performed the forecasts using feed forward Artificial Neuronal Networks. Two simulation experiments have been designed to estimate the ED and to assess SIC. In the first experiment, the independent variable is the number of components of the reconstructed attractor and the dependent variable is the correlation between forecasting estimates and the original series. For the estimation of the ED we have to look for an invariant using Helmert contrasts. In the second experiment, the independent variable is the number of iterations of the forecasting and the dependent variable is just as in the first experiment. In order to assess the presence of SIC it is necessary to contrast if there are significant differences in correlation decay between the different consecutive iterations. Ten samples have been used in both simulation experiments for each ten conditions. The ED estimated with this method is ED= and Presence of SIC has been found too, so we have achieved our objectives. One inconvenience found is the amount of computational resources needed. It will be necessary in the future to contrast if this method can be useful for the analysis of psychological time series.

#### **Subjective Expectations of Financial Series: Comparative Evidence from Germany and Japan** **Rötheli, Tobias F.**

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We experimentally explore how subjects extrapolate different stylized patterns in financial time series like stock prices or exchange rates. The study identifies the patterns in the recent past of a series which lead decision makers (i) to anticipate large or small future changes in a series, (ii) to make similar or widely differing assessments of the future course of a series, (iii) to make more or less correct judgments of the average assessment of all participants, and (iv) to be more or less confident about their own forecasts. The experiment which is the basis of these assessments was conducted both in Germany as well as in Japan and the results provide an interesting comparison of similarities and differences of forecasting styles relevant for asset pricing.

#### **On the Edge of Psychosis?**

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Thirteen years ago, I analyzed the organizational change-taking place at that time. Unfortunately the conclusion drawn in that study, that mania within organizations and depression among personnel would increase, has come true. During the symposium, I would like to ask the symposium participants to use reflection and association to (1) consider what organizational phenomenon is currently underway and what the concepts of the non-linear change represent, (2) predict in what direction the phenomenon will continue to develop, and (3) consider how the manic development of organizations such as the ones described can be influenced. A summary of the example to be used for this purpose follows. Organizations have reacted externally and internally to demands for change by, for example, initiating various development projects. The cultures of public organizations have, as cultures in general, interpreted the new and foreign influences in their own traditional manner that effectively repels outside influences and retains their own culture untouched, the new being partially merged with the old. Management by results is a good example of a cultural product borrowed from the private sector. Public organizations have used consultants to help them learn a new and foreign cultural language: results, key results, results area, results unit, results budget, results manager, and the like. Although the terms have been rather well learned, has the new culture behind the terms accompanied them? Sometimes the philosophy of management by results is adopted by public institutions but remains harmless. A lot of forms are filled out, but, in practice, nothing changes. In other words, issues and changes are made on paper and in working groups, but they have no connection to daily work life or the practical aspects of the organization. In terms of the organizations' regulations, the "real work" is paperwork, and the so-called client-oriented tasks are "non-work", done out of necessity. At other times results by management has even strengthened the organizations' regulation culture. Then management by results - which originally had administrative reduction as a major objective - has led to administrative expansion and the strengthening of its hold, the result being even more bureaucracy. In both cases, work has taken a step even farther away from the real world into a paper-filled abstract world. At worst, regulated organizations become driven into a manic-depressive psychosis. The administrative machine functions faster and requires ever more manic actions from its employees. The more enthusiastic and efficient the functioning of the administration becomes, the more depressed the employees' feel. What can be used to treat an organization's manic-depressive psychosis, a disease that is predicted to become even more prevalent? If an

organization recognizes a need for help, then its administration, management, and employees must first be directly treated. Then treatment must focus on reawakening the spirit of the organization and helping the organization face reality. This process can only take place through animate interchange and discussion between the people involved - no matter how foreign and difficult it is for those who have grown up in a regulative culture

### **Study of Fractal Patterns Feedback as an Element of Making on Identity for City in the Iran**

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Mathematics and geometry were considered as a powerful tool for analyzing circumstances, comparison of situations and designing for architecture and urban construction which were regarded as the builder of public and private legible and, having identity spaces. The life of all live systems has a fractal pattern, it is the same for cities with all their spaces, and this structural relationship may be observed. This work is concerned with the following three issues: -Recognition of fractal patterns and complicated relationship with urban phenomenon; -Relationship between somatic and structural identity in urban spaces with fractal pattern; and -The pattern's correlation with urban spaces and reconstruction of urban spaces.

### **A New Method to Study DNA Sequences: The Languages of Evolution**

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In the last years several authors have reported the finding of deterministic dynamics in the flux of genetic information. Such dynamics suggest that evolution occurs with the emergence and maintenance of a fractal landscape in DNA chains. In this work we examine the idea that the repetition of motifs lies at the origin of these statistical properties of DNA. To analyze such dynamics of repetition we apply a modification of the BDS statistic, a method borrowed from economic statistics, and we adapt it to DNA sequence analysis. We compare the statistical properties of naturally occurring sequences along the evolutionary tree with simulated randomly generated sequences and also simulated

sequences with repetition motifs. We provide a new method to analyze DNA information, which is able to search for a structured signal in genetic information. To better understand the graphic results, we also define a new statistic for a DNA sequence. On the basis of a mathematical interpretation of repetition patterns, a specific fingerprint of DNA sequences is proposed. With this new method we study the statistical properties of exon and intron DNA sequences finding specific statistical differences. Moreover, by analyzing DNA sequences of different species from Bacteria to Man, we estimate the evolution of these linguistic DNA features along the evolutionary tree. The results are consistent with the idea that the flux of DNA information is not random, but that it is formed by patterns of repetitions along the evolutionary tree. The implications for evolutionary theory will be discussed.

### **The Nonlinear Dynamical Hypothesis in Science Education Problem Solving: A Catastrophe Theory Approach**

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The current study tests the nonlinear dynamical hypothesis in science education problem solving by applying catastrophe theory. Within the neo-Piagetian framework a cusp catastrophe model is proposed, which accounts for discontinuities in students' performance as a function of two controls: the functional M-capacity as asymmetry and the degree of field dependence/independence as bifurcation. The two controls have functional relation with two opponent processes, the processing of relevant information and the inhibitory process of disembedding irrelevant information respectively. Data from achievement scores of freshmen at a technological college, were measured at two points in time, and were analyzed using dynamic difference equations and statistical regression techniques. The cusp catastrophe model proved superior comparing to the pre-post linear counterparts. Besides the empirical evidence, theoretical analyses are provided, which attempt to build bridges between NDS-theory concepts and science education problem solving and to neo-Piagetian theories as well. This study sets a framework for the application of catastrophe theory in education.

### **Chaotic and Pseudo-chaotic Systems: Simulations and Implementation**

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Almost in any field of science and technology some sort of stability problem can appear. Instability and chaos are certainly the most important phenomena which should be treated before any other aspect of reality will be attacked. Hence, it is not very surprising that a broad variety of approaches to the problem of stability, instability, and analysis of chaotic phenomena exists. Many of the most popular techniques in the field of stability and chaos are in a certain sense related to the work of A. M. Lyapunov. For instance the well known Lyapunov exponents in chaos theory or Lyapunov functions in stability theory can be mentioned as typical examples which seem to be energy oriented. Tellegen's theorem is one of the well known and appropriate forms of energy conservation statement in the field of electrical engineering. The most important feature of Tellegen's approach is the fact that the energy conservation principle holds without any regard to physical nature of constituent network elements. This is the key idea of the proposed approach to problems of stability, dissipativity, and chaos. Certainly, any realizable system has to fulfill some causality and energy conservation requirements. Recall that existence of an abstract state space representation is necessary for a system to be causal. On the other hand, causality does not imply energy conservation. In the paper basic concepts concerning dissipativity, conservativity, state minimality, internal stability, instability and chaos are examined from a unified structural point of view. Both the linear as well as non-linear state-output system representations are discussed.

### **Modeling the Neurobiology of Schizophrenia: Present Status and Perspectives**

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Schizophrenia is a very complex with regard to the symptomatology, the time course, and the aetiology. Nevertheless, neuropsychiatry has therapeutic success by dopamine D2 receptor blocking medications. Neurobiological research is focusing onto mesocortical hypoactivity of D1 receptor-based, and mesolimbic hyperactivity of D2 receptor-based dopaminergic transmission. Basically, the neurocircuitry models proposed by Nobel price winner Arvid Carlsson are used as a framework to explain positive symptoms (e.g. hallucinations, delusions) and negative symptoms (e.g.

withdrawal on a qualitative level (comp. Carlsson et al. 1999). Still nearly no mathematical descriptions and analyses of those circuits were developed, probably because they are too complex. However, mathematical models in the form of artificial neural networks were applied to simulate acoustic hallucinations showing that intense pruning (loss of synapses) in adolescence could be the cause of spontaneous production of word detection (Hoffman & Hawkins 1989). Lately, the neurobiological data of prefrontal microcircuits were integrated in network models which use biophysically based neurons to explain deficiencies in working memory tasks as they are seen in schizophrenia (Wang et al. 2004). Those models show the relevance of local disinhibitory feedback loops for persistence of neuronal discharge and resistance to destructor stimuli. Now the influence of dopamine can be tested, however modeling the dopamine synapse is another challenge in this new field of computational neuroscience.

### **The Ecology of Education and Our Biological Heritage: How Dynamics Can Get Us Back to the Future**

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The concept of “ecology” serves as an organic model (and metaphor) for studying and explaining complex educational processes as well as for predicting possible trajectories and outcomes of these processes. Underlying this ecological approach is the assertion that human nature is amiss with life in schools because these are, often, artificial environments that run counter to our genetic make up. Findings in History; Psychology; Anthropology; Biology; Ecology; and other disciplines corroborate that our biological heritage is essentially that of pre-agricultural, pre-industrial revolution humans who lived in small, interdependent, egalitarian bands/clans. Consequently, we do poorly in large formal bureaucratic hierarchies with one-way impersonal communication, information and decision-making denied the majority, and cogs-like behavior so common to schools and school systems. To be effective, pertinent, and efficient, schools need to address our biological heritage: small, band-like collaborative groups; personal recognition, respect, acknowledgement as important; opportunities to feel trustworthy and that we can count on others, know what's going on, have a say in important decisions, and influence over our own learning process; occasion to belong and feel part of something useful and significant; etc. In combination, the Nonlinear Sciences (human, physical, and life sciences) can help us get back to

(reclaim/understand) our biological past as well as create educational processes compatible with our genetic make-up and the complex realities of our agricultural-industrial world. I'll discuss how fractal geometry, self-organization and complexity theories, and other Nonlinear Sciences can help us perceive education in more organic ways conducive to accomplishing these goals.

### **Economics, Politics, Econometrics Foreign Aid and Democratization, Evidence from a nonlinear Multinomial Logit Model**

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The promotion of democracy has emerged as a major objective of aid in recipient countries (Barro, 1999; Przeworski et al., 2000; Epstein et al., 2004). Aims and Framework: We adopt an econometric approach to investigate any potential political effect of foreign aid flows in recipient countries. The assessment of the empirical impact of aid on democracy has been confined to the effect of total aid flows, which has been found insignificant. Moreover in these studies it is implied that the causal linkages of political regime with various economic and non-economic variables can be described in a context of simple linear relationships ignoring the fact democratization is often documented to occur globally in infrequent but massive waves. Another drawback of previous empirical studies is that have largely relied on cross-section analysis which is subject to several statistical drawbacks, such as limited robustness in the presence of nonlinearities, model misspecification, co-linearity of explanatory variables, simultaneity bias, and parameter heterogeneity. We extend this literature in a twofold manner. First, we use a discrete response nonlinear approach in a probabilistic framework that is better suited to capture the nonlinear behavior of democratic transitions. Second, we identify the impact of an important determinant of democracy, namely democratic aid, which has increased substantially in the recent years as a tool to promote democracy in aid-recipient countries. Methods and Samples: We classify 61 aid-recipient countries according to their prevalent political regime into three broad classes (termed non-free, partly free, and free) following their Freedom House political status ratings over the 1972-2004 period. We then use a large set of lagged exogenous variables, including political, economic, social, and other factors, to control for the impact of other variables on the political regime of recipient countries. Results: The main results of the paper can be summarized as follows. First, we do not find any evidence that the probability a country demonstrates democratic transition depends on the level

of total foreign aid. In contrast, we find that democracy aid flows exert a statistically significant positive impact on the likelihood of democratic transition. Conclusions: Given the lack of any democratic impact of total aid disbursements and the strength of the assessed positive impact of democracy aid, a by-product of our analysis is that other aid categories may have operated adversely on the democratization of recipients. Implications: Our findings indicate that general-purpose assistance or development aid does not affect the democratization of recipients; in contrast, the results highlight the essential role of democracy aid projects in promoting the democratic transition of recipient countries.

### **Fractal Time in Cognitive Processes**

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The way an observer perceives the world is deeply rooted in the structure of this observer's interface with the outside world [1]. In order to account for cognitive performances such as the generation of succession and simultaneity, the internal organization and complexity of the world/observer interface is assumed to display a fractal structure [2]. The fractal structure is the result of repeated nestings of temporal intervals into the window of the present, the Now. This iterative embedding process shapes the world/observer interface by increasing its complexity with every new nesting of temporal intervals. It is shown that we must assume simultaneity to logically precede succession in order to explain the structures of our temporal interfaces. This assumption is supported by experimental data on the subjectively varying temporal extensions perceived by different observer types. Against the background of my Theory of Fractal Time, which differentiates between  $\Delta t_{\text{length}}$  (successive events),  $\Delta t_{\text{depth}}$  (simultaneous events) and  $\Delta t_{\text{density}}$  (the fractal dimension of time, a derivative of  $\Delta t_{\text{length}}$  and  $\Delta t_{\text{depth}}$ ), such observer types are defined [3]. The fractal structure of our temporal interfaces may result in both complexification and decomplexification of our perceptions. The structure of our interface realities, i.e. our perceived temporal extensions, may thus be modified by adjusting existing relations of inside/outside simultaneity. This would induce an entrainment process, in which the observer's internal temporal structure is enslaved by the embedding one or (vice-versa) makes the outer structure lock into the internal dynamics of the observer.

### **Chaos Theory, Change, and the Process of Psychotherapy**

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Both chaos theory and psychotherapy deal with the process of change. Change is a constant in any system. In dynamical systems change can occur at different rates. We look at three questions in this paper. How does change occur? What facilitates the process? What are outcomes or goals of this process in psychotherapy? Is the therapist a fixed or strange attractor who draws the client into dissipating a system of patterns and habits and into building a new and more complex system? Chaos theory clarifies what happens in non-linear systems. This applies to psychotherapy where change is the goal. Clients come into treatment because of problems they are unable to resolve or because of strong emotional states, which are maladaptive. The process of undergoing psychotherapy de-stabilizes the existing system to re-organize into a new more adaptive and balanced system. Bifurcation occurs very quickly when the control parameter is accessed, or increased. Energy seeks to flow as fast as possible and structured flow moves energy faster as increased levels of ordered complexity are achieved and change is expedited. We discuss how it occurs, when it occurs, internal/external factors, outcomes. This paper will also examine changes in patterns, which occur as improved mental health in a re-organized system is achieved via therapy. Implications: This paper examines chaos theory, the nature and pace of the change process in dynamical systems in a context of psychotherapy.

### **A Complexity Analysis of Borderline Personality Disorder**

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Borderline Personality Disorder (BDP, DSM IV-TR 301.83) is described as a pervasive instability of interpersonal relationships, self-image, and affects and marked impulsivity beginning by early adulthood and present in a variety of contexts as indicated by five or more of nine criteria (see DSM IV-TR, pg. 710). "There is considerable variability in the course of BDP. The most common pattern is one of chronic instability in early adulthood with episodes of serious affective and impulsive discontrol and high levels of use of health and mental health resources ... During their 30's and 40's, the majority of individuals with this disorder attain greater stability in their relationships and vocational functioning ... (DMS IV-TR, pg. 711-712)." Individuals dealing with Borderline Personality Disorder issues frequently demonstrate oscillatory-like behavioral dynamics in which, for a period of time, they will appear to exhibit "negative" behaviors and then, at some unpredictable point, they will appear to alter their behavior such that it appears to exhibit more "positive" behaviors. The unpredictability of the switching between two apparent behavioral pseudo steady-states suggests

that BDB could be viewed within the framework of chaotic dynamics as a strange attractor. This also suggests that perhaps nonlinear complexity analysis methods might be applicable to both the understanding of and the potential classification/prediction of Borderline Personality Disorder Dynamics. In this presentation, we examine the construct of BDP from a complexity theoretic approach. We demonstrate different algorithms for encoding “borderline” behavior patterns, focusing on symbolic encoding in order to make use of symbolic dynamics as a means of understanding, potentially predicting, and hopefully classifying Borderline Personality Disorder client behaviors. We employ measures of complexity to analyze the statistics of the symbols and discuss the importance of random (stochastic) nonlinear error catastrophe and stochastic resonance.

### **Nonlinear Stochastic Modeling of Multiscale Parasitic Behavior - Handling Chagas’ Disease**

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Infectious diseases, in spite of antibiotic and other treatments, remain one of the biggest medical problems to date. The overall problem of understanding host-parasite dynamics is extremely important, as it is intrinsic to the study of infection at all organismal scales. Many examples of such host-parasite systems exist, with debilitating and/or fatal consequences for humans all over the planet; malaria, schistosomiasis, and Chagas’ Disease for example. Epidemiologically, it is estimated that around 2 billion people are estimated to harbor STH and schistosomiasis worms. Morbidity estimates are that 300 million individuals are severely ill with worms, of which 50% are school-age children. Mortality estimates, for Africa alone, find that the death toll due to schistosomiasis may be as high as 200,000 per year. Despite recent advances in the control of Chagas’ Disease, millions of Latin Americans and numerous US citizens remain at risk for infection with the *T. cruzi* parasite, the causal agent in Chagas’ Disease. In terms of disability adjusted life years, Chagas’ Disease is globally ranked behind only malaria and schistosomiasis as the most serious parasitic diseases worldwide. Twelve species of triatomines are known to occur in the United States, the most important being *Triatoma sanguisuga* in the eastern United States, *Triatoma gerstaeckeri* in the region of Texas and New Mexico, and *Triatoma rubida* and *Triatoma protracta* in Arizona and California. Because of its complex life-cycle, *T. cruzi* provides one of the most fascinating and complex, yet sophisticated initial model systems for investigation. American trypanosomiasis, or Chagas disease, is a protozoan zoonotic disease caused by the haemoflagellate *Trypanosoma cruzi*, and is transmitted to humans either

by blood-sucking triatomine vectors, blood transfusion or congenital transmission. This parasite infects over 150 species from 24 families of domestic and wild mammals, as well as humans. In the vertebrate host, *T. cruzi* infects many different cells, but in the human host, the disease is conspicuously limited to the myocardium and to gut nerve fibers. Chagas’ disease is present in 18 countries on the American continent in two different ecological zones. Country-wide cross-sectional surveys in the 1980s found an overall prevalence of 17 million cases, with 4.8–5.4 million people exhibiting clinical symptoms, an annual incidence of 700,000–800,000 new cases and 45,000 deaths due to the cardiac form of the disease. Other studies indicate an infection prevalence of 13 million, with 3.0–3.3 million symptomatic cases and an annual incidence of 200,000 cases in 15 countries, with estimates of death around 50,000 people. Despite nearly 100 years of research on the *T. cruzi* parasite, we still understand very little about its dynamics. Possible outcomes are infection with no symptomology, Chagasian cardiomyopathy (which is frequently fatal), or megasyndromes (which primarily affect the digestive tract, are untreatable, and fatal). In this presentation we examine the use of high performance computational modeling as a means of addressing this large class of research problem. High performance computers have been around since the earliest generations of the Cray, ETA10, Connection Machine and many others. However, with the new advances in grid computing, the new generation of the internet and of software/hardware capabilities coupled with the lambda rail and the teragrid, it is now possible to envision the use of HPC environments coupled in a way that creates, what we have chosen to call “an in silico laboratory.” Such an environment provides a computer-based laboratory to study host-parasite dynamics in ways that are not readily amenable to in vivo/in vitro laboratory research. In this presentation, which requires no biological background, we will examine the development and visualization of a large-scale “in silico” laboratory environment to model host-parasite dynamics that focuses on understanding Chagas’ disease. This project is called the Virtual Parasite Project.

### **Complex Dynamics of Socio-Natural System**

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While non-linear dynamic systems have been proved to be a proper tool of modeling in physics, their application in social sciences is still very limited. The interaction between social and natural phenomena clearly escapes rationality trap, as nature cannot be rational. But very often low-dimensional systems can both represent an interesting dynamics and allow for some analytical tractability along with numerical robustness of results. Here two three-dimensional models of such type will be

presented. The question about sustainability of economic growth under limited natural resources does not have a unique answer. The first model focuses on interaction between economics and nature and shows that Malthusian and neoclassical concepts can represent two extreme cases of more complex dynamical system, which is governed only by three non-linear differential equations for population, natural resources and technology. The system is derived using quite standard relationships, but taking part of them from economics and other part from biology. The second model is about the link between urbanization and demographic transition. While more than three economic and social variables are used initially, the dynamics is governed by the system of three differential equations for capital, total population and rural population. While the first model predicts a possibility of a catastrophe after a period of almost exponential growth, in the second model population stabilization can take place due to low fertility in urban areas.

### **Ising Model of Society**

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Ising model is well known in physics, and Glaeser, Sacerdote and Scheinkman (1996) have used it to explain the spread of criminality. Earlier, T. Shelling (1971) explained segregation using two-dimensional grid with local interaction. In the most of neoclassical economic models agents interact only through markets. This limits the class of interaction mechanisms and does not allow for explaining all socio-economic phenomena. Local interaction represents an alternative order-generating principle. In the present article, the Ising model is used to demonstrate the emergence of spatial clusters due to local interaction. The presence of external field is another model extension. It changes the average preferences or actions in the society. Being combined with local interaction, it produces a stronger effect, resulting in a kind of "social magnetization". Such thermodynamic concepts as temperature and pressure have their analogies in socio-economic models. Temperature is proportional to kinetic energy, which has an analogy with income of agents; higher income gives higher variety of choices and mobility in actions. On the other hand, pressure can be treated as external field that limits this freedom. The standard neoclassical economic model is about "gas society", with relatively high temperature and low pressure. Local interaction makes this society more liquid, and we observe some clusters of neighboring agents who also have similar actions. High external field (pressure) and a low income can lead to solid state (or crystal), where agents have low mobility and few choices in actions.

### **Critical, Subcritical, and Supercritical States in the Brain**

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Many researchers argue that the brain as a complex system operates strongly at the critical point. For instance, Per Bak wrote in his book [1]: "The input signal must be able to access everything that is stored in the brain, so the system cannot be subcritical, in which case there would be access to only a small, limited part of information. Grains dropped on a subcritical sandpile can only communicate locally by means of avalanches. The brain cannot be supercritical either, because then any input would cause an explosive branching process within the brain, and connect input with essentially everything that is stored in the brain. Hence, the brain must operate at the critical state where the information is just barely able to propagate." This paper aims to show that actually both subcritical and supercritical states also exist in the brain and all three states have clear psychological meaning. Subcritical state we associate with subconsciousness, the critical state – with consciousness, and supercriticality – with creativity, which sometimes also call superconsciousness. Realization of these states depends on the branching parameter  $\sigma$  [2]. The general ensemble firing of neurons is classified as subcritical ( $\sigma < 1$ ) if one neuron firing leads, on the average, to less one additional neuron firing, critical ( $\sigma = 1$ ) if one firing leads to another firing, or supercritical ( $\sigma > 1$ ) if a firing leads to two or more neurons firing. In this regard, neural cells triggering each other are somewhat like chain reactions in a nuclear reactor. We relate the branching parameter with degree of subdivision  $g$  introduced by Y. Bar-Yam for neural attractor network models [3]. For  $g=0$  (which means also low average number of neurons activated by one neuron) we have completely subdivided network and this case it is naturally to relate with subconsciousness. We suppose that for  $0 < g \leq C < 1$  consciousness and different altered states of consciousness are taken place. For  $C < g < 1$  (high number of neurons activated by one neuron) we have partially subdivided neural network which Y.Bar-Yam associates with creativity. A comparison of our approach with R. Ferrero I Cancho and R. Sole model emergence of language is made [Cancho R F., Sole R. (2003) Least Effort and the Origins of Scaling in Human Language. PNAS, vol.100, 788-791]. We consider "no-communication" and "perfect-communication" phases in this model as "subconsciousness" and "superconsciousness" states respectively. Recently, D. Chialvo with coworkers experimentally shown, that the brain functional networks are scale-free. We discuss the possibility of subcriticality and supercriticality in such functional networks where control parameter is a clustering coefficient.

## **POSTER PRESENTATIONS**

### **Variability of Brain Coordination Dynamics in Normal Physiology and Pathology**

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Fluctuations in phase synchrony have been characteristically found in recordings from both normal physiological brains as well as pathological ones. These fluctuations, characteristically termed as noise, are logistically difficult to separate from true neuronal activity largely due to current recording and analysis methods. We propose that phase synchrony fluctuations serve to maintain brain activity in an optimal state for cognitive processing, thereby not allowing it to fall into long-term periodic behavior. We compared fluctuations from controls to those found in patients with epilepsy or traumatic brain injuries (TBI). Phase synchronization analysis using the Hilbert Transform was performed on magnetoencephalography (MEG) and electroencephalography (EEG) recordings from controls and patients. In the MEG study, 4 epileptic patients and 4 controls were tested. A total of 14 head-injured children and 2 controls were analyzed using scalp EEG, after performing a Laplacian Derivation. Results - Phase-locking patterns between brain areas were found to display fluctuations at different scales. Both epileptiform activity and TBI had relatively low levels of fluctuations in phase synchrony. This may contribute to the generation of synchronized states seen in patients with these brain disorders. Conclusions and Implications. Determination of phase-locking patterns and their variability in brain recordings reveals characteristics of the pathologies with which they are associated. While there is no clear distinction between noise and high-dimensional dynamics, we propose that the examination of neuronal fluctuations at different levels will provide important insights into our understanding of the relationship between brain and behavior

### **A Study of Mental Health Problems Among the Aged in Chandigarh (India)**

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Results: A Cross-sectional study of 361 aged persons of age 65 years and above was conducted in Chandigarh city, India to study the mental health problems and it was found that females had higher mean score on anxiety, depression, somatic and cognitive symptoms as compared to males anxiety, depression. Anxiety, depression mean score was higher among the aged who lived alone and also it was more in females than males. Widows had higher mean score than widowers among the aged who lived with the family on anxiety, depression and somatic symptoms. Depression and somatic mean scores was higher in females as compared to males in all the microenvironment groups. Statistical Analysis: Statistical t-test & Z test were used for the analysis of the data.

### **Technologies for Biomass Conversion**

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Biomass processing is a new technology within the area of renewable energies. Current energy supplies in the world are dominated by fossil fuels (some 80% of the total use of over 400EJ/year). Nevertheless, about 10-15% of this demand is covered by biomass resources, making biomass by far the most important renewable energy source used to date. On average, in the industrialized countries biomass contributes some 9-13% to the total energy supplies, but in developing countries the proportion is as high as a fifth to one third. In quite a number of countries biomass covers even over 50-90% of the total energy demand. A large part of this biomass use is however non-commercial and used for cooking and space heating, generally by the poorer part of the population. The (technical) potential contribution of bio-energy to the future world's energy supply could be very large. In theory, energy farming on current agricultural land could, with projected technological progress,

contribute over 800 EJ, without jeopardizing the world's food supply. Organic wastes and residues could possibly supply another 40-170 EJ, with uncertain contributions from forest residues and potentially a very significant role for organic waste, especially when bio-materials are used on a larger scale. In total, the upper limit of bio-energy potential could be over 1000 EJ/year. Classic application of biomass combustion is heat production for domestic applications. This is still a major market for biomass for domestic heating in countries like Austria, France, Germany and Sweden. Use of wood in open fireplaces and small furnaces in houses is generally poorly documented, but estimated contributions to meet heat demand are considerable in countries mentioned. A key issue for bio-energy is that its use should be modernized to fit into a sustainable development path. Especially promising are the production of electricity via advanced conversion concepts (i.e. gasification and state-of-the-art combustion and co-firing) and modern biomass derived fuels like methanol, hydrogen and ethanol from ligno-cellulosic biomass, which can reach competitive cost levels within 1-2 decades.

### **EEG Responses to Complex Fractal Stimuli**

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Fractals are complex geometric shapes with a high degree of self-similarity. Recent investigations on humans have shown that fractals have a profound aesthetic appeal; moreover they affect the physiological responses during stress. In contrast, studies of the EEG responses to fractals are uncommon. AIM: The aim of this study is to describe the effects of fractal patterns on the ongoing EEG activity. METHODS: Continuous EEG activities were recorded from 20 healthy children during three different passive viewing conditions: a series of geometric figures, a series of figures with imaginary contours (Kanizsa), and a moving fractal pattern (Mandelbrot set). The Synchronization Likelihood -SL (C.J. Stam), a measure of linear and non-linear interdependencies between EEG segments was

computed. Statistical evaluation was performed using ANOVA. RESULTS: The fractal pattern resulted in an increased synchronization of the EEG activities over the parieto-occipital areas. This increase was observed for both gamma-1 and gamma-2 bands SL, which are considered as the physiological basis of perceptual binding, as well as the broadband SL, indicative of a more complex pattern of interdependencies that is not frequency-specific. CONCLUSIONS: Complex fractal visual stimuli are very useful in the evaluation of the EEG reactivity and the binding phenomenon, and might provide a neurophysiological basis for the aesthetic preference of fractal images.

### **Chaotization and Synchronization Of Rotifer Dynamics in a Heterogeneous Environment**

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The current state of knowledge of plankton population dynamics principles is unsatisfactory on empirical as well as theoretical grounds. The main problems are first, the complexity of plankton dynamics, which are impacted by both inherent non-linearity underlying changes in plankton abundance and some external factors, and second, the lack of experimental and observational data. That is the reason why mathematical modeling is considered as the instrument, which can furnish insights into the phenomena leading to complex plankton dynamics. It is remarkable that complex plankton dynamics can be simulated with the use of very simple conceptual mathematical models. Within the framework of such an approach, Snell and Serra [Snell T.W. & Serra M. 1998] have developed a discrete-time model (Consensus model) of rotifer populations. Rotifers are planktonic animals and inhabit freshwater environments, such as lakes and rivers. Consensus model [Snell T.W. & Serra M., 1998] is realistic enough to capture the relevant biology but is simplified to a level where the parameterization of the model becomes possible. Subsequently, Berezovskaya et al. [Berezovskaya F., 2005] carried out a sophisticated mathematical analysis of the Consensus model and identified a number of dynamical regimes, including stable equilibrium, periodic oscillations and chaotic oscillations in a the model parameter space. The freshwater reservoirs can be significantly heterogeneous. This observation creates the biological basis for considering the dynamics of aquatic communities in a

patchy environment. In this connection, aquatic communities can be mathematically described as a set of interconnecting habitats. Recently, we have modified the Consensus model in order to study the role of biomass exchange between two rotifer populations with different intrinsic dynamical properties in the dynamics of the populations inhabiting heterogeneous environment [Medvinsky A. et al., 2005]. Here we apply the modified Consensus model to a set of coupled habitats. We show that chaos can disturb originally regular oscillations of the rotifer density as the biomass exchange between neighboring habitats increases. As a result, regular oscillations can become chaotic leading to invasion of chaos. However the chaos invasion is found to be spatially confined. This confinement is due to invariance of the attractor size. The rotifer biomass exchange leads to the formation of the regions, i.e. clusters, inside which the rotifer densities oscillate synchronously, while there is no synchronization between oscillations in separate clusters. When the intensity of the biomass migration is changed, the clusters can change their size. The detection of chaotic dynamics in natural waters can be hampered by the fact that chaotic oscillations are spatially confined. This research was partially supported by the RFBR grant 04-04-9649

### **Complexity and Nonlinear Dynamics of the Autonomic Nervous System**

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The autonomic nervous system (ANS) is one of many physiological systems that exhibit complex nonlinear dynamics. The ANS consists of sympathetic and parasympathetic nervous subdivisions, the modulation of which maintains the homeostasis of visceral organs. Under normal conditions, the heart exhibits its intrinsic rate and the sympathetic and parasympathetic tones increase and decrease the rate, respectively. Their dual and mutually antagonistic actions form complex relations to the heart rate variability (HRV) in the maintenance of homeostasis. In response to stress, the dual reciprocal complexity amplifies the stress response. Perfect homeostasis requires such oscillations of the ANS, whereas loss of the oscillations is a strong predictor of sudden cardiac death, especially after myocardial infarction. It is hypothesized that neural oscillations facilitate defence mechanism and adaptation. To test this theory, ten human volunteers were instrumented, both supine and upright, during pharmacological infusions of sympathetic and parasympathetic blockades. The principal dynamic mode

(PDM) methodology was used to investigate separate dynamic characteristics of the ANS. Results demonstrated that the PDM can separate the dynamics of the two systems, which is important because the two nervous subdivisions are known to interact. Changing position from supine to upright causes an increase in sympathetic tone and a decrease in parasympathetic tone. Furthermore, with the pharmacologic blockers, the presence of the unblocked system attenuates the response to perturbations, suggesting complex nonlinear interaction behavior. These findings support the thesis that complex nonlinear dynamics of ANS facilitate homeostasis in response to physiologic stress.

### **Mapping the Mind**

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Traditional approaches to understanding perceptual processes emphasize static representational structures that minimize time dependencies and ignore the potentially dynamic nature of such representations. This study explores the visual perceptual system from a dynamic pattern formation concept in an attempt to describe individuals' similarities and differences in shaping their internal representations. Participants' visual perceptual system is investigated with respect to a specific object. The study particularly probes what is an individual sees when he/she is looking at something. For many investigators the quandary of perception resides in how properties of the world come to be represented in the mind of the perceiver. In this project, however, there is less concern with the contents of perception and more interest towards the dynamics of perceiving. This study explored individual concept space at a specific point of time, and contrast it with the concept space of other individuals.

### **Nonlinear Oscillating Phenomena in Biosystems: Statistical Approach**

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Biosystems have tendency to repeat their activities in time. These cycles are very important in many essential biological processes that occur in a "scheduled" fashion (eating, sleeping, cellular regeneration). Chronobiology is a part of biology that examines these time related

phenomena in living organisms. The most important rhythm is the "circadian" rhythm, which refers to the (roughly) 24-hour daily biological cycle. There are many other important cycles like infradian rhythms (long-term cycles), ultradian rhythms (short-term cycles), tidal rhythms and the others. We have studied the influence of the other biological oscillators on the circadian rhythm (the " internal body clock "). Some very important oscillating parameters like immunoglobulin ( IgA, IgG and IgM ), the blood pressure and the heart frequency are examined. Our sample was the group of 22 young men in the age between 20 and 23. We used ANOVA (Analysis Of Variance) test. Our investigation confirmed that the oscillating character of these parameters is correlated to the circadian rhythm.

### **Clean Technologies for Energy Production from Coals**

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Carbon dioxide is captured from exhaust gases by a selective separation using a cyclic adsorption process, wherein the absorption step of the process is conducted by passing the gas mixture through an absorption zone containing selective absorbents such as carbon molecular sieve and zeolites. Physical absorption system is operated in pressure swing adsorption (PSA) or temperature swing adsorption (TSA), wherein the gas is absorbed and then the initial conditions are modified to desorb the gas. The technical feasibility of the process is dictated by the adsorption step, whereas the desorption step controls its economic viability. Strong affinity of an adsorbent for captured CO<sub>2</sub> from exhaust gas is essential for an effective adsorption step and for this it is developed regenerable sorbents that have high selectivity, high regenerability and high adsorption capacity for CO<sub>2</sub>, properties critical for the success of the PSA/TSA process. There will be used carbon molecular sieve made of ICSI, zeolites, laboratory plant that there is at ICSI, gas analyze devices (gas chromatograph, gas spectrometer, atomic adsorption spectrophotometer, etc).

### **Nonlinear Analysis of Digital Images and Doppler Measurements for Trophoblastic Tumor**

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Cancer can be viewed as a complex adaptive system. Complex adaptive systems can be described mathematically by nonlinear (chaos) theory including asymmetry, fractal structure and autocorrelation factor. Taking into consideration spatial irregularity and heterogeneity of internal structures of tumor cells, we examined deterministic chaos of trophoblastic tumor for organ, cellular, molecular levels on digital images and their Doppler measurements of blood flow. The digital images were tested by evaluation of contours deformation level and quantitative heterogeneous pattern. The proposed algorithm for estimation of spatial chaos in digital medical image is based on calculation of the skew and the spread parameters, fractal dimension and autocorrelation function. Ultrasound images demonstrated higher values of the skew parameter for the uterus of choriocarcinoma patients than hydatidiform mole and healthy individuals. The registered changes in nonlinear dynamics of uterine artery blood flow tending to diminish deterministic chaotic process in choriocarcinoma. Nonlinear analysis of cell images for chorionic villi and tumor suppressor gene p16 evidenced the tendency of increase in spatial chaos for patients with choriocarcinoma. The concept of deterministic chaos is hierarchical for the host during trophoblastic disease.

### **An Application of Latent Semantic Analysis to a Binary Attractor Neural Network Producing Arbitrary States of Latent Order**

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Abstract: The theory of Primary Mental Models (PMM; Pavloski, 2005a,b) portrays qualities of experience as expressions of latent global order in a mental space of relations that emerges from certain types of neural interactions. This presentation reports analyses (inspired by latent semantic analysis) of a neural network that produces latent order through interactions of arbitrary relations within clusters of neurons (Pavloski, 2006). Ten simulations of a 441 neuron, 49 cluster networks were run for the cases of 8, 16, 32, 64, 128, and 256 patterns of neuron activities satisfying each of two possible relations within each cluster (degree of degeneracy). On each of 3600 iterations, the 441 neurons were randomly sampled and their state was updated according to Glauber dynamics (i.e., 1,587,600 samples). Each simulation was then replicated from the same starting state. Singular value decomposition (SVD) of

matrices of neuron activities for the final 3500 iterations was used to identify the neurons composing the clusters whose relations interact to produce the states of latent order. The aim was to determine how accuracy of identification varies with the degree of degeneracy. The first matrix of the SVD portrays each neuron as a vector of length 1 to 441. The task is to find the length that maximizes hits (H; the correct detection of pairs of neurons that are members of the same cluster), and that minimizes false alarms (FA; the incorrect identification of pairs of neurons that are not members of the same cluster). The optimal length of neuron vectors increased, and Pr (H) Pr (FA) decreased with the degree of degeneracy. Including data from both simulations having the same starting state increased Pr (H) Pr (FA). When Pr(FA) = 0, Pr(H) was increased substantially by including as cluster pairs neurons that were each related to a third. It is concluded that SVD provides a promising approach for the accurate detection of latent order. Implications for the analysis of actual neural data are considered.

**Effects of Shallow Breathing on the Fractal Correlation Properties of Heart Rate Dynamics: An Alternative Explanation for the Buteyko Effect**  
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There is a growing interest in the nonlinear dynamics of heart rate fluctuations and in theories, which view the heart as part of a large feedback system, characterized by complexity and fractal long-term correlations. Breakdown of this fractal, scale free organization of cardiac dynamics, either towards periodicity, or uncorrelated randomness, has been associated with aging and serious heart diseases (Goldberger, Peng, & Lipsitz, 2002). It is also well known that breathing patterns affect the heart signal directly through respiratory sinus arrhythmia, or indirectly by altering blood CO2 concentrations. Little is known, however, about the effects of respiration on complexity and the fractal correlation properties of cardiac interbeat interval dynamics. Our main aim in this study has been to investigate and quantify the effects of a specific breathing training known as the Buteyko method, on the fractal scaling of the heart rate signal. The Buteyko

Breathing Method (BBM) is characterized by shallow and slow breathing, aiming at restoring and preserving normal blood CO2 concentrations. At the moment, the BBM is widely used in clinical practice mainly as a treatment for asthma. Although the clinical results are impressive, there is controversy about the physiological mechanisms responsible for the observed improvements, mainly due to the lack of basic research on the subject. Thirty-five undergraduate students participated in a physiological experiment where we measured breathing parameters (amplitude, rate and PetCO2) and continuous ECG, during two three-minute conditions (normal and shallow breathing) performed in counterbalanced order. To assess the fractal long-term correlations in the cardiac interbeat interval time series, we used the fractal scaling exponent 'a' obtained by detrended fluctuation analysis (Peng, Havlin, Stanley, & Goldberger, 1995). The significant differences found between breathing amplitude and PetCO2 levels during the two experimental conditions (PetCO2 was higher and breathing amplitude lower during the BBM) were used as a criterion to verify the effectiveness of the respiratory intervention. Our results showed that during shallow breathing the scaling exponent 'a'; was significantly closer to 1 ( $F(1, 34) = 8.440; p < 0.01$ ), indicating stronger fractal long term correlations in the heart rate signal. Our results show a clear effect of the BBM on the fractal properties of heart rate dynamics. To our knowledge, this is the first study suggesting that slow and shallow breathing may be an effective way to voluntarily improve cardiac dynamics towards a scale invariant organization, characterized by long term correlations and greater adaptability. The clinical implications of these results are important if we consider that traditional breathing training usually involves deep and paced breathing. Viewed from the perspective of complex adaptive systems, this type of respiratory intervention may reduce heart adaptability by creating dominant frequencies and mode-locking. In contrast, shallow breathing is shown to improve the temporal correlation properties of heart rate behavior, a probable indicator of a more flexible and adaptive system state.

**College of Agriculture and Natural Resources Faculty Members` Attitude Toward Using Information Technologies for Teaching**  
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Rapid changes in the computer and information technologies have encouraged universities to re-envision

ways of incorporating technology in educational and research functions (UC Berkeley Accreditation, 2002). Faculty members play focal role to incorporate equipment and software into the educational and research processes (Gilmore, 1998). In the meantime, faculty members' attitude toward using information technologies for teaching and learning activities is a determinative factor, because the attitude of faculty to online instruction affects the willingness of instructors to teach online (Wilson, 2001). The main purpose of this study was to determine faculty members' attitude toward using information technologies for teaching and learning. The objectives of this study were to: 1. Describe personal characteristics of faculty members; 2. Describe the level of using information technology by faculty members in educational and research activities; 3. Determine the relationships between faculty members' personal characteristics and their attitude toward using information technologies; 4. Determine the relationships between the level of using information technology by faculty members in educational and research activities and their attitude toward using information technology. This study used a descriptive and correlational survey method and the population of the study included all faculty members at Tehran and Tarbiat Modarres Universities, College of Agriculture and Natural Resources (N=267). A systematic sampling technique was used to select faculty members in the study (n=158). Faculty attitudes toward information technology were assessed using an on-line questionnaire. Content and face validity were established by a panel of experts consisting of faculty members at Tarbiat Modarres University, College of Agriculture. A pilot test was conducted with 20 faculty members at Tarbiat Modarres University, College of Agriculture. As a result of the pilot test, minor changes were made in the questionnaire. Questionnaire reliability was estimated by calculating Cronbach's alpha. The overall Cronbach's alpha coefficient for the instrument was 0.82. Results of this study show that nearly 92% of the respondents reported owning a personal computer at home and 98% of them cited that they have a computer in their offices. The results of the study illustrated that faculty members use information technologies in research activities more than educational activities. Most (89.9%) lacked experience in teaching learners E-learning. They did not perceive the climate to be supportive of the use of these technologies for education. Almost eighty percent (79.5%) of the faculty members indicated that they had never taught an online class to learners. According to results, the respondents had a positive attitude toward online education and E-learning as a general concept, but they stated that the most effective mode of instruction is combined education (face-to-face classroom instruction

and online education). Results indicated that there was a significant relationship between respondents' age, computer access, their knowledge and skills level, and their attitude toward using information technology. In general, they agreed that these technologies could make a valuable contribution to the learning process. The results of this research could help Iranian universities and educational institutions better understand their faculty members' toward e learning and the use of information technology in education. Yet faculty members' attitudes must be addressed to integrate more fully these technologies into the teaching and learning process.

### **Language Development as a Dynamic Process: Language Attrition in German Migrants in the Netherlands**

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*de Bot, Kees*, University of Groningen

Language can be seen as a dynamic system on different levels: as an inter-individual system in itself that changes due to social changes and language contact, and as an intra-individual part of the cognitive system. The developments of a language, its emergence, change and decline over time are again dynamic developmental processes as is the development of language in individuals, from birth to old age. Language as an intra-individual system is part of the larger cognitive system and it is fully interconnected to other parts of that system. It also consists of subsystems itself, such as the lexicon, the grammar and the phonological system. In this poster a special case of language development will be presented: language attrition, the decline of language skills in individuals over time. Data from a study of attrition in German migrants in the Netherlands will be presented showing the close relation between language and identity and language decline as a result of interacting factors over the life-span. Language attrition is not a linear process of change with a simple relation between non-use and decline, but a very complex and non-linear processes in which many variables interact with that interaction changing over time as well. In this poster we will show how language decline is viewed by those suffering from it, using first-person accounts relating to the process

## **Studies on Dyslexia dynamics: Empirical Characterization with Respond Time Series Analysis.**

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The present research is an empirical exploratory study of Dyslexia dynamics. Dyslexia refers to a deficiency in the processing of distinct linguistic units. Current linguistic models of reading and dyslexia provide an explanation of why some very intelligent people have trouble learning to read. These models emphasize defects in the language processing rather than the visual system (Shaywitz, 1996). The present research hypotheses are associated with the dynamic nature of the phenomenon and aims to reveal its dynamic fingerprints. Seven subjects were involved in a stimulus-respond process. Four were dyslectic and three were non-dyslectic. The stimulus, a triplet of letters, was left for 30 ms, and then the subjects had to recognize the stimulus between two triplets containing the same letter but with different order. This test is actually part of a routine diagnoses test for dyslexia. The Response Times series, RT, (N = 1000), were measured, and they were analyzed as dynamic time series. Such biosignals in normal subjects have been found to possess characteristics of pink noise, indicative of a self-organizing process. In this study, the RT series were analyzed and characterized by recurrence methods of analysis. It was found that an effective approach was the calculation of the ration of consecutive to total recurrence. This refers to the concept of "Arrangement" (Sabelli, 2003), and it is a measure of nonrandom complexity. Plots of the ration of consecutive to total recurrence as a function of embedding dimension were use and they were compared with the corresponding plots of surrogate data. The obtained plots provided a picture, which differentiated dyslectic from non-dyslectic subjects. This empirical investigation is of a twofold paramount importance. First it supports the theoretical models, which emphasize defects in the language processing rather than the visual system. Second provide the basis for further work towards the development of a diagnostic test, easily performed as a computer game, and easily evaluated. In addition, further distinction between dyslexia and dyslexia-like deficiencies could be made.

## **Sexual Presence and Genital Arousal as Modulated by Fractal Ocular Dynamics**

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Background: Presence is a psychological state or subjective perception in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience (ISPR: <http://www.temple.edu/ispr/>). Sexual presence is a special type of presence generated by synthetic 3D sexual stimuli (Renaud, 2004; Renaud et al., 2005). As a kind of perception, sexual presence could possibly be inferred from ocular activity as well as from sexual arousal. Aims and Framework: Our main goal is to better understand the interplay between the feeling of sexual presence generated by 3D animated characters, the recording of eye movements and sexual arousal. Methods and Samples: A small sample (N=17) of male subjects were presented with a 3D animated character depicting a naked adult woman while their eye movements were tracked from an infrared eye-tracking device and their sexual response was recorded from a penile plethysmograph. Presence was measured from a homemade questionnaire. Detrended fluctuation analyses (DFA) were performed on time-series put together from the duration of each ocular fixation. Results: First, from DFA analyses and surrogate data tests, it appears that eye movements dynamics is fractal and distinct from noise (Renaud et al., 2003). Second, from regression analyses, it seems that feeling of presence as well as sexual arousal are modulated by fractal ocular dynamics. Conclusion and implication Fractal ocular dynamics, as a distinct level of perceptual activity, seems to be in resonance with how subjectively convincing and how sexually arousing a sexual illusion is.

## **The Feeling of Presence as Modulated by Nonlinear Perceptual Processes**

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UQAM, University of Montreal

Background: Presence is a psychological state or subjective perception in which even though part or all of

an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience (ISPR: <http://www.temple.edu/ispr/>). As a kind of perception, presence could possibly be measured from ocular activity recorded in virtual reality. Aims and Framework: Our main goal is to better understand the feeling of presence from the recording of eye movements in virtual reality. Methods and Samples: A small sample (N=11) of subjects were immersed in virtual reality environments to execute visual search tasks while their eye movements were tracked from a head mounted display combined with an infrared eye-tracking device. Presence was measured with the Presence questionnaire (Witmer and Singer, 1998). Gaze behavior, as it relates to the geometry of the searched virtual objects, was recorded (Duchowski et al., 2003; Renaud et al., 2002, 2003) and correlation dimension analysis was done on the time-series resulting from this recording. Results: First, from correlation dimension analyses and surrogate data tests, it appears that gaze behavior dynamics is nonlinear, fractal and distinct from noise. Second, the feeling of presence seems to be modulated by the nonlinear perceptual processes. Conclusion and implication: The plasticity as well as the perceptual rooting of the feeling of presence could be explained, at least in part, by the nonlinearity of oculomotor behavior displayed in virtual immersion.

#### **Different Neurons Population Distribution correlates with Topologic-Temporal Dynamic Acoustic Information Flow**

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It is reported a great variety of functional actions of GABA in auditory system. Although many studies reports the presence and distribution of GABA receptors; nevertheless, the studies about the inhibitory GABA-dependent neurons distribution in the Inferior Culliculus are scarce. We are interested in studies on the role played by GABAergic neurons in the acoustic information transmission in the Central Nucleus of Inferior Culliculus. The existence and distribution of GABAergic neurons in CNIC, could give us understandings on how the inhibitory actions of neurotransmitters are participating in ways which the information flow is spatial-temporal associated with the firing synchrony in each isofrequency region. And with these results, we could achieve some insights over the emergence of certain mind properties from neurons dynamics interactions.

#### **Modeling Stress Induced Hypothalamic-Pituitary-Adrenal System Activity**

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The hypothalamic-pituitary-adrenal (HPA) and the rennin-angiotensin-aldosterone (RAAS) system are both activated in stress reaction, in which the hippocampus plays very important role. Final products of these two systems, cortisol and aldosterone, share the same receptors, as well as the same precursors, so in our previously published model of the HPA system activity we have considered these two hormones as each others competitive antagonists, regarding the hippocampal MR. Aldosterone occupied MR exert disinhibiting influences on the HPA system activity (increasing GR mediated cortisol positive, and decreasing MR mediated cortisol negative hippocampal feedback actions), thus increasing the HPA system activity, and fine tuning the individual threshold for the HPA system activation. In this paper, we have further developed our previously published mathematical model, and considered the activity of this system during stress. Numerical analysis based on proposed model shows increased activity of the hypothalamic-pituitary-adrenal system caused by increased CRH secretion, in agreement with known facts from medical literature.

#### **Reversal of Ecology & Improvement of Ground Water Quality by HRTS**

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We are presenting results of more than 2 year research and a data of our Implemented project. Out particular Inspire is the area in the utilization of industrial waste & improving ground water quality as well as the disposal of waste with out any treatment cost. The key area is utilizing the tannery waste to the well-planned and designed particular species of plants and therefore by utilizing the waste as feed to the plants. As well as the waste will be utilized for ground water Quality improvement. By this research activity any industries

can also put up their waste in these areas and there by Green Environment is maintained and sustainability will be supported strongly. Biological output of the plants were collected and analyzed and the data will be projected. To confirm the ground water quality, Piezometer was installed and the Ground water quality sample will be submitted with respect to design in the full paper. Keywords: High Rate Transpiration System (HRTS)

### **Clean Technologies for Energy Production from Coals**

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Carbon dioxide is captured from exhaust gases by a selective separation using a cyclic adsorption process, wherein the adsorption step of the process is conducted by passing the gas mixture through an adsorption zone containing selective adsorbents such as carbon molecular sieve and zeolites. Physical adsorption system is operated in pressure swing adsorption (PSA) or temperature swing adsorption (TSA), wherein the gas is adsorbed and then the initial conditions are modified to desorb the gas. The technical feasibility of the process is dictated by the adsorption step, whereas the desorption step controls its economic viability. Strong affinity of an adsorbent for captured CO<sub>2</sub> from exhaust gas is essential for an effective adsorption step and for this it is developed regenerable sorbents that have high selectivity, high regenerability and high adsorption capacity for CO<sub>2</sub>, properties critical for the success of the PSA/TSA process. There will be used carbon molecular sieve made of ICSI, zeolites, laboratory plant that there is at ICSI, gas analyze devices (gas chromatograph, gas spectrometer, atomic adsorption spectrophotometer, etc). Key words: clean, technology, energy, coals.

### **How Chaosity and Randomness Control Human Health**

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We discuss the fundamental role that chaosity and randomness play in the determination of quality and efficiency of medical treatment. The statistical parameter of non-Markovity and informational measure of memory of dynamical processes from non-equilibrium statistical physics of condensed matters is offered as a quantitative information measure of chaosity and randomness. The role of chaosity and randomness is determined by the phenomenological property, which includes quantitative informational measure of chaosity and randomness and pathology (disease) in a covariant form. For the quantitative estimation of memory effects we use the results of statistical theory of random discrete non-Markov processes in complex systems. Manifestations of the statistical informational behavior of chaosity and randomness are examined while analyzing the chaotic dynamics of RR intervals from human ECG s, the electric signals of a human muscle s tremor of legs in a normal state and at Parkinson disease, the electric potentials of the human brain core from EEG s during epileptic seizure and a human hand finger tremor in Parkinson s disease. The existence of the above stated informational measure allows to introduce the quantitative factor of the quality of treatment. The above-stated examples confirm the existence of new phenomenological property, which is important not only for the decision of medical problems, but also for the analysis of the wide range of problems of physics of complex systems of life and lifeless nature

### **Using of Complex Systems Theory for Optimum (ideal) Blood Pressure Determination**

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Blood pressure (BP) evaluation is nowadays possible at clinic due to auscultatory method of BP evaluation discovered by N. V. Korotkov. At the end of the 20th century "C at the beginning of the 21st century arterial hypertension is widely spread worldwide A close relationship between arterial hypertension and the lethality and invalidity rates due to cardiovascular diseases is revealed. Attempts of medical control over BP are accompanied both by decreasing and increasing risk of these complications. Up to now BP norms are determined statistically; this situation does not satisfy a lot of clinicians and investigators. During 5 years we have been searching for regularities, which can be the basis for the notion of the optimum (ideal) BP, using the

complex systems theory. In this work the BP evaluation results of 1500 persons and literature data are reviewed. Auscultatory and oscillographic methods of BP registration are compared. Initial multivariate statistical analysis did not reveal unique dependence of systolic and diastolic BP values from the height, weight, cardiovascular diseases presence. Correlations were both direct and inverse. Even more complex correlations were revealed between BP, central hemodynamics and hemorheology parameters and functions and structure of individual bloodstream sections. Basing on the assumption that BP is an integral indicator of blood circulation we used Mandelbrot equation and resonance theory elements. We supposed that the optimum BP is a resonance of the diastolic and systolic BP ( $f_s * T_s = f_d * T_d$ ) and the pressure value can be determined, using the equation  $P = 1/T \int p dt$ . The solution of the equation made it possible to suppose and to confirm at the clinic that the relationship between the systolic and diastolic BP is close to  $(2 \sqrt{C Ph}) / (Ph - 1)$ , where  $Ph \sqrt{C}$  is a Phidias number. Obtained data are in agreement with Murray opinion about the minimum work of blood moving through the vessels. The results allow us to move from the statistical to the physiologic principle of optimum BP determination in human beings. The results demonstrate that BP is adequately describe in notions of complex systems theory as applied to blood circulation.

## Invited Speakers' Abstracts for INSC 2006

### "Complexity: The Challenge of a Co-evolving Epistemology and Ontology"

Peter M. Allen

If epistemology is about what we know and how we know what we know – what is inside - and ontology is about what there is to know – what is outside – then the most fundamental challenge that complexity makes is that these can no longer be considered as separable. Traditional science was based on the idea that there was an objective reality outside, and that we could study it and do experiments on it that allowed us to build, cumulatively, an increasingly accurate picture of that reality. Whilst for simple physical problems, and for planetary motion, this was a reasonable working hypothesis, for biological and social systems this has always been a problem. Experiments are not repeatable or transferable, and situations are historically evolved involving local, co-evolving contexts, and therefore can potentially all be unique and lacking in any generic behaviours or laws. Complexity science brings us face to face with this elusive reality, and tells us that we must accept uncertainty, and admit that our cognition, our descriptions and our models are necessarily incomplete and temporary props to our current functioning. They help us make some sense of the past and the present, and are all we have to help us in taking steps into the future.

Examples of these ideas will be given for ecological, social and economic systems, showing that models, despite their necessary incompleteness, can still be useful in clarifying and living with some of the real uncertainties we have, and in this way can help us explore possible futures. However, complexity also tells us that we need not limit our explorations to those suggested by our models, since they are necessarily incomplete, and that we should also indulge in "creative actions" in order to find out more about what might happen, and in this way both increase our possible choices of action, and also improve the scope of our models.

**Peter M. Allen** is Professor of Evolutionary Complex Systems and Head of the Complex Systems Management Centre which is involved in a wide range of research projects including working with: Glasgow Centre for Population Health, Asian Development Bank, the Tyndall Centre and EABIS. He has also co-ordinated the ESRC priority network `NEXSUS` over the past five years. NEXSUS is continuing with two collaborating projects from NEXSUS partners - an ESRC- funded joint project with the University of Sheffield "Modelling the Evolution of the Aerospace Supply Chain" and an IMRC-funded feasibility study "Impact of industrial clusters on evolution." For almost 20 years Professor Allen has been working on the mathematical modelling of change and innovation in social, economic, financial and ecological systems, and the development of integrated systems models linking the physical, ecological and socio-economic aspects of complex systems as a basis for improved decision support systems.

## *“The New Science of Complexity: Promises and Challenges for the 21<sup>st</sup> Century”*

*Tassos Bountis*

Ever since the 1970's, there has been revolutionary progress in the development of new theoretical approaches, computational methods and experimental discoveries, aiming to unravel the mysteries of unpredictable, irregular, chaotic or briefly “complex” phenomena, occurring in virtually all applied and engineering sciences. New theorems of Pure Mathematics, accompanied by a remarkably fruitful exploration of a variety of models using sophisticated numerical techniques, have led scientists to believe that a number of intricate and unexplained problems arising in physical, biological, engineering and even social scientific disciplines can now begin to be understood.

The Theory of Chaos was advanced as a means of exploring the unpredictable evolution of dynamical systems like the weather, the electrocardiogram and encephalogram, nonlinear mechanical, chemical and electrical oscillations, seismic activity and even stock market fluctuations. The Geometry of Fractals was developed in parallel and proved quite successful in analyzing the intricate nature of objects such as trees and rocks, the consistency of tumors, the dendritic structure of the bronchial tubes of the lungs, the cardiac muscle network and the blood circulatory system. Thus, Chaos and Fractals became the main pillars of what was to emerge as the new science of the 21<sup>st</sup> century called Complexity.

In this lecture, I will describe some indicative applications of Chaos and Fractals, by reviewing results obtained by our team at the Center of Research and Applications of Nonlinear Systems at the University of Patras. The emphasis will be on complex physical and biological systems, as well as social models inspired by the theory of paradoxical games.

### *Philosophical Remarks*

The remarkable progress in the new science of Complexity over the last 3 decades has led to a number of conclusions that go much beyond the realms of a purely scientific and technological advancement. Here are some of the important lessons we have learned:

- A) We have discovered that chaos, or the loss of order and predictability, is NOT a property of large and complicated systems, consisting of a huge number of interacting units. **Even simple models, involving very few agents can exhibit incredibly complicated behavior.** For example, every one knows that the normal relationship of a married couple can become enormously complex as soon as a 3d person enters between them. On the other hand, the behavior of a very large crowd in a parade, a religious ceremony or a peaceful demonstration can be perfectly regular, orderly and predictable!
- B) Complexity and disorder do not necessarily lead to uncertainty, or decay to some equilibrium, as ordinary thermodynamics would have us believe. NEW STRUCTURES can emerge out non-equilibrium processes and order can be born out of chaos, following a process called SELF-ORGANIZATION. In other words, **Complexity is the mother of new ideas, entities and forms that can solve old problems**, leading to a higher, more advanced state of affairs.
- C) **Complexity provides a guarantee for the dynamical stability of our world.** By allowing all different living beings, races, religions and nations to coexist in an environment of mutual dependence and respect, complexity offers the opportunity for prosperity and survival, much as we see in wild natural animal habitats, jungles, etc. On the other hand, when ONE species, one religion, one ideology or one nation tries to dominate all others, it can be the cause of great instability and disaster!
- D) **Complexity is beautiful!** How else can we explain the elation we feel when gazing at a starlit night sky, the waves of a stormy sea, the dancing flames in a fire, or the stalactite and stalagmite formations in an ancient cave?

**Tassos Bountis** is a Professor of Mathematics at the University of Patras, since 1990. He graduated from Athens College in 1969 and did his undergraduate studies at Dartmouth College, U.S.A., and his postgraduate studies at the University of Rochester, where he obtained his Ph.D on Theoretical Physics in 1978. He taught Applied Mathematics and Nonlinear Dynamics at the Universities Cal Tech, Clarkson and Austin, U.S.A. and Amsterdam, the Netherlands. He was one of the first Greek scientists, whose research and teaching was devoted to the study of Nonlinear Dynamics and the Theory of Chaos already from the 1970's.

Returning to Greece, he organized from 1986 until today 4 international conferences and 18 summer schools on topics of Chaos, Fractals and Complexity (the most recent ones are "Complexity in Science and Society", Patras and Olympia Greece, July 2004 and the 18<sup>th</sup> Summer School at Volos, Greece, July 2005). He is heading a Panhellenic Organizing Committee of Greek scientists from many fields, with whom he has edited 8 volumes of the series "Order and Chaos" (in Greek). He is a member of the editorial board of 4 International Journals of Nonlinear Dynamics and Applied Mathematics. His research projects are frequently funded by the Greek Government and the European Union and he is a member of the National Council of Research and Technology of Greece.

At the University of Patras, he founded in 1996 the Center for Research and Applications of Nonlinear Systems (CRANS, <http://www.math.upatras.gr/~crans>), whose purpose is to support collaborative research and other scientific activities of Greek scientists in the fields of Nonlinear Systems, Chaos and Complexity. He is the author of 130 papers in scientific journals and conference proceedings and 4 Greek textbooks on these topics. His last book, "The Wonderful World of Fractals", published by Leader Books in 2004, has received favorable reviews and has become popular for its educational character and aesthetic format.

## *“Leadership Emergence in Coordination-Intensive, Creative Problem Solving, and Production Groups”*

*Stephen J. Guastello*

In self-organizing processes, a system acquires a structure without any external intervention. This presentation describes the process by which an initially leaderless group differentiates into one containing leadership and secondary role structures and how the process was aptly described by the swallowtail catastrophe model [1]. A subsequent study identified the control variables in the process of leadership emergence in creative problem solving and production-oriented groups [2] which were found to be different in the two cases. The third study, which is considered in greater depth here, examined a different case of coordination-intensive groups [3]

Coordination-intensive groups are particularly interesting because it is known that coordination can occur without talking and without leaders present, even though talking helps in some respects [4]. Coordination is also interesting because it is a nonlinear dynamical process all by itself [5]. In the experiment on coordination and leadership emergence, the participants (N = 104, group size = 4) played a coordination card game in which 13 of the groups were not allowed to talk to each other, and 13 groups were allowed to talk. After playing the game, the participants rated each other on leadership behavior, styles, and variables related to the process of conversation. Participants could identify no one as the leader or contributor of particular conversational remarks. Ironically, the levels of leadership emergence were equivalent in both verbal and nonverbal groups. A swallowtail catastrophe model was obtained here also, showing that the three control variables were: a broad range of task participation behaviors, whether the group worked verbally or nonverbally, and behaviors specific to task control. The study also represents a convergence between two independent lines of nonlinear dynamics research in group processes.

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## *“Self-Organization of Cognition”*

*Wolfgang Tschacher*

My long-standing interest is the application of self-organization theory (synergetics) to clinical psychology (especially, psychotherapy process [4]) and neurocognition (gestalt phenomena [1], connectivity in the brain). We conducted numerous projects showing that finger prints of nonlinear systems, such as hysteresis and complexity reduction, are ubiquitous in these fields. Nonlinear phenomena are often related to meaningful variables of functioning (in psychopathology) and therapy outcome [3]. The self-organization approach may even be instrumental in linking first-person and third-person perspectives in cognition [2].

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