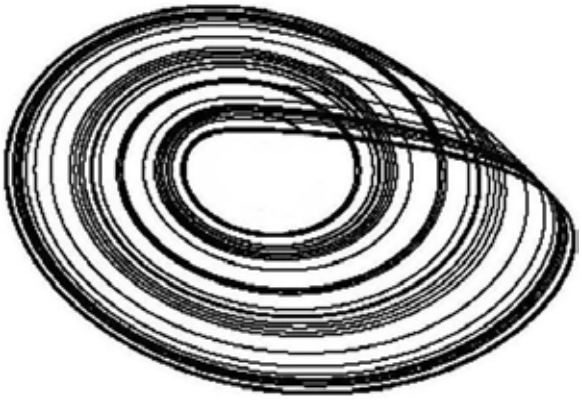
Society for Chaos Theory in Psychology & Life Sciences

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

# Abstracts to the 1st International Nonlinear Science Conference, Vienna, Austria

2003



The Society for Chaos Theory in Psychology & Life Sciences

*Presents*

# THE 1st NONLINEAR SCIENCE CONFERENCE

*February 7-9, 2003, Vienna Austria*

## *Conference Abstracts*[1]

SCTPLS gratefully acknowledges the enthusiasm and diligent efforts of the conference committee: Robert J. Porter, Ph.D. (University of New Orleans and Louisiana State University Medical School), Richard J. Bird, Ph.D. (SCTPLS President, University of Northumbria, UK), Prof. MD Karl Toifl, (Neuropsychiatric Clinical for Children and Adolescents, University of Vienna), and R. A. Heath, Ph.D. (Program Chair, Kingston University, Kingston upon Thames, Surrey, UK); the support of the co-sponsoring scientific societies: Società Italiana Caos e Complessità, and Wissenschaftliche Gesellschaft: Dynamik – Komplexität – Menchliche Systeme; and the generosity of the following sponsoring organizations: Astra Zenica Bank Austria Ceditanstalt Aktiengesselschaft Fresenius Rabi Austria Germenia Pharmaceutical Gerot Pharmaceutical Helmut Zilk Fonds für Internationale Besprechungen Wiens Janssen-Cilag, Lilly, Novartis International AG, and Pfizer Austria.

# Friday
# 7th February, 2003


## Kleiner Festsaal

9am-930am **Welcoming Session. Organising Committee**

9.30am-10.30am **Keynote Address 1: Prof. Dr. rer. nat. Dr. h.c. mult. Hermann Haken**
Professor of Theoretical Physics, University of Stuttgart, Germany.

*Synergetics: How Does Self-Organization Work?*

Synergetics is an interdisciplinary field of research founded by the author in 1969. It studies complex systems that may spontaneously produce spatial, temporal, or functional structures by means of self-organization. The main objective of synergetics is to search for basic principles underlying self-organization in a variety of disciplines, ranging from physics, chemistry, biology to medicine, psychology and sociology. By means of a relatively simple physical system (the light source laser), the basic concepts such as instability, order parameters, control parameters, slaving, critical fluctuations, etc. are illustrated. Jointly with experimental findings these concepts allow for new interpretations and mathematical models. Explicit examples are provided from movement science (coordination between movement of limbs),pattern recognition, and Gestalt-psychology, analysis of EEG and MEG patterns under various conditions, the role of psychopharmacological drugs, and social behavior of groups. Finally, conclusions on a new approach to psychotherapy are drawn.

## 10.30am – 11am Coffee Break

## Series A

**11am – 1pm PAPER SESSION 1 Brain and Chaos**

Bondarenko, V. , Yevin, I., & Koblyakov, A.
Departament of Physiology and Biophysics, SUNY at Buffalo, USA
*Music and Controling Chaos in the Brain*

Investigations of human Electro-Encephalograms (EEG) and the variations of magnetic field generated by intracellular dendritic currents in the brain have shown that these signals are deterministic chaotic processes with degrees of freedom no more than 10 depending on the functional state of the brain (awaking, sleep, epilepsy). Recent research (Birbaumer, Mayer-Kress, Patel, Balaban, Bhattacharya, Petsche) revealed that music tends to reduce the degree of chaos in brain waves. For some epilepsy patients music triggers their seizures. Loskutov and others carried out a series of studies concerning control of deterministic chaotic systems. It turned out that a carefully chosen tiny perturbation could stabilize any of the unstable periodic orbits making up a strange attractor. Computer experiments have shown that it is possible to control chaotic behavior in a neural network by either an external periodic pulsed force or sinusoidal force. Any musical score might be considered as a program of controlling chaos in the brain. One may suggest that the aim of this control is to establish coherent behavior in the brain, because many cognitive functions of the brain are related with a temporal coherence.

Hu, S-J. & Zhong, J. Institute of Neuroscience, Fourth Military Medical University, Xian, P. R. China
*Dynamic responsiveness of neurons*

For some time, the responsiveness of neurons has been detected under a resting background condition. Recently, the responsiveness of neurons under various dynamic states in rats was primarily measured in our group. The main results are as following: (1) Various firing patterns generated in real neurons can be categorized into two basic types, periodic and non-periodic, according to the dynamics of their interspike interval series. (2) Unstable periodic orbit families were identified in non-periodic firing series of neurons, indicating that the non-periodic firing series contain deterministic chaos. (3) In the injured dorsal root ganglion, the neurons with non-periodic firing pattern were more sensitive to stimuli, e.g. norepinephrine and sympathetic stimulation, than the neurons with periodic firing pattern, which is referred as "non-periodic sensitivity" (4) In substantia nigra pars compacta, the neurons with non-periodic firing pattern were also more sensitive to both excitatory and inhibitory transmitters (glutamate

and dopamine) than the neurons with periodic firing neurons. (5) During the critical state near a bifurcation point, the responses of a neural pacemaker to stimuli became more evident, which is referred as "critical sensitivity". (6) The Hindmarsh-Rose neuronal model can simulate both "non-periodic sensitivity" and "critical sensitivity" as indicated above. From these results, we suggest that the responsiveness of neurons may depend on their dynamic background state, which may reflect a universal response property of excitable cells.
(Research supported by NSFC grants (30030040) and the National Basic Research Program (G1999054000) of China)

Keller, K., Lauffer, H., & Wittfield, K.
Mathematical Institute, University Luebeck, Germany,
*Symbolic analysis of high-dimensional EEG time series*

In order to extract and to visualize qualitative information from a high-dimensional EEG time series, we apply ideas from symbolic dynamics. Instead of considering the original values of the time series components, we count certain ordinal patterns. In this way we turn the given time series into a series of matrices whose entries are pattern frequencies. The matrix series is explored by using simple quantities from nominal statistics and information theory. In particular, we discuss the relation of these quantities and give a generalization of correspondence analysis. The method described is very robust and extremely fast from the computational viewpoint. It is applied to detect and to visualize qualitative changes of the EEG data related to epileptic activity.

Creanga, D., Univ. Al. I. Cuza, Fac. of Physics, Iasi, Romania, and Stan, C., Univ. Politehnica Bucuresti, Romania
*Oscillations in The Visual System*

The invertebrate visual system was investigated by means of electrophysiological measurements at the level of Drosophila melanogaster compound eye. For the excitation of the photoreceptor cells, an intermittent light beam was used, with variable frequency and spectral composition. The electroretinographic response (ERG) amplitudes appeared significantly diminished when the excitation frequency is increasing, either in white light or orange (600 nm wavelength) or blue light (400 nm wavelength). When the excitation frequency is higher than a certain critical value, for example 80 Hz, then the modification of ERG can be seen easily. Every second ERG response is characterized by a smaller hyperpolarization component, while the depolarization component maintains a constant amplitude. The critical frequency does not depend on the spectral composition but on the insect peculiarities (eye color, physiological state). Since the hyperpolarization component is generated mainly in the large monopolar cells from the optical ganglion, lamina, it is possible that some oscillations occurring in these cells are responsible for the observed abnormality. Two large monopolar cells, L1 and L2 were identified in the structure of the lamina optical ganglion, lateral inhibition being possible between them. A resonance phenomenon was supposed to occur at the level of these cells. We proposed a mathematical model, based on a Van der Pol oscillator, in order to describe the ERG signal behavior at high frequencies. The standard system of equations was adapted according to the anatomical and physiological elements of the Drosophila melanogaster visual system. The graphic shape of this system describes the experimental recordings at the critical frequency of eye intermittent illumination.

## Series B

**11am – 1pm PAPER SESSION 2 Applications in Life Sciences I**

Yulmetyev, R. Kazan State Pedagogical University, Kazan, Russia
*Fluctuation and noise in the life systems by discrete non-stationary non-Markov processes*

We report results of a study of chaotic dynamics of noise and fluctuations in life systems by statistical theory of discrete nonstationary non-Markov processes. Using the projection operator technique we find at first the chain of finite-difference non-Markov kinetic equations for discrete time correlation function (TCF) and for a set of non-stationary discrete memory functions (MF). The full set of dynamic, spectral and kinetic parameters and kinetic functions (TCF, MF, statistical spectra of non-Markovity parameter and statistical spectra non-stationarity) has made it possible to acquire in-depth information about discreteness, non-Markov long-range effects and long-range memory, statistical long-range correlations and non-stationarity of the underlying systems. The developed theory is applied to analyze: the short- and long-time (Holter) series of RR-intervals of human ECG's in cardiology, physiological time series of human gait for healthy and patients with Parkinson's disease, psychological time series for the human sensorimotor coordination,

neurophysiological time series of electric signals of the human EEG's from brain core at epilepsy, epidemiological time series for the humans with common respiratory and influenza diseases and sociological time series of student academic activity. We discovered that the full sets of statistical discrete non-Markov parameters can serve as a reliable and powerful means of analysis, diagnosis, differentiation and forecast in diverse life systems. Therefore, we conclude that the developed information measures are very important for quantification of convoluted chaotic and regular components of the time evolution of boilogical systems.

Liebovitch, L., Shehadeh, L., & Jirsa, V. Center for Complex Systems and Brain Sciences, Florida Atlantic Unversity, Boca Raton, FL, USA
*How Genes Regulate Other Genes*

The expression of some genes regulates the expression of other genes in a complex web of interactions and mutual dependencies. We formulated five different network topologies of these genetic interactions with random and "small world" connections. We iterated the genetic interactions on the mRNA expression levels until they reached a steady state. For each network topology we computed the statistical properties of the mRNA expressed by determining the probability density function, PDF(x), of the number of genes expressing mRNA amounts between x and x + dx. We found that different network topologies produced different mRNA PDFs. This approach provides a method to analyze the mRNA experimentally measured by cDNA microarrays. The PDFs of the measured mRNA levels can be compared to the PDFs of the models to determine the global pattern of genetic regulation. Microarray data that we analyzed was best fit by a "small world" model where different genes have different patterns of regulatory inputs from other genes, but the same pattern of regulatory output to other genes. Determining the network topology of genetic interactions may provide a practical way to screen biological systems to determine which ones are the best candidates for basic scientific studies and therapeutic intervention.

Rinaldi, S. Dipartimento di Elettronica e Informazione, Politecnico di Milano, Italy
*Chaos and optimality in ecosystems*

Simple nonlinear models show that ecosystems can be chaotic for realistic values of their demographic and environmental parameters. Some field and laboratory data confirm this possibility, while many other data show that a great number of populations are almost chaotic. This is in line with some conjectures on evolution, selection and self-organization which predict that biological systems should tend, at evolutionary timescale, toward the onset of chaos. It is therefore natural to ask which are the special features ecosystems enjoy at the edge of chaos. Answering this question might be helpful for proving the conjectures or, more modestly, for determining their consequences. An answer to this question has been recently given with reference to a particular but important class of ecosystems, namely tritrophic food chains (e.g. plant-herbivore-carnivore). In particular, it has been shown (through bifurcation analysis) that if the nutrient (or the energy) available to the bottom of the food chain is continuously increased, the dynamic regime of the system first switches from stationary to cyclic and, then, from cyclic to chaotic before becoming cyclic again. Moreover, the mean abundance of the top population first increases and then decreases with nutrient and peaks exactly at the transition from chaotic to cyclic regime. This result has important consequences. In particular, if the ecosystem is exploited to produce food, the optimization of the mean yield is obtained by forcing the system to work at the edge of chaos. In other words, the ecosystem can be interpreted as a biological machine which is more effective when it is closer to chaos.

Rojdestvenski, I., Dept. of Plant Physiology, Umeå university, Sweden
*Recursive embedding and self-organization*

We discuss the self-organization properties of a class of systems in which the system's description is embedded in the system as one of its elements. An example of such a system is a living cell, whose description (genome) is encoded into a physical entity (DNA molecule) within the cell. Such embedded description element has to contain the description of itself as one of the elements of the system. This creates bootstrapping, which may be capable of producing a divergent increase in system complexity. We also discuss the similarities between evolution in such class of systems and quantum measurement. We suggest four minimal conditions sufficient for life-type chemical self-organization, namely:

1. The system should contain molecules (residues) capable of forming polymer chains with different links.
2. These polymer chains have to have replication capability

3. Different chains should have different "fitnesses" for different environments.
4. Their concentration should be enough to alter the environment in which they exist

## Series C

**11am-1pm Symposium 1: The Dynamics of Language Acquisition**

**Convenors:** Annette Hohenberger, University of Frankfurt, Germany
Annemarie Peltzer-Karpf, University of Graz, Austria

The study of language acquisition (LA) offers a unique insight into the dynamics of a cognitive module par excellence. The study of LA from a dynamical perspective is an important contribution to the ongoing debate in the cognitive sciences about the relation of innate and environmental factors in the acquisition process.

Language has a highly complex grammatical structure which grows in the mind of a child equipped with a set of innate linguistic constraints/options (universal grammar, UG) in a rich linguistic environment. In recent models of self-organization, the interplay between innate knowledge and the primary linguistic data (PLD) is thought to be mediated by self-organization and neural development. LA is considered a process of differentiation and selection in the course of which the child builds up ever rich representations in phonology, morphology, and syntax. In the sense of synergetics, control parameters (e.g. the number of words in the child's mental lexicon) reaching a critical threshold let new order parameters (e.g. syntax) with new qualities emerge. Of particular importance is the notion that LA does not take a linear path but rather comes in phases of intermittent turbulence, fluctuations, and stability (i.e. the chaotic itinerary).

In this symposium we want to bring together scholars of a dynamical view on LA from different theoretical backgrounds: Generative grammar, genetic epistemology, gestalt psychology (pattern formation), synergetics, and developmental cognitive neuroscience. We want to offer a broad perspective on LA ranging from First and Second language acquisition (L1 and L2) over bi- and multilingual acquisition, to language contact and language change.

Hohenberger, A. University of Frankfurt, Germany
*Procedural and structural self-similarity in first language acquisition*

Language is a dynamical system which is characterized by self-similarity. Two types have to be distinguished: procedural, and structural self-similarity (Loritz, 1999). Procedural self-similarity relates to the process of language acquisition. This process is self-similar in that it iterates cycles of instability (variation) and stability (selection) until the child reaches the attractor of her target language. Control parameters (cognitive and linguistic) determine the sequence of these cycles, e.g, the emergence of syntax out of the lexicon. Structural self-similarity relates to the architecture of the various structural representations: feet, syllables, words, phrases, sentences. These units are of different size and each has its own characteristic processing time. Through recursive embedding of these units, either homologuous embedding (within the same type of structure) or heterologuous embedding (between adjacent types of structures), increasingly bigger self-similar structures grow in the child's mind. Recursivity is a core characteristic of the human language faculty as opposed to non-human communication. Embedding implies symmetry-breaking, through which linguistic structures receive their typical hierarchical and asymmetric fractal shape. The basic building block is best exemplified by the core syntactic architectural module, consisting of a specifier (e.g., a subject), a head (e.g., a verb), and a complement (e.g., an object). Subjects and objects can contain entire phrases, matrix sentences can contain embedded sentences, thereby giving rise to in principle infinitely big sentences— one of the major claims of generative linguistic theory.

Loritz, Donald (1999): How the Brain Evolved Language. Oxford: Oxford University Press.

Plaza Pust, C. Institut fuer Deutsche Sprache und Literatur II, Frankfurt am Main, Germany
*The dynamics of language development and language contact in adult second language acquisition*

Adult second language acquisition raises a number of interesting questions which relate to our understanding of how the evolution of languages is tied to processes of self-organisation. In this paper we will focus on language contact as it occurs in the organisation of multilingual knowledge and discuss some of the potential implications for a dynamic account

of language development in its multiple forms. If we conceive a language-specific grammar as a specific constellation of parametric choices or attractors the acquisition of a second language in adulthood involves the implementation of new parametric options which shall ultimately coexist with the previously available ones related to the L1 grammar. By assumption, the non-linearity which characterises the progression towards this bilingual competence is related to the dynamic tension between autonomy and interaction which arises in the organisation of multilingual knowledge. In this context we will discuss the relevance of system-internal and external feedback processes not only as regards their regulating function (stability maintenance of the L1) but also as regards their potential for change given by their ability to amplify new information (L2 input). In fact, as we will see on the basis of adult L2 German data, learner grammars are pushed again and again into unstable states at which crucial bifurcations take place. On the basis of additional evidence from other forms of language development we are led to conclude that apparent conflicts deriving from language contact gain a new significance under a dynamic approach: they pave the way for necessary changes.

Peltzer-Karpf, A. University of Graz, Austria
*The interplay of nonlinear processes in early neural and linguistic development*

This paper highlights the common grounds of the nonlinear sciences and the developmental cognitive neurosciences. In this particular context, language development is seen as the organization of nonlinear dynamic systems showing degrees of persistent order at first dominated by the search for coherence, followed by the reorganization into different clusters and finally the emergence of coherent patterns with large internal coupling strength and stability. The basic assumption is that the time-course of these behavioural changes is linked to system-specific developmental changes in the central nervous system. Of prime interest are the following postnatal cellular events: a dramatic increase in glucose metabolism which exceeds adult values during childhood; an overshoot phase of synapses and neurotransmitter receptors around age 2 followed by a system-specific decrease; the scaled myelination of nerve sheaths and the growth of long-range fibres from age 2 which are essential for figure-ground segregation and pattern formation in various domains. Psycholinguistic charts drawn from long term studies will illustrate to what extent children can profit from the early exuberance, and in particular, how the joint activity of biological and general cognitive factors affects the dynamics of language development. The focus is set on the succession of several major shifts which occur in more or less regular intervals of five to six months: (1) between 1;5 and 1;8: a rapid lexical increase, (2) around the age of two: first evidence of morphological and syntactic variants, (3) between 2;4 and 2;7: stabilization of S-V-congruency followed by higher syntactic mobility and productive use of morphological markers. How this chaotic itinerary is to be integrated within a network is yet to be solved in the cognitive neurosciences. The nonlinear sciences provide a framework to get to grips with this problem.
The data were collected in the course of two projects funded by the Austrian Nationalbank, 4244 & 6179 and a FWF-project P 10250-SPR
Email:

Tracy, R. Universität Mannheim, Germany
*UG-assisted self-regulation*

This contribution proceeds from the hypothesis that all children initially start out on a multilingual track, thereby constructing several co-existing and potentially conflicting grammatical subsystems. Eventually, structural conflicts need to be resolved, either by deciding that more than one input language is involved (the prototypical bilingual case), or by reaching convergence on a new and more abstract level of representation. In the latter case the learner is led to infer derivational relationships among hitherto unrelated patterns. In my presentation, I will identify several developmental crises that – with a little help from UG – enable the monolingual (German) and the bilingual (English and German) child to reanalyze previous representations and to move on to a new developmental stage.

Wagner, M. Graz University, Austria, and
Harvard Graduate School of Education, USA
*Growth spurts in communication*

In this paper we take a look at the interplay of the rapidly changing neural repertoire and the input which engenders the individual (pragma-)linguistic systems and responds to the immediate communicative needs of the child. We start from the assumption that the infants interaction with the environment helps to sculpt intra- and interregional connections within the brain, eventually resulting in the highly specialized structures required for the developing mosaic of increasingly complex systems. This molding is self-organized; the childs brain takes a very active part in early multimodal interaction. This

means that each of the individual brain growth spurts creates a larger capacity for coding and storing information, which in turn enhances the speed and efficiency of a process that has already been underway. Of particular importance is the notion that language development does not take a linear path but rather comes in phases of intermittent turbulence, fluctuation, and stability. Neural development has its heyday around the age of 24 months, which in turn has its impact on linguistic and communicative development. We will present data of 3 longitudinal case studies. The subjects of analysis are two monolingual German speaking boys and one bilingual German and English speaking boy. The children were observed starting at their age of 17 months and followed up to 34 months. The data were transcribed according to the guidelines of CHILDES (Child Language Data Exchange System) (MacWhinney and Snow 1990) and coded for communicative attempts employing the INCA-A Coding Scheme (Ninio et al 1994). Each communicative attempt by both conversationalists was coded on two levels: 1) the Interchange and 2) the speech act. We will provide analyses of general linguistic capacities (MLU, morphosyntax, lexicon) and of pragmatic development (development of Interchange system, speech acts and combinations of Interchanges and speech acts).
Monolingual subjects in our study had their highpoint in general linguistic and pragmatic development at the age of 25 months. The bilingual child showed this first climax at 28 months. At this time, our subjects engaged in the highest number of different speech uses. This is reflected by a more fine-grained communicative repertoire and by the general ability to engage in an increasingly conventional conversation. The mothers also reacted to this development with a higher number of different communicative intents. The same is true for their lexical and morphosyntactic development. According to our data, the first major milestone in brain development not only coincides with an outburst of morphosyntactic abilities (in turn triggered off by a critical mass of lexical elements), but also with the explosion of communicative attempts at around 25 months. A closer look at the individual differences and similarities in pragmatic development in our three children reveals interesting dynamics.
Email:

# 1pm-2pm Lunch

## Series A

**2pm-3.30pm PAPER SESSION 3**
**Philosophical Issues I**

Voitsekhovich, V., Department of Philosophy, Tver State University, Russia
*The philosophical bases of the theory of evolutionising systems*

The main concept of synergetics is the one of evolutionary systems ("evos"). These are open, non-equilibrium systems. The elements of evos vary. The connections between the elements also vary from strong, long kept ones up to rather weak, breaking ones. Synergetics deals with the laws of movement of "evos" along specific trajectories of development. The ideas of self-development, self-similarity, cyclical development, expediency, non-balance of life and spirit are important parameters of evolution and were developed by Plato, Aristoteles, Decartes, Leibnitz, Kant, Hegel. The concepts of chaos and order have already been considered by Lao Tse, Konfuze, Parmenides, Heraclit, Hegel and others. The idea of an orientation of development of things and life were developed by Heraclit, Hegel, Fichte, Schelling, Solovjev, and also by Teihard de Chardin and V. Vernadsky with their notion of the noosphere. The concept of evolution became more and more important with the rise of Darwinism. The idea of an orientation of development of the physical universe has spread since the works of Einstein, Fridman, Hubble. The goal of a theory of evolutionary systems is a theory of universal history that shows how the evolution of nature, life, society and mind are connected. The works of Vasily Vasilyevich Nalimov are very important in this context.

Fuchs, C. Institute of Design and Technology Assessment, Vienna University of Technology, Austria
*Dialectical Materialism and the Self-Organisation of Matter*

The aim of this contribution is to show that the theory of self-organisation in some respect proves the topicality of dialectical materialism and that an alternative concept of substance makes sense within the framework of dialectical materialism. The first part points out that Marx and Engels opposed the notion of substance because for them this notion was connected with the assumption of mechanical materialism that there is an eternal, unchanging stuff in the world to which all existence can be reduced. An alternative concept of substance is implicitly present in Engels' works because he says that the eternal aspect of the world is that matter is permanently changing and moving and producing new organisational forms of matter. Ernst Bloch has explicitly formulated this concept of process-substance within the framework of dialectical materialism

and in opposition to mechanical materialism. Such an alternative conception of substance can as the second part of this contribution shows also be expressed as the permanent and eternal self-organisation of matter. Concepts from self-organisation theory such as control parameters, critical values, bifurcation points, phase transitions, non-linearity, selection, fluctuation and intensification in self-organisation theory correspond to the dialectical principle of transition from quantity to quality. What is called emergence of order, production of information or symmetry breaking in self-organisation theory corresponds to Hegel's notions of sublation (Aufhebung) and negation of the negation. Self-organisation theory shows that Engels' *Dialectics of Nature* is still very topical and that dialectical materialism contrary to mechanical materialism and idealism hasn't been invalidated, it rather seems to be confirmed that dialectics is the general principle of nature and society.

Degtiar, V. Department of Social Informatics, Moscow State University, Moscow, Russia
*The Life Program, Self-organisation and Gregariousness*

Every biological subsystem possesses encapsulated variables, which can be violated by mighty external and/or internal influences. Changes in encapsulation are bound with the process of self-organisation of neurone and intercellular nets. Irreversible processes make the strategies of self-organisation dependable on the previous history of subsystems. This means that its future depends on its existing "construction". This is why the notions of life program and life trajectory are important. The life program of an organism and the process of its initiation, and maturation of architecture of links between different levels in course of production of one out of a set of life trajectories are analysed from the level of the zygote. The basic mechanisms of maturation of behaviour that determine self-organisation of architecture of neurone and genetic nets are described. Dependence of life trajectory on environment and its branching during postnatal maturation are discussed as the basis of social development. A gregarious way of life ensures mighty social influences on every individual that forces its organism to select one of the life trajectories that is co-ordinated with the direction of pressure of a social system. This is why with the purpose to increase harmony we need to develop a mechanism for the gradual improvement of the system of social control that is based not only on behavioural, but also biological, variables.

## Series B

**2pm-3.30pm PAPER SESSION 4**
**Applications in Social Processes**

Aruka, Y. Chuo University, Tokyo, Japan
*Some Adaptive Economic Processes in Social Interaction*

Associated with human brain activities in social interaction, there may be some kind of reinforcement mechanism like crowd psychology or mimicking drive, or sometimes, a process creating a social mechanism like punishments. Some of these reinforcement mechanisms can be interpreted with a nonlinear Polya urn process of which W. Brian Arthur is fond. He called structure as emergence of a new combination of proportion generated by the stochastic process. In the case of unknown parameters on the distribution of a new emergent agent (mutant), as Masanao Aoki formulated, we can derive emergence of an unknown structure a new structure. In these dynamics, it is important to group by heterogeneous types in a social interaction. We have several subgroup dynamics given by either Dirk Helbing or Steven Durlauf. On the other hand, when analyzing adaptive behaviors, replicator dynamics directly works well as an intriguing compromise device for many applications. When the regret criterion was applied to the evolutionary differential game of replicator dynamics, Sergiu Hart successfully proved that the regret mechanism was equivalently reduced to, or is compatible with, other adaptive mechanisms. Focusing upon a type of learning exhibited by adaptive agents as studied by the Santa Fe institute, economists began to be involved in treating multi-armed bandit problem, in the event, by adopting loss minimizations in the face of uncertainty. The rigid world of optimization characterized by the duality notions shall be replaced in economics soon.

Lawless, W. Paine College, Augusta, GA, USA
*Information density functional theory: A quantum and organizational approach to counterterrorism*

Autonomy is the critical application for agent systems, including agent organizations. To achieve autonomy, collective computational agent models must address the generation of information, *I*, decision-making, the production of knowledge, *K*, from *I*, and the relationship between *I* and *K* with an agent's organization and social structure. This requires that the fundamental problem of the formation of groups be solved, a problem first recognized as the shift between individuals and groups by Allport (1962)

that Luce and Raiffa (1967) concluded could not be solved with game theory. This approach is not entirely new for computational researchers in that autonomy must successfully pass tests of falsifiability. What is new to AI, agent-based models (ABM's), or multiple agent systems (MAS) is the possibility of an *ab initio* approach to decision-making that rationally exploits competition (but see Robocup; www.robocup.org), emotion, and, with the discovery of an interaction cross-section, introduces an analytic approach to the formation of groups and organizations based on first principles (Lawless & Chandrasekara, 2002). For decisions, the speculation is that the acquisition by neutrals of a concept forwarded by a discussant subsequently followed by the opposing concept from a second discussant helps to capture the essence of a problem (e.g., cycling from a "liberal" to a "conservative" perspective), suggests that a number of concept framing reversals are required to choose the optimum solution path (*K* implies that *?I -> 0*, but the inverse implies ideology, and that the number of framing reversals over *?t* measures the degree of an *idp* and the *E* required to achieve *K* fusion. As opponents become equal, bifurcations begin until the audience of observers has reached a decision.

References

Allport, F.H. (1962), A structuronomic conception of behavior, Journal of Abnormal Social Psychology, 64, 3-30.

Lawless, W.F. & Chandrasekara, R. (2002), Information density functional theory: A quantum approach to intent, Proceedings AAAI Fall Conference, November 15-17, 2002, North Falmouth, MA.

Luce, R.D. & Raiffa, H. (1967), Games and decision, New York: Wiley.

Gimeno, R.,Universidad Pontificia Comillas (ICADE), Madrid, Spain, Olmedo, E., Universidad de Sevilla, Sevilla, Spain, Mateos de Cabo, R., Universidad San Pablo-CEU, Madrid, Spain, Escot, L. Universidad Complutense, Madrid, Spain and Grau, P., Universidad Rey Juan Carlos, Madrid, Spain.

*On Detecting Regime Switching Behaviour: An Economic Application of TAR Models*

The presence of systems with two different regimes is a common feature in all sciences. This goes from medicine (REM and non-REM sleep), psychology (bipolar disorder characterized by cycles of manic and depressive behaviour), politics (election and non-election periods), biology (circadian rhythms that regulates sleep and wake cycles), ecology (predator-prey interactions and host-parasite cycles), sociology (migrational phenomenon), management science (technological cycles), or economy (development and crisis periods). The Threshold Autoregressive models (TAR) are the stochastic equivalent to the chaotic Tent Map. They are a suitable tool to analyze short time series with complex behaviour. This is generally the case in the behavioral, social or biological sciences, where long time series are usually not available, and the typical chaos detection methods and estimation of nonlinear models becomes not possible. We present an application of TAR models to the analysis of financial markets behaviour under the influence of technical analysts, emphasising the methodology needed for estimation and testing of TAR models, and giving special attention to confidence intervals, detection of chaos behaviour and prediction

# Series C

**2pm – 3.30pm PAPER SESSION 5**
**Applications in Life Sciences II**

Schuster, P., Institute for Theoretical Chemistry and Structural Biology, University of Vienna, Austria

*Information created by evolutionary processes*

Information is an immaterial concept that turned out to be useful not only in the sciences of communication and computation but also in physics and biology. The usefulness of information in biology has often been challenged and the current view is that any consideration of biological information per se is meaningless but the concept becomes highly relevant in the context with its origin and processing. In the lecture we shall present a simple model system of evolutionary processes that allows for both experimental implementation and computer simulation. Evolution of RNA molecules will be discussed in the context of creation of information in populations through variation and selection. Finally, we shall digress into the notion of biological information at different hierarchical levels.

References:

Peter Schuster, *Biological Chemistry* 382 (2001), 1301-1314

Walter Fontana & Peter Schuster, *Science* 280 (1999), 1451-1455

Rulkov, N., Institute for Nonlinear Science, University of California, San Diego, La Jolla, USA.

*A simple two-dimensional map for modeling of spiking-bursting neural activity*

The complex dynamical behavior of individual neurons, which show both regular and irregular

chaotic oscillatory regimes, is considered an important element in the formation of a variety of collective behavior patterns and transitions between them. Although the complexity in real neurons is the result of nonlinear dynamics in a high-dimensional phase space, many dynamical mechanisms governing the collective behavior can occur in relatively simple neural models. Use of the simple models, which are able to mimic the dynamics of neurons in detail, is very beneficial. The simplicity helps one to clearly see and understand the mechanisms behind the particular types of transition between different regimes of collective behavior. This paper discusses the regimes of synchronization in a simple model that reproduces typical dynamical properties of spiking and spiking-bursting activity of real biological neurons. The model presented is a two-dimensional map, which contains fast and slow variables [see for details N.F. Rulkov, Phys. Rev. E, v.65 (2002) 041922]. Synchronization regimes for spiking and bursting activity in two coupled maps are studied. These regimes of synchronization include synchronization of spikes, synchronization of chaotic bursts, and synchronization of bursts in the form of anti-phase oscillations. The last regime is characterized by regularization of chaotic bursting. The dynamics of synchronization found in these maps is in agreement with the synchronization of chaotic spiking-bursting regimes found in experiments with real neurons. Dynamical mechanisms behind the onset of synchronization and regularization in synchronously bursting systems are explained.

Huett, M-T., Institute of Botany, Darmstadt University of Technology, Germany
*How can noise-induced nonlinear patterns be detected in biological data sets?*

A helpful view towards spatiotemporal patterns, e.g., in biology is that neighbor interactions determine the time development of the individual elements and, in turn, lead to patterns on a large scale (compared to the size of a single element). Often these patterns emerge abruptly, when a critical value of a (slowly drifting) control parameter is passed. Such processes of self-organization, when observed in an experiment, require analysis techniques, which are capable of interpreting the data in terms of such local (neighbor) interactions. The development of new analysis techniques can be complemented by studying model systems, particularly in the experimental investigation of nonlinear systems. The idea is to generate sample data using models and then put similar restrictions on these sample data as in the case of an actual experiment. Examples for typical restrictions are (1) only one of the dynamical variable is measured, (2) the sampling rate is reduced or (3) the values of internal parameters for different time series are unknown. With such sample data one can test how well the analysis tools are capable of handling real-life data. Here we focus on a particular set of analysis tools, namely spatiotemporal filters based upon nearest-neighbor rules similar to cellular automata. With these tools we study sample data with certain statistical properties. A focus is on the phenomenon of spatiotemporal stochastic resonance and on spatial correlations within the noise, which may help distinguish between internal and external noise. Applications to spatiotemporal data from biological systems are discussed.

# Series D

**2pm – 3.30pm Symposium 2: How to teach a multidimensional (bio - psycho - social) diagnostic and therapeutic approach to medical students.**
**Convenor**: Toifl, K., Neuropsychiatric clinic for children and adolescents, A-1090, Vienna.
With contributions from a group of medical students.

With involvement of all work-shop-participants in a lively interactive discussion between the seminar-leader and students will be demonstrated how a multidimensional diagnostic and therapeutic approach could be comprehensively transmitted. The matter of the seminar is subdivided into three sections.

The first part brings out and discusses the theoretical basis of chaos theory and the theory of self-organisation. Thus makes a new line of a comprehensive definition about health and illness of the human system. It refers also to the multidimensional diagnostic and therapeutic approach. The second part forms a medical team of students and all other participants aiming towards a multidimensional diagnosis and therapy. Under guidance of the work-shop-leader the team demands all significant bio-psycho-information of a complex clinical record. The aim is to work out a well comprehensible diagnostic mosaic of the subject. Thereafter the team presents its therapeutical suggestions. Finally to this part the work-shop-leader presents the actual therapy applied to the patient and the further clinical record. The third part discusses under which requirements such an

approach can be established and evaluated in everyday clinical life. Other requirements that would assist the subject will be presented.

## 3.30pm – 4pm Afternoon Tea

## Series A

**4pm-6pm Symposium 3: Chaos and Complexity in Arts and Architecture**
Convenor: Sala, N., University of Italian Switzerland – Academy of Architecture, Mendrisio, Switzerland

The presence of mathematical and geometrical components in arts and architecture is usual. For example, the golden ratio, the symmetry, the tasselations, the Fibonacci's sequence, and the Euclidean geometry.

The aim of the symposium is to present different approaches in the arts and architecture which use complex systems. For example, to analyse some chaotic or fractal shapes inside artistic productions, to determine the degree of complexity in a sculpture, or to study the urban development as a complex system. In fact, urban growth is a complex problem which involves different disciplines (architecture, mathematics, information technology, sociology, ecology, and economy). This symposium will present recent and innovative studies in these fields.

Yevin, I. Mechanical Engineering Institute, Russian Academy of Sciences, Moscow, Russia
*Visual and Semantic Ambiguity in Art*

Non-linear theory proposed different models for the perception of ambiguous patterns, describing different aspects such as multi-stable behavior of the brain (Poston, Stewart, Peregoy, Ditzinger, Haken, Merk, Schnakenberg and others). This paper reviews the phenomenon of ambiguity in art and shows that the mathematical models of the perception of ambiguous patterns should be regarded as one of the basic models of artistic perception. The following type of ambiguity in art will be considered. Visual ambiguity in painting, semantic (meaning) ambiguity in literature (for instance, ambiguity which V.B.Shklovsky called as "the man who is out of his proper place"), ambiguity in puns, jokes, anecdotes, metric ambiguity and ambiguity in the themes in music, mixed (visual and semantic) ambiguity in acting. Ambiguity of sculptures and dolls is connected to ancient opposition alive and dead, spiritual and mechanical. Ambiguity of some kind of arts is used for plot development in literature, cinema and others kinds of art. For instance, the idea of an animated statue is used in Pushkin's poem "Copper Horseman" and in Mozart's opera "Don Giovanni". Ambiguity of acting begets plots called "character invasion". Synergetics of the brain revealed that the human brain as a complex system operates close to the point of instability and ambiguity in art must be regarded as an important tool for supporting the brain near this critical point that gives humans possibilities for better adaptation.

Burkle-Elizondo, G., Valdez-Cepeda, R., & Sala, N. Universidad Autónoma de Zacatecas, Hidráulica, México
*Complexity In The Mesoamerican Artistic And Architectural Works*

Fractal Dimension is a parameter which determines the degree of complexity of a shape. The aim of this paper is to determine the complexity of 90 Mesoamerican artistic and architectural works that included: Tablets, Stelas, Hieroglyphs, Pyramids and Temples, Calendars, Astronomic Stones, Codex Pages, Murals, Stone Monuments and Ceramics. Firstly, all 90 figures were scanned and then saved as bitmap files. Afterward, figures were analyzed using the program Benoit. Sixty-one of the images correspond to the Maya culture developed from 300 BC to 700 AC at Mexico, Guatemala and Honduras. Other 26 to the Mexica culture from 300 to 1100 AC, and the others to Tula, Totonaca and Olmec cultures at México. Box (Db), Information (Di), and Mass (Dm) fractal dimensions were calculated in each of these archeological images. We found a probable pattern taking into account the averages of fractal dimensions for each group of images that could suggest the influence of golden units, golden rectangles and golden spirals on these works. In all 90 images we found fractal dimensions with values from 1.8 to 2.4 indicating complexity of the traces of the Mesoamerican artistic and architectural works. These findings suggest that several of these fractals can be discovered at first sight because its proportions imitate the aesthetics of nature in some way. Others having greater complexity, may arise because their statistical self-affinity is similar to that of real objects. It seems that complex mathematics were used by artists and architects of these cultures when making their non-linear and chaotic works, because they were trying to imitate dynamics of the sky and the complexity of natural phenomena.

Semboloni, F. Department of Town and Regional Planning University of Florence, Florence, Italy
*Avalanches in urban spatial development*

The micro-dynamic models of urban development, usually conceive the evolution as a continuous process of diffusion. The evidence shows that the changing of the urban fabric depends on a great number of little projects and on very few great urban projects, such as, for instance the Defense in Paris or Docklands in London. In this paper I present a model simulating urban development which highlights such phenomena. In fact, in this model the dynamic depends on the accumulation of a potential energy which is suddenly released. In addition, a reaction chain is stimulated by a diffusion process in the neighborhood such as in the sand pile model. The model is developed in a 3-D spatial pattern, composed of cubic cells which take a limited number of states: un-built, housing, working places. The changing of status happens when the potential energy accumulated overcomes an established threshold, and depends on both local and global causes. The global causes are responsible for the accumulation of energy. In turn local causes stimulate the reaction chain resulting in urban avalanches. The model is experimented both in a growth period giving rise to expansion phenomena, and in a stagnation period. In this last case the evolution related to the degradation and rehabilitation of buildings is analyzed. The distribution of events is studied under various conditions, the differences with similar models concerned for instance with earthquakes are discussed, and the strong inertia of the urban fabric is emphasized.

Marsault, X. MAP-ARIA, Ecole Architecture Lyon, France
*Generation of textures and geometric pseudo-urban models with the aid of IFS*

The aim of this paper is to present the first results about a study started as a regional research project on the automatic generation of 3D pseudo-urban models with the aid of fractal techniques. We will refer on the detection of the similarity in the urban textures and on the architectural shapes (isolated or in group) which present some similarities or self-similarities. The goal is to determine the coherence inside the plans of the towns, to detect their internal similarities, searching an approximation with mathematical model. We use a method of fractal compression of the images to encode by IFS (Iterated Function Systems) the couple (the imprint in the ground, the height) of a building of a town plan, and we generate a 2D½ self-similar model for the best approximation to the plan. We have also introduced some operators of interpolation, of filtering, or genetic methods (mutation, fusion) to realise an automatic generation of new pseudo-urban and architectural morphologies which are coded in different levels.

Sala, N., Andrey, S., & Kushi, A. Academy of Architecture of Mendrisio, University of Italian Switzerland, Mendrisio, Switzerland
*Chaotic and Complex Components in Arts and Architecture: Some Examples*

The aim of this paper is to present some relationships between arts, architecture, and chaos theory. We have organized our approach in two different fields:The chaotic components in arts; and the chaotic components in architecture. Many artists have studied the evolution of turbulent systems to produce the same effects in their paintings. We will describe some examples which involve chaotic shapes in different cultures and different periods. For example, we will refer to Leonardo da Vinci, Katsushika Hokusai, Vincent Van Gogh, Gustav Klimt, Nachume Miller, Carlos Ginzburg, William Latham. In architecture, we can analyse the chaotic components using two different approaches:

- In the little scale (for example, to find a chaotic shape in a building or a strange attractor in a plan);
- In the large scale (for example to study cities as complex systems).

In the large scale we will present an approach to define regional urban growth as respecting the some degree of complexity of the territory.

Saleri, R. MAP-ARIA, Ecole Architecture Lyon, France
*Pseudo-urban automatic pattern generation*

This research task examines automatic generative methods that can produce architectural and urban 3D-models. At this time, some interesting (early) applicable results, rising from pseudo-random and L-system formalisms, came to generate complex and rather realistic immersive environments. The next step could be achieved by mixing those techniques to emerging calculus, dealing with topographic or environmental constraints. As a matter of fact, future developments will aim to contribute to archeological or historical restitution, quickly providing credible 3D environments in a given historical context.

## Series B

**4pm-6pm PAPER SESSION 6 Brain Processes**

Kirlangic, M., Ivanova, G., & Henning, G., Technische Universität Ilmenau, Institute of Biomedical Engineering and Informatics, Ilmenau, Germany

*The DC-level: An order parameter of the brain complex open system?*

There is still no consensus on the origin and generation mechanism of the direct current (DC) shifts recorded on the scalp. Nevertheless, they are reported to reflect the changes in the cortical DC potentials and proposed to be fundamental in various states of the brain, e.g. sleep-wake cycle, hyperventilation, apnea, and information processing (Bereitschaftspotential, contingent negative variation (CNV)). These potentials are also studied for operant brain regulation, i.e. neurotherapy or EEG-biofeedback, and for disorders such as epilepsy and attention deficit hyperactivity disorder. In our project involving the development of a flexible neurotherapy device, we realised studies of learning and training the self-regulation of the central or frontocentral DC-shifts with healthy controls (n=6) and epilepsy patients (n=5). For a possible objective evaluation of the training, initial measurements of clinical EEG/DC (at rest, eyes open and closed, during and after hyperventilation and apnea) and CNV (modified S1-S2 paradigm) were carried out. The vertical electrooculogram (VEOG), ECG, and respiration curves were also acquired simultaneously. These measurements were repeated during the course of the training process, and after its termination. Our analysis shows that a) a synchronous similar pattern occurs in VEOG (excluding the ocular movements) during CNV, b) there is a coupling between the DC-shifts and the respiration depth during the self-regulation process, and c) the negative (frontocentral and central) and the positive (occipital) DC-shifts tend to recover after hyperventilation. These results have led us to the hypothesis that the DC-level functions as an order parameter (with the terminology of the synergetics) over the central and peripheral nerve systems. Several further findings in the literature support our hypothesis.

Durstewitz, D., Biopsychology, Ruhr-University Bochum, Germany

*Biophysical models for generating and learning temporal predictions*

Most animals can predict forthcoming events on the basis of environmental signals, as in Pavlovian conditioning. At least mammals and birds, in addition, can predict not only the event to occur, but also its time of occurrence, i.e. the interval between a predicting stimulus and the subsequent event. The neural basis for this ability, or, more generally, the coding of real-time in the nervous system, is not well understood. Recent in-vivo electrophysiological recordings suggest that interval time might be represented through slowly climbing, integrator-like neural activity. I will present nonlinear neural network models which might account for such type of activity and are capable of representing interval time online, building on the dynamical concept of a line attractor. I will furthermore discuss possible biophysical (physiologically realistic) implementations of this concept in the nervous system, and through which biophysical processes neural interval time representations might be adjusted to capture the temporal structure of simple sequences of environmental events.

Dhooge, A., Govaerts, W. Department of Applied Mathematics and Computer Science, Gent University, Belgium, Kuznetsov, Y., Mestrom, W. & Riet, A., Department of Mathematics, University of Utrecht, the Netherlands.

*Matcont : A Matlab package for dynamical systems with applications to neural activity.*

Matcont is a graphical Matlab package for the interactive numerical study of a range of parameterized nonlinear problems. It allows to compute curves of equilibria, limit points, Hopf points, limit cycles and period doubling points of limit cycles on which further bifurcations can be detected and normal form coefficients can be computed. Matcont makes the Matlab ode suite interactively available and can exploit the Matlab symbolic toolbox to compute derivatives of all orders. It exploits sparse matrix storage when computing limit cycles. We present the use of Matcont in several interesting neural models to study spiking. bursting and related phenomena.

Rossberg, A. Zentrum für Datenanalyse und Modellbildung, University of Freiburg, Germany.

*A robust, pathway-independent frequency measure for nonlinear oscillators*

The characterization of biological oscillators usually starts with measuring their oscillation frequency. Often, the frequency is obtained from the power spectrum (Fourier transform) of some measured time-series (signal). But there is a problem: The signal pathway acts as a filter on

the signal, changes the power spectrum, and biases the measured frequency. Measuring oscillations of the SAME oscillator along different signal pathways will yield DIFFERENT frequencies (A.R., lanl.arXiv.org/abs/physics/0203081). A new, robust method to measure frequencies is proposed, which is not influenced by filtering the signal. The method is parameter free. The stronger the nonlinearity of the oscillator, the more accurate it is. Application of the method is demonstrated for the oscillatory components of the heart rate variability of human subjects.

## Series C

**4pm – 6pm PAPER SESSION 7 Mathematical Applications**

Da Luz, M., Buldyrev, S., Raposo, E., Santos, M., Stanley, H., & Viswanathan, G.
Departamento de Física, Universidade Federal do Paraná, Brazil

*Dynamical Robustness of Lévy Search Strategies*

We study the role of dynamical constraints in the general problem of finding the best statistical strategy for random searching when the targets can be detected only in the limited vicinity of the searcher. This problem is of paramount relevance to the biological foraging. We assume only that the number of steps between successively visited sites increases monotonically with the delay time $\tau$ during which a previously visited site becomes unavailable and find that, surprisingly, the optimal search strategy is always described by a Lévy distribution of step lengths L with $1 < \mu = 2$. e also find that the optimal search strategy depends strongly on $\tau$. Our findings appear to be robust even if arbitrary energy costs of locomotion are considered. All these finds agree with experimental data of animal foraging.

Mahmoud, G. Department of Mathematics & Computer Science, United Arab Emirates University, Al Ain, United Arab Emirates.

*Chaotic behavior of nonlinear oscillators*

Oscillatory phenomena are important in biology, physics and engineering, for example, cell division cycle, heart beat, high-energy accelerators, robots, pendulums and electrical circuits. The mathematical analysis of these phenomena leads to the solutions of two (or more) coupled linear (or nonlinear) oscillators. Chaos is observed in many practical applications in biology, economics, physics and engineering. In this paper some classes of nonlinear oscillators are presented. Chaotic behavior and chaos control of these oscillators are discussed.

Winkler, F-G. Vienna University of Technology, Department of Computer Aided Planning and Architecture, Vienna, Austria

*Spacetime Holism and Part-Whole Relationship in Self-Organizing Systems*

It is a common place statement that the theory of self-organization is not fully compatible with the traditional scientific worldview. The critical issues of the discussion are well known: reductionism versus holism, determinism versus creativity, emergent phenomena, top-down causation, part-whole containment, etc. Though it is well accepted that the essential properties of self-organizing systems, indeed, cannot be explained on traditional scientific grounds, there seems to be a tendency to allow some kind of peaceful co-existence of the two paradigms by regarding the world as a hierarchy of self-organizing systems. In our contribution, we try to argue that the critique of the traditional scientific worldview has to go deeper. The closer it comes to life, man and human society, the less adequate is this hierarchical picture. Instead, the world should be understood as a virtually infinite collection of overlapping systems, organizations, and structures. This assumption makes the philosophical issues mentioned above even more critical. As the basis for a consistent treatment of these questions, we suggest a radical world view called spacetime holism. A closer examination of the problem of part-whole relationship leads to a widely applicable concept called "representation," which explicitly presupposes non-hierarchical, overlapping systems.

References

Winkler, F.-G. (1999). "Space-Time Unity and the Representation Problem", in Computing Anticipatory Systems: Daniel Dubois (ed.), American Institute of Physics, Woodburg, New York, Conference Proceedings 465, 131-141.
Winkler, F.-G. (2003). "Spacetime Holism and the Passage of Time," to appear in Proceedings of the NATO Advanced Research Workshop: The Nature of Time: Geometry, Physics & Perception, Tatranska Lomnica, Slovak Republic, May 2002.

Arrow, H., Department of Psychology, University of Oregon, USA

*Bubbles, eruptions, stagnation, and floods: How energy flows in small groups*

We are a deeply social species. People everywhere spontaneously create and congregate in small groups, which forms the "natural environment" for our minds (Caporael & Baron,

1997). Why, then, is so much group interaction frustrating, dull, and unproductive? Drawing on ideas from Holland and Kauffman, this paper presents some ideas about the flow (and stagnation) of energy in groups. Distinctions are drawn between groups that are actually operating as complex systems, shuttling and transforming energy and information in complex, cross-level cycles, and groups in which the dynamics are simple and predictable. I speculate on the role of dyads as incubators for upward cascades of energy, the contribution of perceived and enacted similarity and difference in binding and transforming individuals into group members, and the coupling between individual, dyadic, and group regulatory processes.

## Series D

**4pm – 5.30pm PAPER SESSION 8 Order and Self-Organisation**

Goldstein, J., Adelphi University, Garden City, NY, USA

*The Emergence of New Order: From Self-organization to Self-transcending Constructions*

The phenomena of emergence, i.e., the emergence of new order with new properties, is typically understood in association with processes of self-organization in complex systems. The idea of "self-organization", in turn, is conceived in terms of spontaneity, self-generation, internal-drivenness, and so forth. As a result, the emergence of new order is conceived in a like fashion, e.g., Stuart Kauffman's characterization of the emergence of order in his networks as "order for free." This paper, however, contends that a closer look at what's involved in emergence among a variety of complex systems belies this facile interpretation of how new emergent order arises. Emergent order is more adequately understood as the outcome of a set of radical transformations of already existing order: internal order (in spite of the often heard claim of internal randomness); the order generating capacity of "rules" of transformation; and order in the environment which is incorporated into the system via the system's "containers." Hence, an alternative construct to self-organization is presented in order to be more faithful to the phenomena of emergence: "self-transcending constructions (STC)". The idea of an STC is derived from several sources including Charles Bennett's complexity metric of logical depth, the Cantorian argument at the heart of Turing noncomputability, Jack Cohen's and Ian Stewart's so-called "Existence Theorem for Emergence", and modifications of recursion that are necessary if emergent order is to be radically novel. Implications of appealing to the construct of self-transcending constructions rather than self-organization per se are then drawn-out.

Toifl, K., Neuropsychiatric Clinic for Children and Adolescents, University of Vienna; Austria

*The meaning of quality and creativity of information and time for self-organization in living systems*

Some theoretical considerations about the central impact of information and time on the self-organization of structure and function in living systems will be presented and discussed. When information is seen from a qualitatively oriented point of view, it becomes clear that it is to be found in all material structures and in all forms of energy, and not only where it is quantitatively measurable. Time is discussed concerning the two aspects of it. Kaempfer and Cramer suggest that time has a twofold nature. On the one hand the irreversible course – eg from birth to death – and on the other hand the reversible one – eg the periodic course of oscillations -, which allows the temporary existence of structure and function in self – organizing systems.

Mella, P., University of Pavia, Italy

*Order and chaos in combinatory systems. A different approach to collective behaviour*

My paper aims first to demonstrate that collectivities of *non*-interconnected *similar* agents which develop *analogous* micro *behaviours* can also show very interesting forms of *self-organization* that lead to ordered or chaotic macro behaviour. I have called these collectivities *combinatory systems* since, on the one hand, the *macro behaviour* of the system as a whole derives from the *combination* of the analogous *micro behaviours* or *effects* of the agents, and on the other, the *macro behaviour* determines, conditions, or directs the subsequent micro behaviours. This internal *micro-macro feedback* produces a *self-organization* effect as if an Invisible Hand or Internal Organizer regulated its time path and produced the observable effects and patterns. Combinatory systems are not easily recognizable; nevertheless they are widely diffused and produce most of the social and economic collective phenomena involving the accumulation of objects, the spread of features or information, the pursuit of a limit, and the achievement of general progress as the consequence of the individul pursuit of particular interests. My second aim is to illustrate– with the aid of simple *combinatory automata* – phenomena as intriguing as they are emblematic: the voice-noise effect in organizations; the

clustering and swarming effects in economics; the unjustified raising of retail prices; the Stock Exchange dynamics deriving from the micro-macro feedback between stockbroker decisions and the stock index. We will see that the joint action of crossed and multi-level micro-macro feedback makes it not unthinkable that "a butterfly can cause the collapse of the Stock Exchange".

**Lecture Room HALL WAY**
**6pm – 8pm**
**POSTER SESSION with Refreshments**

Adli, A., University of Tübingen, Tübingen, Germany
*A catastrophe theoretic approach to suboptimality in grammar research*

In this paper I explore the results of a graded grammaticality judgment test for different types of subject-object-sentences in French. Within current approaches in universal grammar research the phenomenon of grammatical gradedness and suboptimality is often ignored, though highly important for the understanding of crucial data. Catastrophe theory presents a geometrical model, which can account on the one hand for the issue of grammatical gradedness and on the other hand for the qualitative concepts and perceptions of grammaticality vs. ungrammaticality. It offers an understanding of the instability in the suboptimal region in between, and of the dramatic changes in grammaticality after certain small variations in the sentence structure. Furthermore, this experiment with adult native speakers shows an effect of age, which is specific to the suboptimal region. This effect can be integrated into the cusp model, too. The poster will provide an "epistemological corner", in which we discuss some of the methodological and philosophical ideas of René Thom in the light of this concrete application. This door is especially open for those, who are less familiar with empirical grammar research.

Aporti, F., Ferro-Milone, F., Cananzi, A., Minelli, T.A., Nofrate, V.,& Pascoli, D. Research & Innovation, Padova, Italy
*Sampling dependence of EEG nonlinear and fractal structures in healthy subjects and Alzheimer patients*

The high sampling rate and digital resolution of present EEG records allow more accurate resolution in spectral analysis and the application of more appropriate methosd based on nonlinear dynamics and fractal geometry, requiring large data sets. The price to pay for this performance improvement is the encumbrance of data memory occupation. The optimisation of performance/encumbrance ratio was the original objective of this research. Pure re-sampling introduces a sort of low-frequency noise, due to loss of precision. On the other hand, filtering suppresses possible high frequency noise. Re-sampling, with associated anti-aliasing filtering, resulting from the balance of the two mechanisms, produces different effects on correlation and fractal dimensions for different spectra. Such a mechanism explains the paradox of a higher complexity at 1024 Hz in AD patients as compared to control ones, and a lower level at 128 Hz. This phenomenon has also been supported by data surrogation. (Research supported by Research & Innovation).

Bassin, M. Synergetic Research Center of Saint-Petersburg Association of Scientists and Scholars, Universitetskaya Naberegnaya, Russia
*Information-Wave Theory of Structures and Systems and its Application to the Life Sciences.*

In the paper are presented foundations of the development by the author during last ten years of an information - wave theory of structures and systems .Three mechanisms of information synthesis were investigated. 1. Changing of probability distribution of occasional possible upshots by means of the identification of the occasions, which occur at different moments of the time.2. The information reception by identification of upshots of occasion .3. The information reception by identification of structures. New complex mathematical structures were introduced. Analysis of their dynamics allowed us to build foundations of united theory of structures and systems interaction, one of the cases of which is a theory of casual processes, and other quantum and classical mechanics. An essential element of the theory is an a priori supposition about a wave nature of phenomenas of our surroundings in the world. Classification of nonlinear waves, vortex and dipole (mushroom) structures is fulfilled. The theory allowed us to explain new physical phenomena, discovered by studying asymmetrical objects motion in non-homogeneous media , as resonance interaction of vortex and mushroom structures with dispersive waves (vortex-wave and structural resonance). Based on this general theoretical position, a system of connected mathematical models, using complex variables, is worked out, which describe the growth and duplication of cells, organisms and populations. Models are used for the analysis of hierarchical systems such as cell - person - human society. (Research supported by the Russian Foundation

of Fundamental Research (projects ? 05-01-1582?, ? 96-06-80418?, ? 00-06-80077?))

Dimitriou, M. Department of Psychology, University of Warwick, UK & Bird, D., Department of Psychology, University of Northumbria, UK
*Chaos in Psychopharmacology: The effects of caffeine on cognition, mood and cortical complexity.*

The aim of the present study was to examine the effects of acute caffeine intake on cognition, mood and endogenous cortical complexity, and in addition examine their interrelations. Participants were randomly allocated to either a 6mg or 106mg caffeine condition. The dependent variables were speed and accuracy of response in each task of the computerised Cognitive Drug Research (CDR) battery and mood ratings as self-reported by each participant on a Visual Analogue Scale (VAS). One-channel EEGs were recorded at rest in wakefulness with 'eyes-open' from two electrodes (Fp1, T3) versus the contralateral earlobe (international 10-20 system) of which the correlation dimension (D2) values were recorded. Two subsequent 3s epochs were chosen of which the D2 as well as the largest Lyapunov exponent were calculated. It was shown that acute caffeine intake increases psychomotor performance, but not performance involving higher cognitive processes such as memory. Caffeine also increased cortical complexity in one extracted epoch, producing a significantly higher Lyapunov exponent for the 106mg group. The exponent correlated positively with psychomotor performance. This relationship could simply indicate that cognitive enhancement is represented by increased complexity at the cortical level. However, the findings of the present study combined with past research allow for the possibility that higher cortical dimensionality might contribute in producing enhanced cognitive performance through providing increased dynamical variability. As a function of neurotransmitter efficiency, this increased variability is caused by a temporary shift in cortical dynamics (i.e. bifurcation), which postulates a transient modification of inherent control parameters within the CNS. This shift is thought to 'prime' the system for more effective cognitive functioning, as it becomes more flexible in accommodating incoming stimuli. The results can be also be discussed in terms of the implications in applying nonlinear dynamics theory in psychopharmacological research.

Chesters, G., Centre for Local Policy Studies, Edge Hill University College, Lancashire, UK
*Global Social Movements and Complexity*

This paper seeks to outline and present findings from recent and original research into the emergence of the global social movement contesting neo-liberal capitalism (funded in part by the Economic and Social Research Council). In doing so, it suggests an analytical framework for the interrogation of this movement that draws upon the contemporary complexity sciences. The paper argues that whilst the development of a complexity perspective in social movement theory is in its infancy, its application appears to have significant explanatory utility. It examines how such a perspective might be developed further and draws attention to the areas of social movement theory that already exhibit an affinity with insights yielded by the 'complexity turn'.
Email: graeme@shiftingground.org

Chistilin, D. Institute World economy and International Relations, Ukraine Academy of Science
*To the wave nature of economic cycles*

The question of economic cycles' origin is still one of the most actual problem up till now. One of the defined economic regularities and reasons initiating cyclic fluctuations in every aspect of community functioning is a trend of population growth, scarceness of resources for production and benefits for consumption. At the same time, diffusion and integration of knowledge in different spheres and common regularities characteristic for organic and inorganic aspects of nature are taking place in modern science. It includes discovery of dynamic chaos, the principle of dissipation in open systems, etc. There is one more accomplishment, which is common for both organic and inorganic nature: formation of wave processes. In inorganic nature the wave process appears as a form of the system's existence and as an environmental reaction against outside disturbance. While considering conditions of origin of stationary waves in physical representations of non-linear processes, it is obvious that the wave process is a qualitative characteristic of the system itself existing in a non-equilibrium state. According to the definition both characteristics – density and viscosity – initiate two opposite processes: twisting and overturning in the case of outside disturbance availability which, in their turn, create the basis for the appearance of stationary waves. By analyzing different communities, social-economic systems we can observe an analogue process. Socium as an environment, a separate element of which is a human being,

possesses two basic characteristics. It involves the organisation of different values of capability for every human being on one hand and organization of scarce resources for production and level of consumption of limited benefits, on the other hand. These two characteristics create two opposite trends of production and consumption in both population growth and scarceness of resources over the long term. These two trends operating in opposite directions initiate stationary wave process, which economics defines as an economic cycle. Thus, the property of an organic system to initiate wave processes under the influence of the external environment is a necessary condition for supporting dynamic stability of the system during its development, i.e. supporting homeostasis.

Codreanu, S., Babes-Bolyai University, Dept. of Theoretical Physics, Romania & Codreanu, T., Dr Gray's Hospital, Elgin, U.K.
*Suppression of chaos in some nonlinear biological models.*

We present two nonlinear biological models: a one-dimensional model of malignant tumor growth and a two-dimensional model of competition between the populations of two species. These models are first analytically and numerically studied and then a procedure of suppression of chaos is applied. Both systems have a rich dynamics, including a chaotic behavior. by using a control algorithm, which acts in the system variables, some periodic motions and even the steady-states have been stabilized.

Damgov, V. Space Research Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria.
*Class of Kick-Excited Self-Adaptive Dynamical Systems: "Quantized" Oscillation Excitations*

A class of kick-excited self-adaptive dynamical systems is formed and proposed. The class is characterized by a nonlinear (inhomogeneous) external periodic excitation (as regards the coordinates of the excited system) and is remarkable for the occurrence of the following objective regularities: the phenomenon of "discrete" ("quantized") oscillation excitation in macro-dynamical systems having multiple branch attractors and strong self-adaptive stability. The main features of the class of systems are studied both numerically and analytically on the basis of the general model of a pendulum under inhomogeneous action of a periodic force (referred to as a kicked pendulum). A diagram involving multiple bifurcations for the attractor set of the system under consideration is obtained and analyzed. The complex dynamics, evolution and the fractal boundaries of the multiple attractor basins in state space corresponding to energy and initial phase variables are obtained, traced and discussed. An analytic proof is presented showing the existence of "quantized" oscillations for the kick-excited pendulum. An analytic approach is given applicable to the cases of small and large amplitudes (small and large non-linear influence). The spectrum of possible oscillation amplitudes for the pendulum is studied as well as its motion in a rotational regime under the influence of an external non-homogeneous periodic force. Generalized conditions for the excitation of pendulum oscillations under the influence of an external non-linear force are derived. A wide spectrum of applications of the formed class of systems is presented.

DeVaney, T.T.J., Ahammer, H., & Tritthart, H.A.. Institute of Medical Physics and Biophysics, University of Graz, Austria
*The time dependance of the fractal dimension and invaslog during the invasion of melanoma into healthy tissues*

Spheroid confrontation studies of labeled melanoma spheroids and embryonal chick heart spheroids has enabled us to show that the degree of invasion of healthy tissue is cell size and clonally dependent. In order to determine an ideal time point for observation a time study was undertaken and the results analysed using the Invaslog – a parameter that reflects the degree of invasion as assessed by pathologists- and the fractal dimension assessed by the box count method. This showed that the Invaslog increases with time, as would be expected, and the fractal dimension increases with the same trend. This seems to indicate that the fractal dimension would be suitable for determining the degree of invasion and due to its robustness a more stable parameter.

Gregson, R. Australian National University, Canberra, Australia, & Geake, J. Oxford Brookes University, UK
*Tribonacci. Long Memory, and Stochastic-deterministic Mixed Series*

Short realizations of long memory time series processes that can be derived from the Tribonacci series by damping its explosive properties are examined. A modification of the Tribonacci series formed by imposing a modular constraint on its expansion, called Tribmodk, is used to illustrate the effects of small changes in

its parameters on a diversity of statistical properties variously used to characterize a quasi-periodic trajectory, which may be suspected to be chaotic or at the edge-of-chaos, and almost certainly falls into the family of transient nonlinear nonstationary series that arise in psychology. The entropic analog of the Schwarzian derivative, ESf, is introduced, in first-order and higher-order analyses , and the potential use of the Tribmodk series as a source of time series in psychophysical serial extrapolation experiments is noted. These series create conceptual problems in distinguishing in human sequential performance between identification, estimation and prediction. Comparative analyses, falsely assuming that the processes are purely stochastic and stationary, are tabled to show that the processes may be described but not functionally mapped by excessively complicated classical ARMA modelling. Mixing deterministic and stochastic components has complicated consequences, not necessarily diminishing the stability of the trajectories.

Grizzi, F., Russo, C., Franceschini, B., Barbera, R., & Dioguardi, N. Gastroenterology Department, Istituto Clinico Humanitas, Milan, Italy.

*Fractal Evaluation of Human Ph Recording Time Series*

Human processes are characterized by irregular and discontinuous fluctuations, that render their behaviour complex in time. Examples of human irregular signals are the fluctuations in the rate of the heart and the blood pressure in the arteries. Recently, Glass and Mackey have introduced the concept of *dynamical disease*. In many different human diseases, the normal organization breaks down and is replaced by some abnormal dynamics. Since even today there is no rapid and reliable quantitative index of oesophageal acid exposure in time, the aim of this study was to introduce the concepts of the fractal geometry for evaluating the irregularity of the pH recording time series. The goal of fractal analysis is to determine if experimental data contain self-similar features, and if so, to use fractal methods to characterize quantitatively such a data set. Twenty pH recording time series were analysed with a computer-aided method, based on the Richardson fractal dimension. For each patient was evaluated an equal interval of time. Our preliminary study allows the following suggestions to be made: *a.* the method is rapid, objective and reliable; *b.* the fractal dimension reveals different phases of the dynamics of the oesophageal reflux disease; *c.* this kind of analysis suggests the possibility to reduce the total recording time, from the commonly used value of 24 hours; this result agrees with the principle of the fractal geometry, called self-similarity. In conclusion, it is our intention to apply the developed method not only for basic science purposes, but also as clinical diagnostic routine.

Javorszky, K. Institute für angewandte Statistik Vienna, Austria.

*The Interplay between Structured Sets and their Sequential Description*

We present a model to demonstrate concepts of logic, philosophy, information theory and theoretical genetics. The main idea is to treat consecutive and contemporary assemblies of information carrying media as equally suited to contain information. The technical method uses the consecutive property of media, while in biology one observes the concurrent existence of specific realisations of possibilities. Genetics connects the two approaches by using an interplay between consecutively (sequentially) ordered logical markers and the state of the set it is copying into the DNA. We had to evolve several mathematical tools to assemble an industry-strength interface between sequentially ordered carriers and the same number of carriers if they arrive contemporaneously. We have used linguistic theory and formal logic to conclude that results of a scientific investigation are a (set of) logical sentence(s) relating to an assembly of n objects which present group structures among each other. We use the concept of multidimensional partitions hitherto left undefined and arrive at a maximally structured set. The interaction between a sequence and structured set allows us to demonstrate concepts of diversity, similarity, evolution, possibilities and realisations - from the philosophical vocabulary; doubly and thrice true sentences, degrees of contradiction and impossibility - from the metier of logic; transmission efficiency improvements and a model of the memory – from the field of information theory. The interplay between a long sequence and a broad presence opens up a ways of talking exactly about ideas hitherto outside mathematical exactitude.

Knezevic, A., & Martinis, M.. Department of Theoretical physics, Rudjer Boskovic Institute, Zagreb, Croatia

*Change of the heart rate variability during ergometric measurement*

By using the rescaled range (R/S) method we have analysed changes in the structure of heart rate variability patterns during ergometric measurement. The time series of heart beat intervals are analysed in the case of stable angina pectoris (SAP) and compared with a group of healthy subjects. Patients with SAP have lower values of the Hurst exponent during increased physical activities, in comparison with the healthy subjects for which it is observed to be increasing.

Lambropoulos, N. London Metropolitan University, Learning Technology Research Institute, London
*Creative Process: a Constellation of Chaotic Nexus*

We report results of a one-year study (2001) of the Creative process as a self-organized, autopoietic system. The naturalistic case studies including our participant observation, were based on a dual basis of introspective views and results extracted from studies of 6 individuals in their working places. Our analysis suggests that two interactive, fractal lines move chaotically, towards and in reverse. These two lines start from the Self and the Other (information given and environment), which are interwoven in a fabric constructed of nexus. These nexus depend on the strange attractors of personality and the previous nexus, which in turn react as new attractors, and together with external factors (Other), influence the whole process both during the initial forming and the progress. The fractal construction appears as the result of every step and is given by the underpinned structure, analyzed in the four levels of the creative process (preparation, incubation, illumination, verification) through the thought/action/reflection loop while the entire process is based again on the same pattern. Actions function as verifications of repetitive processes and yield the artwork. As a result, microscopic or macroscopic zooming in and out gives the same result, the fractal icon of the creative process. (Research supported, in part, by the Art and Design Department, Institute of Education, University of London).

Obcemea, C., Memorial Sloan-Kettering Cancer Center, New York, NY USA
*Chaotic Dynamics of Tumor Growth and Regeneration*

Tumor growth exhibits a wide variety of dynamical time behaviour. Current growth models such as the continuous-variable logistic, Gompertz or Gomp-ex models however exhibit only smooth monotonic approach to an asymptotic limit point and none of the other time-dependencies. This paper argues that the richness of this dynamical behaviour could be understood within the framework of chaos, i.e. the study of the bifurcation structure of nonlinear equations. We illustrate this idea using the simplest example of discrete logistic map and relate the system parameters to cellular stimulants/ inhibitors such as growth factors, cytokines and angiogenic stimulating factors.

Otranto, E. Istituto Nazionale di Statistica, Dipartimento delle Statistiche Economiche, Roma, Italy.
*Stock and Watson Models with Markov Switching Dynamics: an Application to the business cycle.*

Recent econometric works analyze the business cycle using Markov switching approaches. In particular, the Hamilton model extended to the Stock and Watson dynamic factor model was used to examine the differences in expansionary and contractionary phases. In this paper, this model is applied to four Italian economic variables to detect business cycle turning points and a coincident indicator. The results are evaluated in the light of the turning points and the indicator proposed in Altissimo et al. (2000).

Prorokovic, A., Gregov, L., & Valerjev, P.
University of Zadar, Department of Psychology, Zadar, Croatia
*Mental load assessment by the means of non-linear analysis of heart rate variability*

Many attempts have been made to evaluate mental workload using heart rate variability, but mostly with different kind of linear analysis, which are not enough sensitive to many influencing factors in the interaction of subject with task. In addition, claims that the normal heart rate variability reflects deterministic chaos now have been supported by many researches, including our previous studies as well. In this paper, an attempt was made to evaluate mental workload using chaotic analysis of ECG signals. The experimental section of the paper focuses on the estimation of non-linear measures of heartbeat dynamics (attractor plots, correlation dimensions, Lypunov exponent) in different resting and mental work situations. The results indicate that some of non-linear measures are sensitive to the amount of mental workload and could be very useful as a dependent variables in experiments dealing with assessment of cognitive activity in general.

Puebla, H., Álvarez-Ramírez, J., & Cervantes, I.
Instituto Mexicano del Petróleo, México, MEXICO
*Suppression of Nonlinear Waves in Excitable Media via Feedback Control*

The aim of this work is to design a feedback control law to suppress nonlinear waves in excitable media through weak external stimulus. Two nonlinear, one-dimensional, reaction-diffusion equations are used to describe an excitable medium where a propagating pulse can exist. We consider only a weak stimulus in the slow variable to suppress the propagating pulse. The control law proposed in this work is a simple feedback action based on the dynamical model of the slow variable. The effectiveness of the control law to suppress and control the propagating pulse is illustrated via numerical simulations.

Puebla, H., & Álvarez-Ramírez, J. Instituto Mexicano del Petróleo, México, MEXICO.
*A Robust Controller for Hypnosis Based on Modeling Error Compensation*

One particular application area of control theory in biomedical processes is the determination of the amount and the time-history of drug administration. For instance, in anesthesia, safe desired levels of the patient's: muscle relaxation, analgesia and hypnosis are controlled and guaranteed by means of monitored administration of specific drugs. In this work, a robust controller design for hypnosis control using the bispectral index (BIS) is proposed. A seventh-order nonlinear pharmacokinetic-pharmacodynamic representation is used in the control design. Under a cascade control structure, the control design in each loop is based on modeling error compensation techniques. The master controller compares the actual BIS and the reference value, and provides expired Isoflurane concentration references to the slave controller. The slave controller manipulate the anesthetic Isoflurane concentration entering the respiratory system. The controller performance is illustrated via numerical simulations.

Robertson, R., Bird, D. Northumbria University, UK, Goldstein, J., Adelphi University, and Porter, R., Directions for Mental Health, Clearwater, Florida, USA
*The Case of the Missing Third: Induction, deduction, and what?*

The ontological question of the "missing third" may lie in nonlinear systems theory. Our presentation begins with a brief history of the third way concept. We address the form the question has taken, the problems that have arisen, and the solutions suggested for resolution. For example, in the thesis and anti-thesis dialectic, a new synthesis may emerge. Or, with the separation of subject and object, a need arises for the specification of some "thing" that is the relationship between the two. Similarly, the new concept of becoming ("entelechy") exists between the beginning and ending. The focus of the presentation will be a number of issues dealing with the missing third idea in nonlinear science and theory, including ideas of iteration, sequence and recursion; self-reference; feedback; emergence; non-linear dynamics, the limits of synthesis, and self-transcending constructions, particularly "emergence". Some specifics will include implications of Gödel's work, G. Spencer-Brown's Laws of Form, and C. S. Peirce's and William James' prescient ideas, with particular reference to physiology and psychology.

Sedivy, R. University Hospital Vienna, Austria
*Applications of fractal analysis in tumor pathology*

Fractal geometry has gained increasing attention in tumor pathology recently. This geometrical tool allows the quantitative description of even complex structured objects such as tumors by a measure. A general overview of what was done and how fractal analysis could be applied in diagnosis is presented. Particular examples are given about gynaecopathology, breast cancer, and melanoma.

Soos, I. Praha, Czech Republic.
*The Integrarchic Society*

All actual social systems being pathological, I examine the possibility of healthy individual and social self-organization; with a holistic approach based on Natural Laws. The correct solution of the few aeons old and actually culminating (in)human predicament lies not in the changing of power-relations, but in the removal of power (kratos) from any relationship at all, and the adoption of individualization for the sake of freedom and co-operation where every symbiotic

association is formed around an objective that is particular to its constituents, and has its own psycho-physical existence. Any future human development possibility (even survival possibility) must be contemplated from the point of how it fits into the Natural Order according to its integrarchic (integrity within integrality) system. Its principal sphere is biological in its whole psycho-physical concept, denominated as the 'planetary biosphere' with its main relevant quasi-self-sufficient differentiations of 'major ecological community' and the 'single human individual'. Both are concrete psycho-physical organisms, autonomous holons in their own right. Within these stations fit spatially the diverse forms and stages of their biological and social developments in free association and organization, remembering that social development is also a biological development, and that it must harmonize within the biological sphere. In this study healthy human individuals combine into a great variety of social holons, including reproductional, educational, sanitational, cultural, scientific (which includes research and technology of philosophy, psychology, biology and physics), productional, communal, communicational, commercial and recreational holons, forming *social co-operative organizations of human coexistence* of various interlocking spheres and levels, each forming part of the corresponding natural biological order.

Spohn, M., Graduate School of International Studies, University of Denver, Colorado, U.S.A.
*Operationalizing Violence*

Earlier findings in this ongoing study have shown patterns of correlation between the processes by which individuals become dangerous violent criminals and societies become violent (violent societies being defined here as societies or communities where the state or governing body does not hold a monopoly on violence). This methodological piece applies three different nonlinear models to the analysis of these patterns: cusp catastrophe, agent based modeling, and Langevin equations, a differential set used in the analysis of social field theories. Each one of these offers different insights about the critical points and phase transitions of the processes of violentization and adds to a more complete understanding of the patterns of violent human behavior.

Stamovlasis, D. & Tsaparlis, G., University of Ioannina, Department of Chemistry, Ioannina, Greece
*A Complexity Theory Model in Science Education Problem Solving: Random Walks for Working Memory and Mental Capacity*

The present study examines the role of limited human channel capacity from a science education perspective. A model of science problem solving has been previously validated by applying concepts and tools of complexity theory (the working memory, random walk method). The method correlated the subjects' rank-order achievement scores in organic-synthesis chemistry problems with the subjects' working memory capacity. In this work, we apply the same nonlinear approach to a different data set, taken from chemical-equilibrium problem solving. In contrast to the organic-synthesis problems, these problems are algorithmic, require numerical calculations, and have a complex logical structure. As a result, these problems cause deviations from the model, and affect the pattern observed with the nonlinear method. In addition to Baddeley's working memory capacity, the Pascual-Leone's mental (M-) capacity is examined by the same random-walk method. As the complexity of the problem increases, the fractal dimension of the working memory random walk demonstrates a sudden drop, while the fractal dimension of the M-capacity random walk decreases in a linear fashion. A review of the basic features of the two capacities and their relation is included. The method and findings have consequences for problem solving not only in chemistry and science education, but also in other disciplines.

Tretter, F. State Mental Hospital Haar, Munich, Germany
*Problems of matching empirical data and theories of clinical psychology /sociology to systems theory*

Developing dynamic models on psychological or sociological issues very often is difficult because of a lack of time-related data. Furthermore there are severe differences between theoretical fields of psychology (e.g. Dörner)/ sociology (e.g. Luhmann) and systems theory. Very often mathematical models are applied in these fields without discussion of the current state of theories in the respective field. Very often also there is a lack of appropriate empirical data. Examples in clinical psychology/sociology are given. From a viewpoint of philosophy of science, scientific

progress in the humanities is switching between stages of qualitative observations and theory building and stages with quantitative research. Also in model building can such cycles be observed. Thus an integration of various approaches can be explicated. Within this framework guidelines for a "good practice of modeling" should be developed. For example "transdisciplinary" theory-oriented working groups should be established for evidence-based modeling (comp. Mittelstrass). Empirical researchers, practitioners and theoreticians should co-operate in such groups. This approach was already developed in environmental research (comp. Meadows). Evidence-based estimations of variables, rates, coefficients etc. must be done. Then mathematical models can be applied and computer-assisted testing can be done. Finally new research perspectives can be defined.

Zhong, Z., Xing, J-L., Hu, S-J., & Yang, G-S., Department of Physics, The Fourth Military Medical University, Xi'an, PR China
*A Novel Bursting Mechanism of Type A Neurons in Injured DRG*

The bursting behavior was investigated in the neurons of dorsal root ganglia (DRG) injured by chronic compression. The bursting was found to stem from a spindle-like subthreshold membrane potential oscillation associated with pain pathology (Xing 2001,Amir 2002). Since stochastic dynamics can also produce this pattern of bursting (Makarov 2001), the deterministic dynamics of interburst intervals (IBIs), extracted from raw membrane potential recording, was identified by detection of the hierarchy of unstable periodic orbits (UPOs) in the IBI series. The results showed a number of statistically significant UPOs of order-one, order-two, and order-three. These facts suggested that investigated bursting behavior can be depicted by type 3 bursting dynamics produced by subcritical Hopf bifurcation (Christopher 1998), based on Bertram's classification scheme (Bertram et al, 1995). According to some researchers' results (Izhikevich 2001), the dynamic response of a neuron firing with this bursting mechanism will act as a resonate-and-fire neuron having selective interaction with other neurons. This fact implies that the coding rule of injured DRG neurons acting as a resonator differs greatly from normal DRG neurons acting as an integrator.

# Saturday 8th February, 2003

## Series A

**9am – 11am PAPER SESSION 9 Medical Applications**

Schiepek, G., Eckert, H., & Weihrauch, S. Universitätsklinikum der RWTH Aachen, Klinik für Psychosomatik und Psychotherapeutische Medizin, Aachen, Germany.
*Assessment of Dynamic Systems –Data Based Real-Time Monitoring in the Management of Change Processes*

This is a contribution to the assessment of second order qualities of dynamic processes. First order qualities are the signals produced by the system itself or by the introduced measurement procedures. This can be electromagnetic signals of the brain, observed behaviours of the members of a social system, ratings produced by subjects involved into any process, and so on. Second order qualities are dynamic properties calculated by some algorithms applied to the data. Following the theory of self-organization and taking it as a basis for the understanding of human change processes, these are the properties of critical instabilities and of changing degrees of coherence and synchronization between subsystem dynamics. Critical instabilities can be observed by the fluctuation intensity of the signal and by its local complexity. The data used in order to illustrate the methods are daily self-ratings produced by psychosomatic in-patients treated at a hospital ward of the University Hospital Centre Aachen. The computer based algorithms applied to time-series data allow for a real-time monitoring of the processes. By this practitioners will get a navigation instrument on their way through the turbulences of pattern transitions. The introduced assessment tools will be integrated into a concept of general psychotherapy as a data based synergetic management of processes.

Orel, V., Romanov, A., Dzyatkovskaya, N. & Mel'nic, Y. Physics-Technical Laboratory, Institute of Oncology, Kiev, Ukraine
*Windows of Mechanoemission Chaos in Blood and Oncogenesis*

The development and spreading of the tumour process is accompanied by changes of nonlinear (chaotic) dynamics of process mechanochemical interactions of the group of cell surfaces. Mechanochemical activation of biological sample which is layered onto chromatographic paper is accompanied by mechanoemission (ME) chaos in blood effects too. The objective of this work was to apply the ME method to windows of ME chaos during oncogenesis. The methods used were based upon multi-computer structures when assessing the processes of determinate chaos at different levels of the biohierarchical organization. We have studied blood RE in operable patients with cancer of esophagus and gastric proximal compartment before and after radiotherapy. Remote pre-operative gamma-irradiation of cancer patients was performed with "Rocus-M", using fractions of 5 Gy daily for 6 days to the total of 30 Gy. It was established that patients (5 persons) who showed direct effective results after radiation and followup surgery, the phase diagram of the blood RE acquired mostly a chaotic character. Conversely, the patient group (5 persons) who died 5–7 days after surgery, showed the most vivid periodic character of blood RE following gamma-irradiation. Obviously, it is the border of various levels of biohierarchical organization where, owing to the antagonism of cause-effect correlation, a big region of nonlinear processes exists, which may cause disastrous effects, such as self-organization/disorganization, that are typical for windows of ME chaos reactions during oncogenesis.

Ahammer, A., DeVaney, T.T.J., & Tritthart, H.A.
Institute of Medical Physics and Biophysics,
University of Graz, Austria
*Fractal dimension of in vitro cancer spheroids invading host tissue spheroids*

Fluorophore labeled cancer spheroids were confronted with fluorophore labeled host spheroids and incubated up to five days. As the spheroids were 3-dimensional objects, these confrontations are a more realistic model than 2-dimensional assays of cell mono-layers or single cells. The invasion process of the cancer into the host was visually documented by digital images taken with a confocal laser scanning microscope. This microscope enabled the production of optical sections without destroying the specimen. The artifact corrected digital images were binarised, reflecting the area of the cancer and host respectively. Quantitative parameters calculated from the area and perimeter of the invaded tissue showed a strong correlation to the invasiveness of the cancer. The Fractal Dimension of the boundary of the binary images was calculated and it was possible to show that the Fractal Dimension could serve as a quantitative measure of the invasiveness of the cancer too. The Box count method and the Dilation method (Sausage method) were used and led to the conclusion that the Dilation method, based on the Minkowski- Bouligand Dimension was the preferred method for calculating the Fractal Dimension. Therefore, the Fractal Dimension gave a quantitative value for the dynamical behavior of a cancer spheroid invading into a host spheroid. The higher the value of the Fractal Dimension, the higher the invasiveness of the cancer.

Zhirkov, A., Kostenko, V. Department of Urgent Cardiology, Research Institute of Emergency Medical Care, St.Petersburg & Subbota, A., Military Medical Academy,St.Petersburg, Russia
*Harmony and Chaos in Organization of Heart Rhythm*

The use of heart rhythm for the evaluation of human psycho-emotional condition is well known. A number of abnormal psychophysiological reactions sharply increases in pathological conditions such as myocardial infarction. We researched the correlation between results of psychological tests of Eysenck, Lusher, Spilberger and a quantitative analysis of the electrocardiogram (ECG). Criteria of harmony (Golden Section Rule) and chaos (fractal picture using Mandelbrot's multitude algorithm) were used for ECG analysis. The results of examination of 120 patients were compared with the disease outcomes. It was revealed there is a correlation between the results of psychological examination and the ECG parameters used for the research (p=0,02-0,05; N=0,43-0,74). A significant correlation between ECG, psychophysiological parameters and outcomes has been discovered retrospectively. These data show the possibility of using models of complex dynamic systems in medicine, particularly in cardiology.

## Series B

**9am-11am PAPER SESSION 10 Social Science Applications I**

Rinaldi, S. Dipartimento di Elettronica e Informazione, Politecnico di Milano, Italy
*Modelling love dynamics: the case of "Jules et Jim"*

Although love stories are characterized by remarkable time evolutions of feelings, they have only recently been modelled as dynamic processes. The aim of this talk is to show how this can be done and what kind of results can be expected from this formal analysis. A general model taking into account three mechanisms of love growth and decay (the pleasure of being loved, the reaction to the appeal of the partner, and the forgetting process) is introduced. The model is then adapted to special classes of individuals (secure and non secure, synergic and nonsynergic) in order to detect if they are inclined to develop smooth or wild love stories. Finally, a particular and quite complex case involving a triangle is analyzed in some detail. It is the turbulent love story described in "Jules et Jim", the autobiographic novel of Henri Pierre Rochè (1953), from which Francois Truffaut derived his famous 1961 film (starring Jeanne Moreau , Oskar Werner and Henry Serre). The characters of the three individuals are identified from the novel and encapsulated into a model which is then analyzed and shown to be chaotic. In other words, the evolution of a love story can be unpredictable because the characters of the individuals have the power to generate their own deterministic chaos. This has interesting consequences for the interpretation of both the novel and the film.

Remondino, M. Computer Science, University of Turin, Italy
*Agent Based Process Simulation and Metaphor Based Modelling for Social Sciences*

Simulation is an increasingly popular way of describing social models, alternative to other two symbol systems: the verbal argumentation and the mathematical one. The advantage is the high portability on computers; programs can then be used to model either quantitative theories or qualitative ones. There are mainly two approaches: Process Simulation, which is generally used to create models of well known parts of enterprises or mechanical/electronic systems and Agent Based Simulation, which allows to study the emergence of social behaviour with the creation of models, known as "artificial societies". The main goal of this work is to present a hybrid formalism, which uses the best parts of the two, to build realistic economical and management models. The parts of a system that can be described and modelled through a process based approach, are seen as specialized, or structured agents, which don't evolve and are only capable of getting an input and producing an output. These agents are placed side by side with others, with a simple structure, yet reactive to the stimuli that come from the environment, and capable of self-organization. The unstructured agents are used to describe the parts of the whole system which are fuzzy or that cannot be strictly modelled within a scheme of elementary processes, or are inserted within a single process, describing the parts of it which are unknown or too difficult to describe. Metaphor Based Modelling is then introduced as a technique for converting a real social system into a computer model.

Kubo, M. & Sasakabe, Y., National Defense Academy, Yokosuka, Japan
*Formation, Disorder, and Reformation of Mobile Agents by Chaotic Itinerancy*

We report the importance of chaotic itinerancy to an autonomous collective system that can adapt to an external environment and its internal condition. Recently, as autonomic computing paradigm, methodology to realize highly autonomous group of agents is an urgent issue. Each agent observes its belonging group and evaluates. The collection of the evaluation promotes dynamics of reformation of their group. As a result, new improved group formation emerges. To realize this scenario, agents should make some groups to coordinate each other because a single individual's power is too powerless for a group. However, it is very difficult for them to deduce better formation a priori because of the nonlinearity of the feedback loop of the social dynamics. Therefore, the group has to reform itself by trial and error. Namely, various group formation candidates emerge by local interaction among the agents that try to make subgroups. We think that chaotic itinerancy of chaotic oscillators is quite adequate because various synchronized patterns emerge from the oscillator network. From this standpoint, we propose a new reformation dynamics for a group of autonomous agents and so approach the transportation problem of micro machines. Using computer simulations, the agents can adequately produce their topological pattern for a variety of corridors.

Zidansek, A., J. Stefan Institute, Ljubljana, Slovenia
*Self-organization in sustainable development*

Results of a self-organization study of sustainable development are presented, using time dependence of quantitative sustainable development indicators. The relation between economic, environmental and social development is observed with special emphasis on the effect of

government policy, business responsiveness and other globalization processes. Analysis of these time series provides qualitative advice for strategy of individual players in the networked global society. Particular emphasis is given on effects of such individual strategies on global security and terror issues.

## Series C

**9am-11am Symposium 4: Cellular Self-Organizing Nets and Chaotic Dynamics to Model And Control Complex Systems**
**Convenor:** Fortuna, L., Universita' degli Studi di Catania, ITALY

Considering the Darwin contest even if the adaptive evolution occurs gradually accumulating small variations, probably today, as conjectured by Stuart Kaufman in his book " The Origin of Order, Self Organisation and Selection in Evolution ", the concept of random variation emphasised by Darwin cannot be considered the best law for successful evolution. Starting from this consideration we developed a research project with the main task of modelling complex systems like those including nonlinear dynamics and characterising some problems in Psychology and the Life Science. At the same time we are looking to new strategies and innovative interacting architectures, like the Cellular Nonlinear Networks (CNN) able to model these dynamic. Moreover the novel role assumed by the spatial diversity in complex systems will be underlined stressing the conjecture that spatial diversity generated by deterministic dynamics improves self-organisation and synchronization. The contributions in this Symposium will include topics referred to the low order dynamics analysis and control and subjects on spatially extended systems. Particular attention will be devoted to the application on the new presented techniques to the fields of life science and to the impact of some phenomena in the social contest. We propose six or seven contributions, and different types of experiences, depending on the convenors research affiliation, will be reflected in an organised way in the workshop. The Symposium aims to show as multidisciplinary institutions with different backgrounds, like industrial companies and public research department, are agreed to deeply investigate chaotic systems for modelling complex phenomena by using innovative tools like CNN and the same emerging properties of the nonlinear dynamics to control and synchronize their behaviour.

Caponetto, R., Fortuna, L., & Frasca, M.
Dipartimento di Ingegneria Elettrica, Elettronica e dei Sistemi Università degli Studi di Catania, Catania, Italy.
*The role of diversity in spatially extended systems.*

In systems formed by networks of simple non linear cells some of the fundamental features of complex systems such as self-organisation and pattern formation appear. The role of spatial diversity in these systems is dealt with. Remarkable improvements regarding regularisation and pattern formation, obtained in networks of non linear systems are obtained by introducing spatial diversity. In particular generating spatial dissymetries by using chaos enhances regularity and pattern formation capability with respect to the case in which diversity is generated by random processes. Several examples are reported showing the previous conjecture. In particular, lattices of non linear systems are used to experimentally study their global spatio-temporal dynamics, according to the variation of microparameters (to take into account the spatial diversity) and macroparameters, like the coupling coefficient or the neighbouring dimension. The introduction of a small amplitude chaotic spatial diversity could control chaos in both 1D and 2D large scale connected arrays of non linear circuits like Cellular Neural Network (CNNs).

Genesio, R. & Bagni, G. Dipartimento di Sistemi e Informatica, Università di Firenze, Firenze, Italy
*Simplified dynamic models for complex data*

Time series of biological data usually exhibit oscillatory behaviors. This occurs as an effect of periodic forcing, as well as an unforced evolution of autonomous systems in study. Such behaviors can result in periodic signals but commonly they are "approximately" periodic, in the sense that their observed main amplitude and frequency seem to have small fluctuations in time: the signals appear to be similar to certain chaotic solutions of dynamical systems. The investigated problem concerns the description of the above signals in terms of the dynamics of nonlinear simplified models, which are able to express the essential elements of the observed complexity but depend on a reduced number of parameters. The general aspects of defining the class of studied signals, of introducing some other information which can characterize such signals and of

measuring the distance beetween given and modeled data are considered, as well as the identification questions which are about the structure and the parameters of the approximating models.

Bonanno, G., Lillo, F., Micciche, S. & Mantegna , R.N. Istituto Nazionale per la Fisica della Materia, and Dipartimento di Fisica e Tecnologie Relative, Unita` di Palermo, Universita` di Palermo, Palermo, Italy
*Complexity in financial markets*

Financial markets are model complex systems [1]. The comprehension of the key aspects of market dynamics can be instrumental to an accurate description of the stylized facts occurring in financial market. We focus our talk on the empirical observation that cross-correlation of returns and volatility are present between each pair of equities traded in a given market. Specifically, we investigate the hierarchical organization of the investigated stocks obtained by determining a metric distance between equities and by investigating the properties of the subdominant ultrametric associated with it [2]. This method coincides with single linkage clustering of multivariate analysis. We investigate the role of noise dressing on the detection of the underlying hierarchical structure both in returns and volatility and we compare the topological properties of the minimal spanning tree with those of widespread market models such as the one factor model.

[1] Giovanni Bonanno, Fabrizio Lillo and Rosario N. Mantegna, Levels of Complexity in Financial Markets, Physica A, 299, 16-27 (2001).
[2] Rosario N. Mantegna, Hierarchical Structure in Financial Markets, Eur. Phys. J. B 11, 193-197 (1999
Email:

La Rosa, M., Nicolosi, D., & Occhipinti, L. Corporate R&D - Soft computing Nano-Organics Si-optoelectronics & Micromachining Operation, STMicroelectronics, Catania, Italy.
*CNN As Paradigm For Complex Dynamic Systems Modeling*

L.O. Chua and L. Yang have introduced cellular Neural/Nonlinear Networks (CNN) in 1988 as a novel class of information-processing systems. The CNNs perform brain-like type computations reproducing two fundamental features: nonlinearity and local interaction. The basic theory describes the CNN as a regular architecture made of cells coupled to each other using a precise neighborhood configuration. Moreover the local identical structure of the couplings allows the reproduction of large arrays of CNN described by nonlinear differential equations. The building block is the cell containing linear and nonlinear circuit elements, which interacts both directly and indirectly with the others and performs continuous time dynamics in a discrete space. In the study of complex systems interesting spatio-temporal phenomena, i.e. autowaves and pattern formation, have been obtained using CNNs with suitable template values. The CNN architectures implemented in a complete platform with dedicated hardware and programming procedures represent a paradigm able to simulate and reproduce complex dynamics evolution of large array systems. Devices implementing the CNN-UM approach have been already designed and developed within independent research programs (e.g. DICTAM project). In particular applications like real-time image processing and high speed computing (Tera-Ops/sec) have been proved on CNN-UM Hw prototypes.

Andriani, P. Durham Business School, UK, & Passiante, G., Department of Innovation Engineering, Faculty of Engineering, University of Lecce, Italy.
*Micro-diversity and sustainable innovation*

Ashby' s theorem of *requisite variety* and Fisher's theorem on genetic diversity and adaptability suggest that the capability of adaptation of a species (or of an organisational form) is related to its degree of internal diversity. Similar results emerging from studies of technological evolution (Mokyr 1990), diffusion of technologies in history (Diamond 1997; Diamond 2002) highlight the link between the capacity to innovate and system's diversity. The diversity we mean is not merely taxonomic classification but instead 'ecological'. Such diversity is the synthesis of variety (for instance, number of categories used to frame the number of technological and/or industrial species), disparity (distance between categories) and balance (frequency of individuals across species) (see (Stirling 1998)). When the elements composing diversity interact with each other, diversity can become autocatalytic and promote the formation of further diversity by means of innovation (Kauffman 2000). This dynamic aspect of diversity, which calls for a theory of innovation and regional economics based on endogenous self-sustaining economic networks, requires us to couple a system's diversity with connectivity. These considerations lead us to the following research questions:

1. Is the capability of innovation (or adaptation) of an economic and social

system dependent upon the system's degree of diversity and web of connectivity?

2. Can therefore the study of the conjugated variables diversity-connectivity shed light on the dynamic of innovation?

The unit of analysis of our research are networks of organisations, which present different mixtures of self-organisation and hierarchical properties. In particular we intend to inquire:

- Industrial clusters
- Virtual networks
- Community of economic and social agents, (for instance open source communities)

The research will be articulated in three main packages:

WP 3.1 Statistical analysis of the correlation between sustainable innovation and rate of internal diversity in systems of firms and/or community of agents (for example the Linux community). This phase will also include an analysis of the evolution of the internal diversity characterising the unit of analysis (systems of firms and/or community of agents) and its relationship with sustainable innovation and adaptation.

WP3.2 Computer models of socio-economic systems. The approach to be followed is agent-based modelling. The model will start from Saviotti's matrix, which describes agents as interactive matrices of enabling technologies and correlated products/services. The principles of simulations are those typical of agent-based modelling, that is: limited number of agents, local interactions, local knowledge and capability of learning from experience. The model (or series of models) intends to explore:

1. Emergence of critical mass effects in connection to internal diversity
2. Generative mechanisms of internal diversity
3. Coevolutive effects resulting from the closure of the socio-economic system on non-linear dynamics

The modelling process will make use of findings and results of the other work packages

WP 3.3 This packet has two objectives

1. Elaboration of a theory concerning the relationship between evolution of internal diversity and sustainable innovation (this packet will make use of the latest thinking in complexity thinking, namely the writing of Stuart Kauffman).

2. Application of the above mentioned theory to an appropriate organisational setting, such as the integrated organisation or large corporation. The measure of the degree of internal diversity and mechanisms of connectivity within the boundary of an integrated organisation is to be correlated with some indicators of innovation (for instance, if appropriate, patents)

Rinaldi, S. Dipartimento di Elettronica e Informazione, Politecnico di Milano, Italy

*Peak-to-peak dynamics*

A particular form of deterministic chaos, called peak-to-peak dynamics (PPD) is reviewed. When a continuous-time system of order $n$ has PPD, the amplitude and the time of occurrence of the next peak of its output variable can be predicted from information concerning at most two previous peaks. In other words, $n$ differential equations can be substituted by a reduced order model, if attention is restricted to the peaks of the variable of concern. The observation of the output peaks is equivalent to the observation of the system on a Poincaré section. This is why the existence of PPD is simply related to the dimension of the attractor. The usefulness of peak-to-peak analysis for the retrieval of one-dimensional dynamics within the attractor and for the estimate of the first Liapunov exponent is demonstrated through examples. Particular attention is devoted to the possibility of exploiting the PPD reduced order models for forecasting the next peak and for the regularization of the dynamics of chaotic systems by means of piecewise constant controls.

## Series D

**9am – 11am Paper Session 11 Theoretical Issues**

Arahovitis, I., Department of Mathematics, University of Athens, Greece

*Theorizing on the Elliot Wave Principle and Adopting a Chaotic Aspect*

An often used tool of Technical Analysis is the empirical Elliott Wave Principle (EWP), where Fibonacci numbers play the crucial role. Fibonacci numbers also appear in discrete dynamical systems. A classical example used by Arnold, Herman and others, is the two-parameter sine-circle map, where Fibonacci numbers are implicitly present, when, during iteration the golden number $\Phi$, i.e. the limit of the Fibonacci sequence, is used as the winding number for the map. Then, in case the sine-circle map is invertible, we are led to almost periodicity, which in turn is one of the many routes to chaos. Therefore, in order to give EWP a rigorous theoretical background, we can, via Fibonacci numbers correlate it to the above form of the sine-circle map. However, this excludes the possibility that chaotic behavior hidden in the stock and money market, can be treated. Therefore, to be more realistic incorporating all possibilities, we adopt the sine-circle map as the

appropriate one, but also allow for non-invertibility of the map, necessary for chaos in one dimension.

Popp, F. A. International Institute of Biophysics, Neuss, Germany
*Coherent States and Squeezed Light in Biological Systems*

After it has been shown that biological systems produce squeezed light (Physics Letters A 293 (2002) 98-102) there is evidence now also for the basic significance of coherent states in biology. Basic experimental results will be demonstrated. They invite us to understand biology in terms of optimization procedures of information transfer. Since the biophoton measurements show evidence of the openness of living matter, a number of interesting questions arise, concerning the definition of information and the development of consciousness. It seems that the Darwinistic point of view has to be substituted by a more well-directed evolutionary principle, where the potential information follows unlimited optimization, while the actual information is completely indeterminable.

Glattre, E. & Nygård, J. Cancer Registry of Norway. Montebello, N-0310 Oslo Norway
*Fractal Meta-Analysis and Chaos-Bound 'Causality'*

Repeated testing of a causal hypothesis often results in inconsistent outcomes. Contradictory results pop up often enough to arouse suspicion that central epidemiological paradigms may be invalid. Mending attempts have been made with quantitative and qualitative meta-studies, hitherto, with limited success. We apply a fractal meta-analytical procedure on three published meta-studies, a study on the use of oral contraceptives (OC) and risk of breast cancer and two Cochrane Library studies on chemotherapy and survival of lung and advanced ovarian cancer. We place the risk of disease (rD) as an expression of a so-called "disease determining bio-chaos", bC:rD, defined as the complexity of a multitude of interacting factors influencing the risk of disease. The procedure consists of 1) the fractal investigation of bC:rD, carried out on the time-series of relative risks (RR) expressed by the corresponding bC:RR (rD=RR), and 2) 'de-fluctuation' analysis of (linear) associations of exposure and risk of disease hidden in bio-chaos. By these analyses, we found the RR-series to be fractal and, by means of Bak's criteria, the corresponding bC:RR to be in self-organised criticality (SOC) for all three materials. In SOC the expected 'next' RR will take on any (possible) size without changing bC:RR and therefore exposure. In the breast cancer study, for instance, there is therefore no definable association connecting OC to risk of breast cancer.

Koski, K. University of Lapland/Hogeschool voor de Kunsten Utrecht, Netherlands
*Non-linear Storytelling in Environmental Installation System*

Human-machine interaction in theatrical performances causes new ways of storytelling. My interest is in dramaturgy and narration of non-linear interaction. I directed Samuel Beckett's Play to have interaction with live actor and real time 3D-graphics. It was based on the idea of systemic psychology and organism-environment –system theory, which is Finnish in origin. It rejects mind-body dualism and considers them as one organism. Any organism is always connecting with its environment and they form a single system together. I'm interested in the rules of this kind of art system, both theatre and installation area. I'm building up an environmental installation: re-narration of Play. This environment is going to be structured and navigated by using chaos theory. Storytelling will be non-linear, following our associations. Beckett's texts can be seen to be very mathematically structured, even divided into algorithms. I want to produce a Beckettian installation machine, which functions as a chaotic storytelling apparatus. The combination of a mathematical/natural scientific and intuitive hypertext framework is an interesting and useful idea in all interface designs. Rhrizomatic structure of lexias and links will work dynamically with participants/organisms' own associations, within the limit of given possibilities. The organism will work as an actor inside of its environment. For example waving his hand will produce a certain series of happenings.

## 11am-1130am Morning Tea


## Kleiner Festsaal

1130am-1230pm **Keynote Address 2:**
**Professor Tönu Puu,**
Institutionen för nationalekonomi,
CERUM, Umea University, Umea,
Sweden

*Oligopoly Dynamics – A Traditional Area for Complex Dynamics in Economic Theory.*

Economics recognizes two opposite market forms: competition and monopoly. In the competitive case the firms are very numerous and small in relation to the total size of the market. In consequence they consider market price as being given independently of any action they can take on their own. In the case of monopoly one single firm dominates the whole market. Its supply influences market price appreciably, and it takes advantage of this to increase its profits by deliberately limiting the supply, thus establishing a monopoly price.

Duopoly, though contextually the first step from monopoly towards perfect competition, is analytically not a case of intermediate complexity, but more complicated than any of the extremes. This is so as the duopolists have to consider, not only the behaviour of all the consumers in terms of the entire market demand curve for the commodity, but also take account of the behaviour of the competitor, including possible retaliation on his own actions. The formal theory of duopoly goes as far back as 1838, when Cournot treated the case where there is no retaliation at all, so that in every step each duopolist assumes the latest step taken by the competitor to remain his last. The process was assumed to lead to a steady state, nowadays called a Cournot equilibrium, though it is by no means certain that it is stable. As a matter of fact, the following discussion will show how cycles and chaos may arise from very simple Cournot adjustment procedures. Exactly a Century later, in 1938, von Stackelberg made some ingenious extensions of the Cournot model, by assuming that any of the competitors might try to become a "leader", by taking the reactions of the other competitor according to Cournot in explicit consideration when devising his own actions. The tenability of such a situation would, of course, depend on whether the competitor was content with adhering to his Cournot-like behaviour, i.e., being a "follower". It had been realised that the Cournot model may lead to cyclic behaviour, and David Rand in 1978 conjectured that under suitable conditions the outcome would be chaotic.

A Cournot oligopoly is not the only type of interest. Bertrand in 1883 launched some extremely critical comments on Cournot's work, and questioned the whole meaning of mathematical economics. The point of controversy was the following: Cournot assumed the supply quantities of a homogeneous good to be the choice variables for the competitors. According to the criticism, given the good was homogeneous, one firm could, by undercutting the competitor's price, however slightly, recover the entire market as its share. In the end this warfare would lead to collusive monopoly, or to competitive pricing at the level of marginal costs. The argument was elaborated by Edgeworth in 1897, and out of this argument came product differentiation. Buyers would have preference for the product of one seller, and so only gradually desert their favourite brand when price differences became too pronounced. The now classical solution is due to Chamberlin 1932. Another development was due to Hotelling 1929 who assumed that, though the commodity itself was homogeneous, the competitors could establish bounded local monopolies, guarded by transportation costs.

The extended decade 1929-1941 was particularly rich in original contributions to oligopoly theory. In 1936 and 1939, Palander focused on duopoly when the demand curve was kinked linear and the marginal revenue curve hence jumped up, producing two different local profit maximising intersections with the curve of marginal cost, which was assumed constant or even zero. The Cournot reaction functions, then became piecewise linear, including a jump, and they could produce several, coexistent equilibria. He further gave examples of 2-period oscillations, and 3-period cycles. Also in 1936, Abraham Wald considered the same type of problems, in an article which later became celebrated as the first rigorous statement of existence problems for multi-market equilibria, left open by Wálras and later elaborated by Arrow and Debreu. Without any doubt oligopoly theory is the most promising area in economics for studies of nonlinear dynamic phenomena, and only a tiny fraction of original contributions have yet been studied with

the new methods that modern chaos research has provided.

# 12.30pm-1.30pm Lunch

## Series A

**1.30m-3pm PAPER SESSION 12 Applications in Economics and Management II**

Yegorov, Y. Institute for Advanced Studies, Vienna, Austria

*Social Dynamics in a Continuous Heterogeneous Space*

We observe a lot of heterogeneous spatial patterns of different economic and social variables (like housing prices, wages, unemployment rates, population density, etc), which do not show a sign of convergence to significantly more homogeneous patterns. This persistent heterogeneity takes place not only for the world as a whole but also at the level of particular countries or groups of countries, like the European Union, where the mobility of economic factors (labor, capital) is not legally restrictred. Transportation costs explain only part of this heterogeneity. Heterogeneity of population density, both at country and world levels, became more pronounced with increasing urbanization. New economic geography explains cities'growth by scale technologies and positive externalities. Repulsive factors, like congestion, are also present and do not allow for an emergence of "black holes". The present study intends to formalize the relation between population density and other economic variables by introducing a potential of attractiveness and relating individual decision of location to it. Some ideas are similar to those in statistical physics but assumptions about agents' behaviour are chosen to be consistent with microeconomic theory. For exaplme, the principle of minimal potential energy is replaced by maximal utility from consumption, while deterministic decision to maximize individual objective is replaced by an exponential distribution of probabilities to stay in particular locations, in line with McFadden's logit model. The dynamic story comes from population and economic growth, which represents a driving force that reshapes the spatial pattern of socio-economic activities.

Houchin, K., Management and Labour Studies, Stevenson College, Edinburgh, & MacLean, D., Department of Management Studies, University of Glasgow

*Organisation Development through the lens of complexity theory*

Complexity theory has a number of differing perspectives, all of which share common concepts. These concepts include sensitivity to initial conditions, feedback, disequilibrium and emergence of order. We use these concepts to describe the first four years of the development of a public sector organisation. We examine why the order emerging in the organisation was different from that originally intended. The organisation for example became hierarchical rather than flat structured and flexible. Two things were crucial to our understanding of the order that emerged; the boundary between the organisation's shadow and legitimate systems and the underlying dynamic of anxiety reduction. We present some of the difficulties we found in applying complexity theory concepts to a social system; the difficulties of precise definition of initial conditions and the circularity of the concepts. We question the description of organisations as natural complex adaptive systems. In our conclusion we state that if complexity theory is to provide a useful descriptive framework for human systems it has to be informed by our understanding of the dynamics of human behaviour. As new patterns of social actions and relationships emerge they will be ascribed meaning. This meaning in turn impacts on the further development of the system.

Valderas Jaramillo, J. Department of "Economía Aplicada I", Universidad de Sevilla, Sevilla, Spain;& Mateos de Cabo, R., Universidad San Pablo-CEU, Madrid, Spain

*Time continuous modelling: A bridge between the simple and the complex*

The purpose of this paper is the description of the time-continuous stochastic modelling techniques, applied extensively to Financial Markets nowadays. In contrast to the most outstanding developments in Economic Theory, which generally stem from the adaptation of very successful tools and models that were initially developed for other Natural and Experimental Sciences, mainly Physics, these techniques were introduced originally within the economic literature. These tools, widely used for the analysis of complex systems, seemingly random and very hard to forecast, have been demonstrated to be very successful for some subjects of science and very promising for others. The introduction of the brownian motion and other fundamental concepts for the theory of stochastic processes was made by Louis Bachelier in 1900 for the analysis of

financial series. The characteristics of brownian motion, particularly its geometric complexity, and the fact that brownian motion is in the foundations of stochastic calculus, makes the models based upon it reproduce this complexity, which relates the topic of time-continuous modelling to the paradigm of complexity theory and non-linearity. Nonetheless, the introduction of this new methodology for the study of financial time series was forgotten in Economics, but not in Physics, due to a number of theoretical and economical reasons that we will try to point out in this paper. It was not until the second half of the XX$^{th}$ century when this methodology arises again in Economics, with such a scope and deepening, and so successfully that authors who helped to this development have been awarded with the Nobel Prize. We will analyze in this work the historical genesis of these techniques, the reasons why these techniques were ignored in economics and why they were readressed in the second half of the XX$^{th}$ century. Finally, we will state the limits of these techniques and the new promising alternatives, related with non-linear techniques and the theory of complexity, which have arisen in the field of Financial Economics to overcome these limitations.

## Series B

**1.30pm-3.30pm Symposium 5: From chaos to clinic: emerging applications in nonlinear brain dynamics**

**Convenor:** Stam, C.J. Department of Clinical Neurophysiology and MEG Centre, VU University Medical Centre, Amsterdam, Netherlands.

The brain is the most complex system we know; understanding its normal and disturbed dynamics is one of the greatest challenges of science. However, conventional approaches such as frequency analysis of the EEG, or identification of "activated areas" with PET and fMRI are not fully adequate to capture the dynamic complexity of the brain. Concepts and analytical tools derived from chaos theory are more promising in this respect, and were first applied to the EEG by Agnes Babloyantz in 1985. Since then the field of nonlinear EEG analysis has undergone a rapid and sometimes spectacular development. From early attempts to prove the existence of chaotic dynamics, attention has shifted to ever more sophisticated techniques to characterize complex, nonstationary and nonlinear dynamics in the brain. Recent progress has been most clear in two fields: (1) prediction, up to 20 minutes ahead, of oncoming epileptic seizures. This was first reported by German and French investigators in 1998, and is now the focus of intense research; (2) understanding of synchronous oscillations underlying consciousness and cognition, as well as their breakdown in neurological disease. In particular synchronous oscillations in the gamma band (around 40 Hz) and the theta band (4-7 Hz) are now associated with conscious perception and working memory processes. Recent studies suggests that these processes break down in Alzheimer's disease, causing cognitive dysfunction. The purpose of this symposium is to demonstrate the state of the art of applied nonlinear EEG / MEG (magneto encephalogram) analysis, with a focus on epilepsy and cognition.

Stam, C.J., van Cappellen van Walsum, A.M., Pijnenburg, Y.A.L., Scheltens, Ph., Vriens, E.M., Strijers, R.L.M., Altenburg, J., Vermeulen, R.J., Spijkstra, J.J., Girbes, A.R.J., van Dijk, B.W.
Department of Clinical Neurophysiology, MEG Center, Department of Neurology, Department of Child Neurology, Intensive Care, VU University Medical Center, Amsterdam, The Netherlands

*Synchronization likelihood: interacting dynamical systems in the brain in health and disease.*

Optimal information processing in the brain requires activation of local, specialized neural networks as well as mechanisms to integrate this distributed information over space and time. There is increasing evidence that synchronous oscillations of widely distributed neural networks play a key-role in this integration process, and represent an important solution to the famous "binding problem". A proper understanding and characterization of the synchronous oscillations can be obtained by modeling the brain as an ensemble of coupled nonlinear dynamics systems. This approach has led to the development of new tools such as "phase synchronization" and measures based upon "generalized synchronization" which can quantify nonlinear coupling between multiple time series. However these measures may be biased by other factors then the actual coupling between two systems. To solve this problem we introduced the synchronization likelihood (SL) which is especially suited to track weak, nonlinear and non stationary couplings in EEG and MEG (Stam and van Dijk, 2002). SL could demonstrate changes in theta, alpha and beta band coupling in healthy subjects during a working memory task. In Alzheimer's disease, a loss of beta and gamma

band synchronization was demonstrated even in a simple eyes-closed no-task state. Finally, epileptic seizures were characterized by an increase in synchronization likelihood of the EEG. Pilot studies in neonates and adult intensive care patients suggest the potential usefulness of SL as a tool for automatic seizure detection.

Stam, C.J., van Dijk, B.W. (2002) Synchronization likelihood: an un-biased measure of generalized synchronization in multivariate data sets. Physica D. 163, 236-251.

Molnár, M.. and Gaál, Zs. Institute of Psychology, Hungarian Academy of Sciences, Budapest, Hungary; Nagy, Z. & Magos, T. National Stroke Center, Budapest, Hungary; Kondákor, I., Department of Neurology, Pécs, Hungary; Stam, C.J., Department of Clinical Neurophysiology, VU University Medical Centre, Amsterdam, The Netherlands

*Nonlinear electrophysiological measures in patients with vascular dementia*

Vascular dementia (VD) is a condition of increasing clinical importance characterized by focal neurological signs accompanied by intellectual decline. Multiple lesions can typically be found in different cortical areas and in the white matter causing variable, but progressive clinical symptoms. In the present study several methods were used for the analysis of the EEG recorded in healthy age matched controls and in VD patients to assess the functional concomitants of this pathological condition, not necessarily revealed by computerized imaging techniques. A special emphasis was put on recently developed methods tuned to reveal the presence and degree of nonlinearity in the EEG such as the synchronization likelihood (Stam et al, 2002). The synchronization likelihood is a measure of the dynamical interdependency between different time series, such as simultaneously recorded EEGs in different locations. Decreasing synchronization can be interpreted as a manifestation of a loss of (long distance) association fibres, underlying the clinical symptomatology. Visual evoked potentials using the standard oddball paradigm were also recorded in both the control group and in VD patients. Characteristic changes in the above indices were observed in the VD group which are discussed in terms of their regional distribution and their potential value in the diagnosis of the functional integrity of the central nervous system.

Mormann, F., Kreuzl, T., Riekel, C., Andrzejakl, R., Kraskov, A., David, P., Elgerl, C., & Lehnertz, K. Department of Epileptology, University of Bonn, Germany; Helmholtz-Institute for Radiation and Nuclear Physics, University of Bonn, Germany; John von Neumann Institute for Computing, Research Center Jülich, Germany

*EEG analysis and seizure prediction*

An important issue in epileptology is whether epileptic seizures can be anticipated prior to their occurrence. Of particular interest is the question whether information extracted from the EEG of epilepsy patients can be used for the prediction of seizures. Several studies have claimed evidence for the existence of a pre-seizure state that can be detected using linear and nonlinear EEG analysis methods. In this study we evaluate the predictability of seizures by comparing the predictive performance of a variety of linear and nonlinear measures comprising both univariate and bivariate approaches. We compare 30 measures derived from the theory of dynamical systems in terms of their ability to distinguish between the interictal period and the pre-seizure period. We analyze continuous multi-day recordings from several patients and used Receiver-Operating-Characteristics (ROC) to distinguish between the amplitude distributions of the time profiles calculated for the respective measures for both the interictal and the pre-seizure period. Allowing different lengths of the pre-seizure period and different smoothing filters for the time profiles of the different measures we apply different analysis schemes including "best channel selection" and "adaptive baseline". Our analysis shows a similar performance of linear and nonlinear measures. We do, however, find a distinct difference between bivariate and univariate approaches with a higher performance of the bivariate measures. Furthermore, we use seizure time surrogates as a test for statistical validity and significance and demonstrate the importance of this concept for the field of seizure prediction.

Micheloyannis, S., & Stam, CJ University of Crete, Medical division, Greece and VU University Medical Center, Amsterdam, The Netherlands.

*Neuropsychological studies in health and disease using nonlinear EEG analysis.*

EEG signal analysis methods revealed from nonlinear methods and chaos theory began a new era in studies of cognition and brain dysfunction. Several studies show that such methods add new knowledge and better evaluation. In a study in normals, we found that simple mathematical thinking activates more prominently the right hemisphere, a new knowledge revealed by a

nonlinear parameter. Using the new method introduced by CJ Stam for synchronization evaluation (Synchronization Likelihood=SL), the findings during a Working Memory function were indicative of increases in SL for lower frequencies and decrease for higher frequencies. SL variability was higher for low frequencies and decreased in higher frequencies, indicating changes of SL in small-scale fluctuations. In another study using spectral and SL estimations to interpret cortex activations during performance of perceptuo-semantic tasks, we found activations related to the difficulty of the tasks, on the left frontal, temporal, central and right parieto-occipital regions. The SL findings were more obvious for theta left frontal (increases related to the difficulty of the task) and alpha1, alpha2, beta right parieto-occipital (increased desynchronization related to the difficulty). An increase in SL in a frequency band could be interpreted as an increase in coordinated activity. A decrease could indicate the opposite or increased local activation that diminishes cooperation with other regions. SL of different frequency bands could express different modi of neuronal assembly function. The additive and different information relative to spectral analysis concerning the widespread coordination of the neuronal assemblies will be discussed in relation to main points from the literature referring to normals and brain dysfunction.

Ferri, R., & Stam, C.J., Sleep Research Center, Department of Neurology, Oasi Institute for Research on Mental Retardation and Brain Aging (IRCCS), Troina, Italy; Department of Clinical Neurophysiology and MEG centre, VU University Medical Centre, Amsterdam, The Netherlands

*Nonlinear analysis of normal and pathologic sleep EEG*

We used the non-linear cross prediction (NLCP) algorithm to investigate whether non-linear brain dynamics occur during sleep, taking into account the presence of the 'cyclic alternating pattern' (CAP) which consists of transient arousal complexes (phase A) that periodically interrupt the tonic theta/delta activities of NREM sleep (phase B). Sleep EEG tends to show non-linear structure only in CAP periods, during which non-linearity can be detected mostly for the A1 subtypes. The same algorithm, applied to the sleep EEG of newborns, did not allow us to detect clearly nonlinear dynamics; probably because of the incomplete maturation of intracortical connecting pathways which might be crucial for the development of nonlinear dynamics in the brain. On the contrary, the NLCP test showed clear nonlinear structure of the EEG in subjects affected by electrical status epilepticus during slow-wave sleep; probably chaotic dynamics were also found. Finally, we used the synchronization likelihood, which characterizes generalized synchronization in order to evaluate, during sleep, the degree of coordination in activity of different cortical areas. Increase in sychronization was detected mostly during the CAP phases A1, with a dynamically evolving complex pattern. The synchronization likelihood, measured in one patient with nocturnal frontal lobe epilepsy, provided important insight into the ictal brain dynamics by showing significantly increased synchronization in the alpha band, during the seizures, which was followed by an increase in synchronization in the delta range, towards the end of each seizure. These studies show that the tools for nonlinear EEG analysis are helpful in understanding the different brain dynamics during sleep.

van Putten, M.J.A.M. Ziekenhuis Leyenburg, Leyweg 275, 2545 CH The Hague, The Netherlands

*Proposed link rates in the human brain*

There is increasing experimental evidence that particular forms of neuronal synchronization are necessary for the integration of distributed neuronal activity to realize time-dependent coherent neuronal assemblies in the brain. These time-dependent neuronal assemblies are believed relevant for the symphony of emotions, perceptions, thoughts and actions, as present in the brain. This paper discusses a method to detect time-dependent, frequency specific, synchrony between simultaneously recorded EEG signals. In particular, we introduce a link-rate as a measure of the incidence of phase synchronization and phase desynchronization. To this end, the instantaneous phase of the individual signals is derived on the basis of the Hilbert transform, and provided for the individual frequency ranges. For each of the frequency ranges, phase synchronization is derived from the pairwise difference of the instantaneous phases of individual recording sites as a phase-locking value and is quantified by measures of circular statistics. Analysis in moving windows permits time-resolved measures, and the subsequent application of thresholds on the phase locking value permits quantification of coupling and decoupling events, and thus the link-rate.
The concept will be illustrated using various EEG recordings from different patient categories. Firstly, we use data from a normal control, a patient suffering from epileptic seizures and a patient with diffuse brain damage due to anoxia.

These examples show very different results, where it is found that the link rate is substantially increased in the normal control as compared to the two patients. In addition, the link durations have increased values in the patient suffering from the epileptic seizure. Secondly, we will present results of the analysis as applied to controls performing different mental acts and patients suffering from Alzheimer's disease.

## Series C

**1.30pm – 3.30pm PAPER SESSION 13**
**Applications in Education and Social Sciences**

Davis-Seaver, J. Department of Curriculum and Instruction, North Carolina A&T State University, Greensboro, North Carolina, USA
*Chaos in the Classroom*

This paper posits that the cognitive activity of critical and/or creative thinking is a chaotic activity that requires an interactive chaotic dynamic in the classroom. Several years of research in elementary, high school and university classrooms show that when this dynamic is fostered, critical and creative thinking is highly likely to occur. Analysis of classroom discussions and activities includes cross-referencing critical thinking and chaos theory principles to show cause and effect and graphs of the analysis that produced strange attractors. Implications for classrooms of the future are discussed. This research has significance for the fields of pedagogy, cognitive psychology, and especially critical thinking theory. It sheds light on the processes of critical and creative thinking, and establishes ties to the current studies in brain research as it relates to the teaching/learning process.

Xu, W. & Li, Q. School of Chemical Engineering and Material Science, Beijing Institute of Technology, People's Republic of China
*Chemical kinetic systems derived from chaotic arms races model*

So far the arms race still exists in our world, therefore the study of this problem continues to be of practical significance. There have been many arms race models reported and reviewed. The model studied in this paper is based on a four-variable system proposed by Tomoch and Kono[***Chaos***, 8(4), 808-813 (1998)] to describe the chaotic evolution of arms races. It is well known that chemistry is an experimental science and some theoretical models of other fields can be studied with practical chemical reactions. But the variables in chemical systems cannot adopt negative values because the concentrations of molecular species can never be negative. Therefore, when we use chemical mechanisms to study dynamical behaviors of an arms races model we must make some mathematical transformations, so that the model can be transformed into a dynamically related chemical system admitting only nonnegative concentrations. In this paper, we make this transformation with both linear and nonlinear methods, respectively. The obtained chemical kinetic models have the same qualitative phase space features as that of the original system. Studying the arms races problem with a chemical reaction mechanism, to our knowledge, has not been reported before and is interesting and of significance.

Reschke, C. University of Witten/Herdecke, Department of Macroeconomic and Institutional Change, Witten, Germany
*Implications of Complexity for Evolutionary Economics and vice versa*

The aim of this paper is to sketch a map of some of the issues in building an economic theory of social evolution on the basis of personal construct theory. I show application possibilities at the example of the bio-pharmaceutical industry. Methodologically, a successful integration of these areas requires a transfer of complexity methods and development of further methods in the complexity area. The paper therefore poses challenges to complexity researchers as well as discusses how these areas intersect conceptually. I review approaches to complexity from physics, computer science and biology. The unit of evolution is taken from psychological personal construct theory. Some attention is given to the tension between `reductionism' and complexity. Each of these disciplines offers a specific way of dealing with complex phenomena, with distinctive advantages and disadvantages. Physics measures potentially relevant characteristics. Computer science aims at algorithmic accounts of how complex systems can be artificially constructed. Biology harbors sometimes more holistic views besides - of course - evolutionary theory. Holistic approaches are a tricky issue, since they may serve to replace scientific investigation into the `proof' of hypotheses with veils of beautiful concepts that prove in the end to be merely of a `shamanist' or marketing function. This notwithstanding, they may serve a limited but useful purpose in hypothesis generation. Evolutionary thinking asks for the adaptive value of specific characteristics. It shifts attention from a generalized standard optimality criterion to a

differentiated account of selection criteria and selection conditions in specific circumstances.

Andergassen, R., Nardini, F., & Ricottilli, M., Università degli Studi di Bologna, Italy
*Technological Paradigms and Firms' Interaction*

This paper deals with the aggregate effects of small, exogenous but idiosyncratic technological shocks on locally interacting firms. Its main purpose is to model a situation in which technological paradigms emerge through endogenous propagation and diffusion of information leading to an aggregate pattern. We develop a theoretical framework in which large technological correlations emerge due to localised interaction of single firms. The paper states some simple results on spill-over dynamics determined by firms trying to improve their current technology and thus generating new information through investment in R&D and through localised technological search. The first part shows that different growth regimes can arise from the general framework of interaction that we propose. The second part shows that the interesting regime characterised both by long run innovation growth and endogenous short run fluctuations emerges spontaneously.

## Series D

**1.30pm – 3pm PAPER SESSION 14**
**Biomedical Applications**

Mayer-Kress, G., & Newell, K. Penn State University, University Park, PA, USA
*Time-Scales in Stochastic Map Models of Chaos in Isometric Force Production*

We discuss the aspects of time-scales in modeling the continuous isometric force output of both children and adult participants. The force production is in relation to a constant target force level where it could be shown by Newell et al. that the amount and structure of force variability changes significantly with experimental conditions. Among them are: information available, force level, and individual differences such as age and health. We have modeled the control of isometric force production with a class of piece-wise linear, stochastic maps possessing multiple time scales. At the core of our model is a piecewise linear, one-dimensional map that is invertible everywhere. It has three parameters that can be estimated from the observed data. The stochastic component consists of additive Gaussian noise. The different time-scales can be generated by different delays in feedback loops that are modelled as a finite-dimensional extension of the core function. The model had been shown to simulate the basic findings of the structure of human force variability that decreasing variability is correlated with increased dynamical complexity as measured with the "Approximate Entropy (ApEn)" statistic. Furthermore our results indicate that time-series exhibiting properties of low-dimensional chaos can be generated by invertible iterative maps with time delay and under the influence of stochastic perturbations. These results might provide a theoretical alternative to low-dimensional chaos as a mechanism for erratic behavior. This delay feedback mechanism might be especially relevant for understanding cardiac and brain wave dynamics.

Martinis, M., & Knezevic, A. Department of Theoretical physics, Rudjer Boskovic Institute, Zagreb, Croatia
*Time statistics of heart beat intervals and Cauchy distribution*

By analysing the time series of beat-to-beat (R-R) intervals, we found that Cauchy or Bright-Wigner (BW) type distributions give good representations of the real R-R intervals, even in different regimes of ergometric ECG measurements. The separation of healthy subjects from those with stable angina pectoris (SAP) can be seen in the 2--dimensional parameter space of the Cauchy distribution.

Mirow, S. Dept. of Psychiatry, University of Utah School of Medicine, & Porter, R., Directions for Mental Health, Clearwater, Florida, USA.
*Inter-relationships of temporal patterns in simultaneously recorded measures of movement and heart rate before and after psychotherapeutic interventions*

We recorded heart rate and movement for 24 hour periods, before and after psychotherapeutic interventions, for five incarcerated youth. The subjects had histories of early childhood trauma and displayed behaviors suggestive of Posttraumatic Stress Disorder. We supposed that measures of the variability, spectral structure and coherence, and between-signal relationships, might reveal temporal patterns consistent with both subject history and the influences of treatment. Results support our expectation and provide clues to how nonlinear systems theory may be used to elucidate the relationship between psychological and physiological states, particularly for individuals with childhood histories of abuse and neglect. (Work supported by Copperton Place).

## 3.30pm-4pm Afternoon Tea

## Series A

**4pm-6pm PAPER SESSION 15 Applications in Psychology I**

Van Lieshout, P. University of Toronto, Speech-Language Pathology, Oral Dynamics Laboratory, Canada

*Coupling dynamics in speech gestures*

Findings will be presented from a study on the influence of movement amplitude and rate on the nature and stability of gestural coupling during speech production. Both factors have been found to be relevant with respect to coordination in limb control, but thus far their impact on speech related motor tasks have not been investigated. Kinematic data have been collected on 10 normal speaking individuals producing VCV nonwords in which the first and second vowel combinations induced natural variations in tongue height. Coupling between motion primitives of tongue and lip gestures is quantified in terms of relative phase and its circular standard deviation [1]. Results will be interpreted in the framework of nonlinear dynamical systems theory, in particular coordination dynamics [2]. [Research supported by the Natural Sciences and Engineering Research Council of Canada (NSERC)]

References:

1. van Lieshout PHHM, Rutjens C, Spauwen PHM. The dynamics of interlip coupling in speakers with a repaired unilateral cleft-lip history. *Journal Of Speech Language And Hearing Research* 2002;**45**:5-19.

2. Kelso JAS. Principles of dynamic pattern formation and change for a science of human behavior. In Bergman L, Cairns R, Nilsson L, Nystedt L, eds. *Developmental Science and the Holistic Approach*, pp 63-84. Mahway, NJ: Erlbaum, 2000.

Yevin, I. & Apenova, S. Russian Academy of Sciences, Dolgoprudny, Russia

*Pavlovian Conditional Reflex As a Pattern Recognition Process*

Animals and human systems of pattern recognition as well as most of artificial neural network models of pattern recognition are able to restore one of the stored pattern using incomplete date. For instance, H.Haken's synergetic computer could recognise one of many stored human faces, when only a small part of this face is presented. The main objective of this paper is to show that, as discovered by I.P.Pavlov's conditional reflex, one can understand as a restore of the full complex pattern by presenting only the part of this pattern. In his well known experiments when the dog during feeding process hears the sound of a bell ring, the full complex pattern can be described as "food + sound of ring". The conditioned reflex in this case can be described as the restoration of this complex pattern when presenting only the part of this pattern, namely, "the sound of ring". Using a process of switches of different conditional reflexes we can also explain this result by the usual model of pattern recognition. The relationship between P.Anochin's principle of advanced reflection and attractor network models of pattern recognition is also discussed.

Renaud, P., Décarie, J., Gourd, S.-P., Paquin, L.-C. & Bouchard, S. Laboratoire de cyberpsychologie et Laboraroire DEII, Université du Québec en Outaouais, Institut Philippe-Pinel de Montréal, Université du Québec à Montréal, Québec, Canada

*Computing perceptual and motor invariants in immersive environments*

This paper presents theoretical considerations and results revolving around the study of perceptual complexity from a behavioral dynamics point of view. The key role of the Gibsonian concept of affordance is brought in relation to eye movement analysis and the resort to virtual environments in the understanding of perceptual-motor processes. From a head-mounted display, head and eye movements are recorded using tracking devices (magnetic and infrared) that render the 6 degrees-of-freedom associated with the position (cartesian translations: x, y and z) and orientation (eulerian coordinates: yaw, pitch and roll) of the head, and the 2 degrees-of-freedom of one eye. A collision detection algorithm measures the continuous line of sight's deviation from the features of pre-selected virtual stimuli. As additional measures, head movements and fluctuations in the distance maintained from the pre-selected areas are recorded. These data are sampled in time so as to constitute time-series expressing fluctuations in the active expression of visual perception. Analyses of the emergent properties of the perceptual and motor dynamical patterns are done. These help understanding how behavioral dynamics, and especially motor coordination underlying perception, is organized. The focus is put on the picking-up of invariant visual structures.

Mens-Verhulst, J., & van Dijkum, C., Utrecht University, Utrecht, The Netherlands

*The Dynamics of Fatigue: Insights From Simulation in Self-Regulation*

A computer simulation has been developed that reflects the microdynamics of dealing with fatigue and associated complaints. The theoretical basis was derived from Leventhal, Nerenz and Steele's the self-regulation model. According to this model, people with health problems dynamically cycle three processes - representation and assessment (of the illness and its treatment), coping, and evaluation. Through learning, the representations, assessments and coping strategies will alter. The empirical basis for the study was a representative three-week diary study, part of a nation-wide survey provided by the Netherlands Institute for Primary Health Care (NIVEL). The variety of interactions between the variables of the system (as was supposed in theory and observed in empirical data) was translated into differential equations. Thereby it appeared that the development of complaints should be expressed in a non-linear difference equation. The results of the simulation experiments demonstrate the dynamics and especially the non-linearity of the process of self-regulation, and the influence of the rate of learning. As such, it offers new insights into the variable distribution of fatigue complaints and into the consequences for intervention. These insights may be generalised to other complaints – especially if they have no medical explanation. Besides, some health psychological assumptions about the fatigue trajactories and interventions' research are challenged. In this paper we will present our findings, reflect upon their theoretical and empirical meaning, and discuss the methodological challenges of our simulation study.

## Series B

**4pm – 5.30pm PAPER SESSION 16**
**Organisational Processes and Complexity**

Pugacheva, E., Baikal State University of Economics and Law, Irkutsk, Russia
*Coping with Chaos: The Experience of Russian Economy*

The last decade in Russia is the time of drastic socio-economic transformations, crisises and processes of self-organization. Its full of nonlinear effects and attempts to cope with chaos. The experience of Russia is analyzed. The main methodological landmarks of such analyses are: 1) nonlinearity of economic transformations; 2) nonequilibrium of economic processes; 3) openness of economic system; 4) irreversibility of economic evolution; 5) multy-alternativity of economic development.

Di Lorenzo, P., Dipartimento di Matematica - Seconda Università di Napoli, Italy
*Chaos hides in recorded monodic music: what is the role of timbre?*

Non-linear time series analysis also allows us to investigate order and chaos structures hidden in a signal recorded as a numerical array. I selected a melodic fragment from the historical vocal Neapolitan barocco repertoire (aria *A Serpina penserete* from Serva Padrona by G.B.Pergolesi). In the original version the melody is played by a soprano accompanied by a string orchestra and a basso continuo. I recorded several audio fragments of the same original soprano melody with different instruments: lute, blockflote, soprano voice (with the linked words, without words but with one single vowel phonema for all notes; with identical vowels of the original text without consonants), violin, harpsicord etc. Each record (in mono wave format) is sampled in a numerical array of amplitude points. Then I analysed the data to recognize and analyze orbits, attractor, power spectrum, Poincaré sections, correlation functions, etc. Finally, for each record I computed, compared and classified some of significant analytic chaotic parameters (fractal dimension via correlation and capacity dimension, Lyapunov exponents etc.). The results can be used to characterize music and timbre into different intervals of the space of chaotic parameters.

Stein, A. Wagan Institute, Garrison, New York, USA
*Embodying complexity at the end of life*

Dying peoples unpredictable, often uncanny emergent experiences, can be accepted as a legitimate part of the dying process rather than explaining them away in classical form. Only to the extent that the therapist can eschew her traditional role of explaining and interpreting a patients self-organizing experiences on terms similar to his patients stance can she entertain questions and discussion.

## Series C

**4pm-6pm Symposium 6: The Human Body as a Complex System**
**Convenor:** Kratky, K. Institute of Experimental Physics, University of Vienna, A-1090 Vienna, Austria

Kratky, K. Institute of Experimental Physics, University of Vienna, A-1090 Vienna, Austria
*Comparative and integrative medicine*

If traditional healing systems such as Ayurveda and Traditional Chinese Medicine are compared with scientific Western medicine, there seems to be a gap that cannot be bridged. This has changed, however, since the rise of the study of complexity (feedback loops, nonlinearity, chaos, self-organization, and coherence). Phenomena of regulation and (feedback) control occur, which are changing the basis of Western medicine and also help to understand findings of alternative and complementary medicine. To achieve this goal, high-standard technical equipment is necessary in many cases. In the work of Helmut Sauer, regulation thermography has been used to study the response of the body to a temperature stimulus from outside by measuring the skin temperature via noninvasive methods. Since human regulative systems are interconnected within the body, the skin temperature yields information about the health status. Then, Chang-Lin Zhang looks for the structure behind the acupuncture meridians and presents an invisible dissipative structure of electromagnetic field composed of chaotic standing waves. This structure offers a new method to evaluate health status of a person in a holistic and quantitative way. In the last contribution, Axel Schaefer considers the properties of human heartbeat in view of nonlinear science. Especially, the influence of bright light (of different colors) on the heart-rate variability is studied, which yields information about the sympathetic and parasympathetic nervous systems of a person.

Sauer, H. IIAS, Waldbronn-Reichenbach, Germany
*The regulation thermography of men*

The temperature of the body is widely independent of the outside temperature. You can find a radial decrease of temperature from the inner body to outside and an axial decrease from top to down, which means from the head over the trunk to the extremities. The maintenance of the temperature inside the human body depends above all on its metabolism. However the temperature of the skin and extremities depends on the temperature outside, the activity of metabolism, the regional circulation, the regulation by the vegetative nervous system, the regulation by the hormonal system as well as numerous endogenous and exogenous rhythms. Measurements of the skin temperature on defined points and the setting of a standard skin stimulus (mostly a cooling of the nearly undressed body at 20-22 degrees Celsius) enforce the organism to a 'regulation'. This can be a possible increase of temperature, no change or a decrease of temperature. The measurements are carried out either with a point-measuring-device or with an infrared camera, both being non-invasive and therefore without any danger for the patient. The following insights in linked systems are possible: statements to the vegetative (nervous) stability or rather instability, the activity of metabolism, the immune capacity and situation, the disposal to allergies, inflammations, and auto-immune diseases. By this method we can realize typical patterns for each patient. The recording of dynamic processes by regulation thermography is an elegant, non-invasive economical way to insights in numerous regulation of human systems, to start and follow a therapy and demonstrate its success.

Zhang, C-L., College of Life Science, Zhejiang University, Hangzhou, China
*Acupuncture system: function versus structure*

Within the last half-century, scientific Western medicine has tried to find the 'structure' of acupuncture meridians corresponding to the 'function' well known is Eastern medicine. First, researchers expected to find some static structures ('pipelines'), which would be completely corresponding to the acupuncture meridians. This failed. On the other hand, many methods of objective detection on acu-points and meridians have been developed, in particular based on the unique electrical characteristics that distinguished them from surrounding skin. This apparent discrepancy was not solved until the detection of a new kind of structures, the 'dissipative structures'. In fact, a new invisible dissipative structure of electromagnetic field composed of chaotic standing waves has been found. The structure corresponds to a great extent to the mysterious acupuncture system. Many puzzling phenomena related to acupuncture and other complementary medicines such as the holographic properties of the acupuncture system, the transmission of signal along meridian and its speed, the relationship between organs and acu-points and the effort of needling without remedy become easy to understand. What is more, the revelation of an invisible dissipative structure offers a new method to evaluate the instantaneous status of a person, holistically and quantitatively. For example, 'coherence', 'harmony' and 'wellness' can be determined in a quantititative way. This opens not only a new chapter to

present physiology and biology, but also a new way to approach physics.

Schaefer, A. Institute of Experimental Physics, University of Vienna, A-1090 Vienna, Austria
*Human heartbeat and light:Influence of various light sources on the dynamics of heart rhythms*

The human heartbeat is a good example of a nonlinear oscillation. Under ideal conditions in a healthy person it seems to maintain an intermediate state between "order" and "chaos". In our experiments we investigated the effect of an exposition of volunteers to different sources of bright light (red, green, blue and daylight white). The dynamic parameters of the heartbeat before, during and after light treatment are compared and discussed. The electrocardiogram (ECG) signal of the tested persons was translated into a 3-5 min time series of the heartbeat intervals, the *Heart-Rate Variability* (HRV). Besides simple statistics, the HRV can be evaluated in a more detailed fashion by spectral analysis and nonlinear time series analysis. A Fourier analysis reveals the modulation of the HRV by slower physical rhythms like respiration and variations of the blood pressure and circulation. These rhythms permit conclusions on the sympathetic/ parasympathetic activity of the autonomous nervous system and the influence of light exposure on it. A "*self-similarity parameter*" is obtained by a *Detrended Fluctuation Analysis* (DFA). It is a measure of the similarity of small parts of the HRV time series to the whole and indicates the state of "order" or "chaos" of the rhythm under examination. Other nonlinear parameters yield further information concerning the effect of light on the dynamics of the human heart. These findings are complemented by measurements of lumirubine in urine and melatonin in saliva before and after light exposition.

## Series D

**4pm-6pm Symposium 7: Foundations of Self-Organisation**

**Convenors:** Fuchs, C. and Hofkirchner, W. Institute for Design and Technology Assessment, Vienna University of Technology, Austria.

Since the sixties and the seventies, the disciplines of science have been increasingly focussing on self-organisation and complexity studies. Although interdisciplinarity is one of the main characteristics of self-organisation theory, the approaches are rather scattered and a unified theory of self-organisation remains to be established. The aim of this session is to explore foundations of such a yet-to-be-developed unification. Topics to be covered in this session include: the exploration of the philosophical relationship of self-organisation theory and classical, modern and postmodern philosophy, the relationship of information and self-organisation; and differences and similarities between physical, biological and social self-organisation

Arshinov V. & Budanov, V. Institute of Philosophy, Russian Academy of Sciences, Moscow, Russia
*Cognitive Foundations of Synergetics*

What are the cognitive bases of synergetics? The term "cognitive bases" is used in order to avoid the traditional hierarchies of the gestalt-images used in philosophical and methodological approaches and to make use of interdisciplinary, multi-variant categorical networks which employ interconnected metaphors, analogies, models and concepts. We start from the fact that synergetics, being an essentially interdisciplinary post-non-classical science, must operate interdisciplinary in order to be consistent. In this context there is an interest in a cognitive science that functions as a post-non-classical, interdisciplinary way of studying reason, knowledge and synergetics. Such a cognitive science is an interconnection of disciplines such as linguistics, neurobiology, psychology, anthropology and philosophy. It has a network character. Thus research in the fields of Artificial Intelligence, communication studies, computer science (in particular computer networks and research about the Internet) and the theory of autopoiesis are of fundamental importance for cognitive science. Synergetics is frequently comprehended in an instrumentalistic and neopragmatic sense, but also in a way as suggested by radical constructivism. Not sharing entirely the cognitive position of the latter, we are inclined to accept a more moderate constructivist position which can be called *interdisciplinary constructivism* and is related to the works of Francisco Varela. A post-non-classical instrumentalism of synergetics has interdisciplinarity as its intention, that is why it is inter-subjective and open for dialogue.

Collier, J. Konrad Lorenz Institute for Evolution and Cognition Research, Altenberg, Austria
*Why Self-Organization and Emergence are Linked*

Robust emergence requires that neither the states nor the evolution of a system are derivable from information about its components and their

pairwise relations. Simple systems permit direct and precise derivation of both. Complex systems often permit derivation of their time evolution to arbitrary accuracy for any finite time, even if this is not possible for some states of the system. Dissipative systems with both multiple attractors and dissipation times on the same order as the periods of the properties that determine their identity as systems, however, are immune to both state and dynamical reduction. I will argue that this class of systems is identical to the class of spontaneously self-organizing systems.

Darvas, G. Institute for Research Organisation of the Hungarian Academy of Sciences, Budapest, Hungary

*The Arrows of Symmetry, Entropy and Orderedness in Self-organising Systems*

Laws of symmetry breaking and the second law of thermodynamics will be compared. We show that the laws of nature formulated for closed, irreversible systems cannot be applied for self-organising systems.

The extent of symmetry decreases during evolution of matter, all in inanimate nature, organic nature and social systems. Symmetry of matter means certain order. Weakening of symmetry means less order. According to thermodynamics, closed irreversible systems tend towards less ordered systems. The less the matter in a closed irreversible system is ordered, the higher is its entropy.

These two directions coincide in principle. The universe evolves towards less ordered, less symmetric states. However, if we consider concrete self-organising systems, a contradiction appears. According to statistical thermodynamics, when a gas fills a box almost uniformly, this is its least ordered state. According to our symmetry concept however, this is considered its most ordered, most symmetric state. There is a difference between the interpretation of a locally ordered system and the orderedness of the higher level system (the full box), or the universe.

Thermodynamics focuses on the evolution of concrete closed systems. In physical terms no transitions between phases are supposed, i.e., no new physical structures appear in the system. The evolution of matter, in a philosophical sense, studies the sequence of formation of different forms of matter in separate domains (local environments) of space, which can be treated like open systems in interaction with their environment. Self-organisation of matter takes place in local, open environments, where entropy may, and symmetry does actually, decrease.

Jimenez-Lopez, E., Mautern a. d. Donau, Austria

*Weltanschauungen and Perspectivism Derived from Bertalanffy's Thinking May Help Humans to Self-organize their Role on Earth*

Human gregariousness seems to motivate every mind to invite and even encourage other minds to organize together anything that suddenly seems to become the common concern of all those who recognize the need of working together for the betterment of their common concern. So far this is not so good because from time to time every human recognizes that other humans are deeply concerned in doing or attaining something that contradicts what he or she and his and her immediate colleagues have determined as their main interest even as if it were their reason for being alive. The whole historical trajectory of humankind even before the so called civilizing processes started to be conceived and organized has been and continue being until today a sanguinary confrontation among gregarious groups of people trying to disorganize what other gregarious groups are trying to achieve. Most human actions can be considered self-organized by one or another group of people. Today in the year 2002 humankind is facing the worst crisis ever faced because many groups are trying to organize themselves and their capabilities in order to use unilaterally the capabilities of other groups . and also in order to destroy the achievements of other self-organized groups and even to annihilate or massacre them. However it can be assumed that there is still some hope for humans to realize that they may cooperate through increasingly well comprehended Weltanschauung Systems to identify how to make complementary their very diverse appraisals, after recognizing that human intelligence may play a sensible role on Earth learning continuously to develop the perspectivism as a sensible epistemological tool. The development of self-organizing capabilities in human minds, after their successful emergence, must bear in mind that human spontaneity, based on simple common sense, is causing the human species to become an endangered one.

Kharel, M. Kathmandu, Nepal

*The Dynamism of Competition and Co-operation in Self Organization*

The association of forces, from the Big Bang up until today, whether physical, biological, psychological or social, is an intrinsic property. These forces are either competitive or co-operative forces. Co-operative forces are constituted by activities such as: the interchange of matter and energy (Einstein Theory), the

relation of particle and sub-particle, of sub-particle and energy as well as of energy and spirituality (Capra 1982); the maintenance of global temperature, water cycles, gaseous cycles, biological cycles; assimilation, synthesis (photosynthesis), symbiosis, interaction of biology with physical objects thereby forming an ecosystem as well as human interactions leading to positive understanding. Products of competition are e.g.: the emergence of Coacervates, the first pre-biotic life, out of an infinite number of molecules in the Hot Dilute Soup (Oparin Theory); the survival race of nucleic acid (DNA) from pre-biotic up until today (Dawkins 1989), evolution through natural selection (Darwin's Theory), social domination in human society. Tao religion suggests that an intriguing tussle of opposite forces, termed Yang and Yin, produces a third force with additional characteristics as the vital force of life, i.e. Chi. In society, there is a paradigm shift from 'competition for competition's sake' to 'competition for co-operation's sake' which is essential for better achieving better self regulation (organisation). The competition for creating a healthy environment, the competition for making people happy, the competition for making society and communities beautiful, the competition for making society as well as the world equitable, justifiable and harmonious; the competition for loving others etc. can open a new course of human activities that is based on complementary interactions of competition and co-operation. Presently competition means jealousy, dominance, greed, supremacy and this results in problems for society and doesn't favour the real human zeal for peace and happiness. Hence the substance of competition should be shifted from jealousy, hate, dominance and greed to love, sacrifice, altruism and humanism.

Capra, F. 1982. The Turning Point. Falming, Harper Collins Publishers, London.
Dawkins, R. 1987. The Selfish Gene. Oxford University Press, New York.

Klauninger, B. Institute of Design and Technology Assessment, Vienna University of Technology, Austria
*An Onto-Epistemological Model of Cognition*

This onto-epistemological approach aims to explain how subjective reconstruction of objective aspects of reality is possible. Cognition is not a passive act of receiving environmental information, but rather an act of participating where observer and object form a meta-system. As this participative act takes place objectively, it is (in contrary to the constructivist approach) possible that several dimensions of multi-dimensional reality are mirrored in the system's constructions. These re-constructions stay valid until they become contradictory to other environmental data (falsification) which makes it necessary for the system to change its construction. So the act of reconstruction can be regarded as non-linear, non-deterministic feedback process within the intersection of the effective fields (Wirkungsfelder) of the systems involved.

Hofkirchner, W. Institute for Design and Technology Assessment, Vienna University of Technology, Austria.
*A Unified Theory of Information Requires a Unified Theory of Self-Organisation*

An as yet-to-be-developed single, comprehensive and unified information science needs a well-defined concept of information along with just as well-defined concepts of overlapping, adjacent, or at any rate to-be-related concepts like "data", "knowledge", "wisdom", and so on. Such concepts are what the Vienna Unified Theory of Information (UTI) research group has been aiming at. We argue that the proper meta-theoretical foundation of a theory like this is a theory of evolutionary systems (self-organizing systems) which is just emerging by resorting to a general system theory and a general evolution theory. Looking for a general theory of evolutionary systems means to stress that being a self-organizing system is, so to say, the genus proximum of the whole bunch of different self-organizing systems, while acknowledging that there have to be markers that demarcate the differentiae specificae of ever more complex self-organizing systems. As we postulate a coincidence of self-organization and information, information emerges when evolving systems cognize their umwelt, when they communicate with each other, and when they co-operate while establishing a metasystem or supersystem in whatever realm of reality, that is, according to whatever type of self-organization.

## 7.30pm for 8pm Drinks and Conference Dinner

# Sunday
# 9th February, 2003

## Series A

**9am-10.30am PAPER SESSION 17**
**Applications in Mental Health**

Koopmans, M. Metis Associates, Bronx, NY, USA.
*Dynamical perspectives on the origins of bind interactions in the family and their relationship to mental disorders.*

N-bind theory concerns itself with the contribution of dysfunctional patterns of interaction in the family to the symptoms and clinical manifestation of schizophrenia. The theory invokes a nonlinear dynamical framework to further develop Gregory Bateson's double bind theory which describes the frequent occurrence of contradictory communicative expressions in families with a schizophrenic member, and Theodore Lidz' theory which argues that the confounding of roles in the family characterizes those families who have a schizophrenic member in their midst. In its updated form, the theory, n-bind theory, integrates Bateson and Lidz' conceptualization of the relationship between family dysfunction and mental illness into a single framework, which characterizes both types of contradiction as 'bind patterns.' However, Bateson and Lidz' models carry very different implications about where bind patterns come from. In a conceptualization largely derived from Bateson's theory, n-bind theory describes how turbulence in the family results in an inadvertent misalignment of communicative frames. It is also possible, as Lidz suggests, that regardless of whether there is turbulence in the family or not, a power difference between spouses, or a lack of connectedness results in a redefinition of the relationship between a parent and child in terms of the emotional needs of one of the adults. Such a redefinition, which typically catches the child in a bind, does not require turbulence in response to environmental pressure. The difference between these two accounts is further explored, and a broader conceptualization of the origins of bind patterns is provided than that offered in the original formulation of n-bind theory.

Lipscomb, P. University of Washington, Seattle, WA, USA
*Does Complex Adaptive Systems Theory Explain Therapeutic Change?*

In separate works Palombo and Miller claim to have found in the theories of chaos and coevolutionary complex adaptive systems an **explanation** for the therapeutic change produced by psychoanalysis. They identify each of patient, analyst, and the treatment dyad as a complex adaptive system, whose component agents mutually adapt and coevolve over time. But, while they acknowledge that the treatment dyad differs in important respects from other coevolutionary complex adaptive systems, they neglect the logical implications of those differences for a claim of explanation of therapeutic change. In addition to making numerous mistakes in their presentation of mathematical concepts, both authors err in invoking the general as a putative explanation for the specific. In this presentation I note some of the mathematical confusions, analyze the central error in their arguments, highlight what is nevertheless useful about their formulations, and suggest how those parts might be presented more effectively.

Tretter, F. State mental Hospital Haar, Munich, Germany
*The clinical neurobiology of opiate withdrawal – a non-linear phenomenon?*

There is evidence that not only chronic consumption of opiates can "switch" in a non-linear way into physical dependence (Wolffgramm 2000) but also the withdrawal syndrome from a psychophysiological point of view is a non-linear process: when studying the so called ultra rapid opiate detoxification by application of the opiate antagonist naltrexone and anaesthesia. The intensity and duration of the withdrawal syndrome is not determined by the dose of adaptation of the patients (Tretter &.Rath in prep.). One theoretical model for understanding those processes on a qualitative level is the "neurochemical mobile" indicating that various interdepending neurochemical systems are influenced by opiate application as well by withdrawal. The ways to model this system will be discussed preferentially with regard to the methodology of system dynamics (Sterman 2000).

## Series B

**9am-11am PAPER SESSION 18 General Applications**

Schwartz, I. Naval Research Laboratory, Washington, DC, USA
*Noise induced chaos and Transport in population dynamics*

Dynamics of large populations is a fascinating area which covers many fields, including

epidemiology, predator prey dynamics, and chemical dynamics. In many models of large-scale epidemic population dynamics, for example, mass action nonlinearities arise due to the interaction of two or more groups. Such interactions play an important role in the dynamics, and capture all ranges of behavior, from periodic to chaotic time series. From realistic measured and estimated parameters, however, observed chaotic outbreaks from data cannot be reproduced. In this talk, I will review some simple examples of population models, and show how stochastic parameters can generate chaotic-like behavior. I will also show how one may predict when noise generates global behavior from the topology of the models.
Sponsor: ONR

Glendinning-Hall, S. Health Development Agency, UK
*From systems to evidence: a study in applying complexity theory to a health promotion programme*

This paper examines the value of complexity-orientated systems/evidence work for a WHO/Europe-backed health promotion programme. Firstly, by reflecting in terms of organisational development how this work may enable the programme team to function more effectively as a team. This involves study of how complexity can help untangle bureaucracy's confusing effects. In turn reflecting on efforts to remove 'silo-working' and how systems work drawing on complexity can improve the success of this drive to integration on a more self-organised basis (co-existence). Secondly, how the contribution of complexity-orientated systems/evidence work can help capture evidence of impact of the national programme at the school level when faced with the challenge of proving the causal link between health promotion in schools and raised educational attainment. Specifically we suggest the value of complexity theory to help clarify the team's theoretical understanding is a first step to constructing a more adequate concept of evidence necessary to better provide evidence into impact for funders.

Thomassen, A., Utrecht School of the Arts, Hilversum, The Netherlands
*Engendering a continuum of flow within a dynamic CHI system applying a framework of Second Order Cybernetics*

This paper discusses the assurance of a continuum of flow of a cyclic process within the context of potentially disruptive GUI interactions within web-based applications. The conceptual framework of Second Order Cybernetics and the issues of Equilibrium, Feedback Mechanisms and principles of Steady State and Darkness will feed a heuristic approach on design for Web-based applications, in particular process management systems. Within the expertise field of human-computer-interaction and graphical user interfaces in particular a lot of time and effort has been spent on increasing the value of the usability of interaction within the human-computer-interaction. Although such design heuristics have been developed for many applications, they provide heuristics developed solely for interface design without the acknowledgement of the dynamics of the human part and the computer part, which could finally lead to insufficient design. Dynamics of both the Human and the Computer are difficult to oversee, let alone to react and pre-act thereon. To increase the value of usability, the concept of Flow is proposed for the assurance of a continuum of the flow of a cyclic process within the context of potentially disruptive GUI interactions within web-based applications. As an example the Leda system [Learning Environments for the Digital Academy] will be introduced to which these heuristics are applied using concepts of Second Order Cybernetics that will offer insight into the dynamics.

Baskin, K., Institute for the Study of Coherence and Emergence, Philadelphia, PA, USA
*Human Adaptability on the Meso Level: Organizations as Ecosystems*

Complexity theory suggests that any complex system can be viewed from three perspectives: (1) as a whole system composed of adaptive agents; (2) as an adaptive agent in a more inclusive system; and (3) as an environment in which its own adaptive agents act as whole systems. The literature on organizations considers them almost exclusively from the first two perspectives – as whole systems composed of employees and as adaptive agents in their markets. This session will explore what happens when we begin recognizing that, in addition to whole systems in their markets, organizations are also environments in which their employees work to meet "personal" needs. The session will begin with a summary of some findings from my research study on organizational sub-cultures, funded by ISCE. It will focus on the central importance of the local interactions among employees in their work groups, how such work groups develop organizational sub-cultures, and how people in any organization tend to believe that the way their sub-cultures encourage them to

experience the organization *is* reality. The paper will conclude by analyzing the advantages managers, especially senior managers, can accrue by, first, recognizing that the sub-cultures through which they experience the workplace are likely to be very different from others and, second, encouraging others to contribute more significantly to the organization's external purpose by helping them meet their personal needs.

## Series C

**9am-11am PAPER SESSION 19 Applications in Psychology II**

Schiepek, G., Strunk, G., Weihrauch, S., Bölker, S., & Nelle, I.
Universitätsklinikum der RWTH Aachen, Klinik für Psychosomatik und Psychotherapeutische Medizin, Aachen, Germany.

*Nonlinear Dynamics and Complexity in the Experience of Emotions*

Using the method of diaries, subjects encoded emotionally important events (event sampling) for several months. Important emotional qualities as well as aspects of the expression of feelings and self-esteem were encoded by visual analogue scales, from 4 to 10 times per day. Time series containing up to 1000 measurement points were analysed by the PD2 algorithm introduced by J. Skinner and his group, as well as by a method developed to identify local complexities of a time series. Both complexity measures are able to describe nonstationary developments of the process. Results are compared and discussed, from a methodological point of view as well as from a theoretical one. The dynamics of emotions seem to represent self-organized, nonstationary patterns, which could be fingerprints of the evolving personalities.

Schiepek, G., Trump, T., Eckert, H., & Weihrauch, S.
Universitätsklinikum der RWTH Aachen, Klinik für Psychosomatik und Psychotherapeutische Medizin, Aachen, Germany.

*How to Identify Critical Phase Transitions in Human Development Processes – Complementary Information from Complexity Resonance Plots and Recurrence Plots*

Within a large empirical study on the relationship between processes and the outcome of psychotherapies (N=94), we identified critical phase transitions of these therapeutic change processes. On the one hand, we used the method of Recurrence Plots, introduced in order to identify similar sequences of time series. The method is based on the well known embedding procedure of time series in a reconstructed phase space. The resulting plots represent the phase transitions and the degree of the determinism of a time series. In a complementary manner, the method of Complexity Resonance Plots identifies critical transitions by statistically significant intensities of the local fluctuations and distributions of a time series (this product is called "complexity"). As we used a therapy feedback sheet including 53 items, we get information about synchronized sequences of intensified complexities of the items. Both methods lead to complementary and mutual validating results.

Jay-Shake Li, J-S. & Huston, J. Institute of Physiological Psychology I, University of Düsseldorf, Germany

*Applications and Limits of the Extended Return Map in the Analysis of Behavioral Dynamics*

The analysis of phase space is an important part in the study of dynamics. However, behavioral analysts generally do not know all of the variables involved in the systems under study. Thus, a phase portrait must be reconstructed using one dimensional time series data. One of these techniques is the so-called return map, or recurrent plot. Early applications of this tool towards analysis of operant behaviors indicated limited promise of this approach. In our previous works, we modified the return map and introduced a new analyzing method, which we called the "extended return map (ERM)". We applied the ERM to analyze rats' behavior controlled under fixed-interval reinforcement schedules in a Skinner-box, and successfully produced distinct, two-dimensional patterns out of the one-dimensional inter-response-time data. Further studies verified that the patterns seen in the ERM reflected behavioral dynamics of fixed-interval-responding. However, the averaging step in the definition of ERM is quite unusual in the non-linear dynamical systems approaches and raised questions about the validity of the ERM and what the ERM-patterns actually mean. In the present study, we show that the ERM is not suitable for analyzing pure deterministic systems, but for a special kind of point process, whose occurring probability is defined by dynamical functions consisting of abrupt switches of modus. These kinds of systems can successfully model fixed-interval-responding, and also have other applications, such as, in the analysis of learning and in behavioral pharmacology.

Schiepek, G., Eckert, H., Droste, S., Weihrauch, S., Picht, A. & Altmeyer, S.
Universitätsklinikum der RWTH Aachen, Klinik für Psychosomatik und Psychotherapeutische Medizin, Aachen, Germany.
*Real-Time Monitoring in Psychotherapy Processes. the Contribution of Nonlinear Dynamics to the Management of Change Processes.*

After all of the empirical studies and theoretical understanding of self-organized developmental processes we have to ask: What do we do with this knowledge? One of the possible answers leads to the technology of real-time monitoring of human change processes. Data stem from daily ratings on a coding sheet reflecting important aspects of psychotherapy processes (e.g. progress, relationship, ward atmosphere or social support from the natural social environment, emotions, process involvement and self-relatedness). Data are registered by PCs at the therapy ward or by Personal Digital Assistants. Results like raw data of time series, developments at the level of factors, local complexities and critical fluctuations, local degrees of coherency (synchronization) are available during the process. By this method, client and therapist are able to utilize such information for ongoing treatment decisions and the feedback-driven navigation through self-organizing change processes.

## Series D

**9am-11am Workshop 1: Nonlinear Dynamics in Work Organizations: 20 Years and Counting**
**Organiser:** Guastello, S., Department of Psychology, Marquette University, Milwaukee, WI, USA

Applications overview of basic dynamics to organizational behavior from the early 1980s involved catastrophe models. There was a shift in focus to chaos and self-organization in the early 1990s. Importantly, the change in a system from one self-organized state to another is an example of a catastrophe process. Empirical studies are presented.

The organization is a complex adaptive system that receives and interprets environmental stimuli which themselves may be complex and dynamic. It generates response options and information through its creative problem solving capability. The butterfly catastrophe model of motivation combined many previously-known dynamics affecting personnel selection and training, motivation, and work performance, absenteeism, and turnover. Creative products are the result of a chaotic idea generation process. Individuals filter out some ideas and attract others depending on their goals for problem solving. The idea elements and unique mental organization and experience are shared with other problem solvers in group settings. Local interactions among group members culminate in the eventual self-organization of the group such that the role of a general leader emerges along with several other, more specific roles. Control parameters vary by type of group task. Work group coordination applications involve psychological theory, game theory, chaos and self-organization. The basic process of coordination is non-hierarchical, meaning that a leader is not required. The process is fundamentally nonverbal, although verbalization enhances performance to some extent. Experiments on work flow in an organizational hierarchy open up new questions pertaining to the cognitive ability to control chaos and other dynamics.

## 11am-11.30am Morning Tea


## Kleine Festsaal

11.30pm–12.30pm **Keynote Address 3: Professor Jack Cohen,**
Reproductive Biologist, Birmingham Women's Hospital Assisted Conception Unit, Birmingham, UK

*"Why is Negentropy, like Phlogiston, a Privative?" or "Life must be natural, not negentropic"*

The Western world of the twentieth century had a folk-cosmology whose central paradigm was the Second Law of Thermodynamics and increasing entropy, physical constants and anthropic argument (the Universe could not have been other). Heat Death was its apotheosis, and Life was antithetic to its assumptions. Schrödinger's "negentropy" concept exemplified this. I show that this is as false as phlogiston, for much the

same reasons. Our newer, chaos-based vision requires four revisions of our assumptions. The central paradigm of thermodynamics changes slightly, incorporating gravity, and the new cosmology is evolutionary rather than entropic: diverse Life replaces Heat Death. I challenge anthropic argument, showing that *any* working system must appear to be designed, even unique. As well as the divergent effects of chaos, there are several diversifying engines in the modern dynamics of symmetry-breaking and bifurcations. Therefore the development of complexity is natural, not exceptional: Kauffman's "adjacent possible" is also accessible. Genuinely emergent processes are selected to leave erstwhile constraints behind, so that exciting new properties can appear to come very cheaply (although eyes were expensive). Examples of iterative and recursive phenomena – like Pooh and Eeyore chasing Heffalumps – explain why hyper-parasitic wasps are like security firms specializing in shoplifting from supermarkets.

# 1pm – 2pm Lunch

## Series A

**2pm-3.30 pm PAPER SESSION 20**
**Psychotherapy and Dynamics**

Toifl, K. Neuropsychiatric Clinic for Children and Adolescents, University of Vienna, Austria
*Psychosis, defined as self-organization of a dysfunctional Self. Consequences for scientific research.*

In our concept psychosis is defined as an individual, self-organizing and finally dysfunctional development of the Self. In this concept self is an expression of the completeness of a human being. There exists a goal-orientation of development. In principle it is foreseen that a unique and healthy Self can develop. A healthy Self shows in the bio-psycho-social areas of being human, many, flexible and goal-oriented strategies and capabilities which enable her or him to organize the demands of the individual life with as much autonomy, flexibility and satisfaction as possible. The Self needs for its self-organizing development, in addition to energy, primarily information. This information is evaluated by the psychological domain and integrated within the biological-neural system. Through the self-organizing integration process of information into a whole, the Self becomes a structure comprised of information. In order that a healthy Self can be formed, information is needed which supports the attainment of this goal. If the quality of information is rather inhibiting in the sense of the desired goal, then the development of a healthy Self is hindered. The Self is not only an integration vehicle for information. It is also a self-reflexive vehicle which consciously or unconsciously influences the self-organizing process of development.

For our research project we utilize Qualitative Content Analysis. Based on the literature and our own clinical experiences we defined 10 major categories from the bio-psycho-social aspects of a human being which appeared to us to be the essential factors of influence for the development of a healthy Self. On the basis of this categories a manual for a semi-structured interview was prepared. The semi-structured interview was carried out with the patient alone as well with the entire family. The information gathered will be taken apart and processed step by step. The evaluation follows the theories and analytical steps which were defined at the beginning of the project. In the first step, the information was rated according to if and when it should be classified in one of the 10 categories. In the 2 $^{nd}$ step follows deductively the identification of sub-categories within the major categories. In the 3 $^{rd}$ step each sub-category is further classified according to whether the information is estimated as supportive or inhibiting in view of the development of a healthy Self. In the 4 $^{th}$ step the type, quantity and relationship of supportive and inhibiting information undergoes a final rating.

Orsucci, F. Institute for Complexity Studies, Rome, Italy
*Synchronization as a basic process in psychotherapy*

Synchronization of linear and nonlinear oscillators is reviewed in its history in physics and biology. The detection of semiotic structures in cognitive systems has provided a door to access the study of synchronization in interpersonal relations. Psychotherapy is a special kind of personal relation aimed to a finalized change in one of the partners in the systemic coupling. Some examples of using Recurrence Quantification Analysis to study these processes are provided. These findings suggest a reliable implementation of biophysical strategies (e.g. OGY, Pyragas and Pecora-Carroll) to handle and control synchronization in the psychotherapeutic field.

Mayring, P., University of Klagenfurt, Institute of Psychology, Austria
*Qualitative Methods for Research of Nonlinear Phenomena in Human Sciences*

Chaos-theoretical approaches often use mathematical procedures in their empirical work, overlooking the potential of qualitative oriented research methods, developed or rediscovered during the last decades in human sciences. An overview of such possibilities is given. Descriptive approaches, open field research, single case analysis, open-ended interview and observation techniques, different modes of text interpretation, process analysis and inductive data analysis are analyzed in their capacities to deal with nonlinear phenomena. The main advantage is, that the procedures try to analyze the phenomenon in its natural context and complex environment with few deformation by research methods. Examples from psychological research are given. Those qualitative approaches are not understood as strict alternative to quantitative research. There are several possibilities to combine and integrate qualitative and quantitative methods.

In the second part of the paper a concrete research plan from our ongoing research (project "Organization of the Self of Psychotic Adolescents", together with K. Toifl, University of Vienna/Austria) is discussed. A combination of open-ended family interviews and observations together with interpretative and content-analytical data analysis seems to be able to catch the complex processes of self organization and self destruction within psychotic adolescents, in comparison to other clinical or non-deviant adolescents.

Perhaps the one-sided commitment of human sciences to experimental, quantitative research methods and the neglect of qualitative approaches is a reason for simple, linear and restricted outcome.

# Series B

**2pm-4pm Symposium 8: Nonlinear Dynamics and Epilepsy**

**Convenor**: Iasemidis, L. Department of Bioengineering, Arizona State University, Tempe, USA

Le Van Quyen, M., Chavez, M., & Martinerie, J.
Laboratoire de Neurosciences Cognitives et Imagerie Cérébrale, Hôpital de la Pitié-Salpêtrière, Paris, France

*Characterization of Brain Spatio-Temporal Dynamics: Application to Epileptic Seizure Anticipation*

The growing need for a better understanding of large-scale brain dynamics has stimulated in the last decade the development of new data analysis techniques. Progress in this domain has greatly benefited from developments in nonlinear time series analysis. In recent years, the application of these tools showed that it is possible, by extracting information from the EEG, to allow anticipation of epileptic seizures several minutes in advance (1). More recently, application of a phase synchronization measures has been shown to be useful in gathering spatio-temporal information about the epileptogenic process. The method is based on a direct estimation of the instantaneous phase of a signal and, hence, is ideal for analyzing nonstationary EEG recordings with synchronization properties that evolve over time. In our presentation, we will demonstrate the capacity of this measure for seizure anticipation in continuous recordings of long periods of time. In particular, we will propose a general statistical approach for detecting quantifiable spatial or temporal shifts in EEG synchronization, including a systematic study of false positives. The results open new perspectives for the anticipation of epileptic seizures, as well as for the modeling of the underlying neurophysiology.

[1] Le Van Quyen M et al. *The Lancet* 2001; 357: 183-188.

Prasad, A., Narayanan, K., Tsakalis, K., & Iasemidis, L. Brain Dynamics Lab, Dept. of Bioengineering and Electrical Engineering, Arizona State University, Tempe, Arizona, USA

*Hysteresis in Coupled Chaotic Oscillators and Application to Epileptic Seizures*

A universal behavior of hysteresis is observed in systems of coupled chaotic oscillators with a diffusive type of coupling. During the observed transitions, the systems move from spatio-temporal chaotic states into (and out of) spatio-temporally synchronized quasi-periodic states, characterized by spatial convergence (divergence) of the maximum Lyapunov exponents of the individual oscillators. Results with Rossler and Lorenz coupled chaotic oscillators will be presented. These new results from widely accepted nonlinear models in various coupling configurations, in addition to their general application to dynamical systems of spatial extent, shed light into the understanding of the mechanisms and modeling of the transition of the epileptic brain into and out of seizures. In particular, we will show that convergence / divergence of Lyapunov exponents of critical brain sites before / after epileptic seizures follow hysteretic loops very similar to the ones of the coupled systems of spatial extent we investigated. Therefore, the variation of the coupling constant between critical brain sites over time appears to

be a critical parameter for the observed transitions of the epileptic brain into and out of seizures. This investigation is the first step into the interpretation of the observed resetting of the epileptic brain at seizure points [1] and into the modeling of the phenomenon with nonlinear models [2].

[1] L.D. Iasemidis et al., "Dynamical resetting of the human brain at epileptic seizures: application of nonlinear dynamics and global optimization techniques", *IEEE-TBME*, in press; also in *Biocomputing*, Kluwer Academic Publishers, pp. 140-158, 2002.

[2] Supported by NIH, DARPA (USA)

Iasemidis, L., Prasad, A., Narayanan, K., Sackellares, J., Pardalos, P., Shiau, D-S., & Chaovalitwongse, W. Brain Dynamics Labs, Dept. of Bioengineering, Arizona State University, Tempe, Arizona, USA, and Depts. of Neurology, Neuroscience, Statistics, Bioengineering, Industrial and Systems Engineering, University of Florida and the Malcolm Randall VA Medical Center, Gainesville, Florida, USA

*Prediction of Epileptic Seizures by Linear and Nonlinear Methods*

Since the first evidence of predictability of epileptic seizures was published [1], several research groups set off to replicate the results. Thereafter, even more ambitious programs have been established to address the issue of prediction of epileptic seizures. Such efforts, if successful, may lead to a new treatment for epilepsy, a disorder that affects 1% of the population worldwide. Our group has reported highly significant success rates for prospective seizure prediction, in the range of 90% sensitivity, and specificity values of 0.1 false positives per hour, in patients with focal epilepsy [2], [3]. Methods with such a performance can be used in implantable devices for diagnostic and therapeutic purposes, in particular, closed control loop devices with EEG seizure warning software controlling implanted brain stimulators. In this communication, we compare several linear and nonlinear methods for seizure prediction developed by collaboration between our groups. It will be shown that the performance (sensitivity and specificity) of simple linear methods that involve measures like FFT, autocorrelation, principal components over time and space (brain sites), is significantly less than the one of nonlinear methods that involve Lyapunov and Phase spatio-temporal profiles.

[1] L. D. Iasemidis & J.C. Sackellares, "Long-time scale spatio-temporal patterns of entrainment in preictal ECoG data in human temporal lobe epilepsy, *Epilepsia*, 31: 621, 1990.
[2]L. D. Iasemidis et al., "Phase Entrainment and Predictability of Epileptic Seizures", In: *Biocomputing*, Kluwer Academic Publishers, pp. 59-84, 2002.
[3] L. D. Iasemidis et al., "Adaptive epileptic seizure prediction system", *IEEE-TBME*, in press.
[4] Supported by NIH, DARPA (USA)

McSharry, P., Smith, L., & Tarassenko, L. Mathematical Institute, University of Oxford, Department of Engineering Science, University of Oxford, and Centre for the Analysis of Time Series, London School of Economics, London, UK

*The Value of Nonlinear Statistics for Identifying Epileptic Seizures*

A common problem across the life sciences is the detection of dynamical changes. While there are a variety of traditional statistics to detect such changes, ideas from the theory of nonlinear dynamical systems have provided new statistics for this type of detection. Processes that give rise to observations that display complex behaviour may be low dimensional. If one can identify such low dimensionality, then it may be possible to construct mathematical models that will provide an adequate description of the system's dynamics. Unfortunately, in the real world, observed time series are noisy and often of insufficient duration to identify the underlying dynamics using mathematical tools. For the detection problem, a nonlinear statistic need not quantify some theoretical invariant of the system to be useful; it need only have skill at detecting precursors. Regarding medical diagnosis, the clinically relevant question is whether or not the information reflected in a proposed test statistic justifies its use. Specifically, complicated novel (potentially nonlinear) methods add no diagnostic value unless they either complement or systematically outperform traditional linear methods. To have marginal value, of course, any nonlinear statistic must add information not available from traditional statistics like variance. The performance of linear and nonlinear statistics for detecting precursors of epileptic seizures from intracranial electroencephalograms are contrasted. In particular, the need for performing null hypothesis tests using relevant surrogate data is illustrated.

Sackellares, J., Shiau, D-S., Pardalos, P. & Carney, P., Depts. of Neurology, Neuroscience, Statistics, Bioengineering, Industrial and Systems Engineering, University of Florida and the

Malcolm Randall VA Medical Center,
Gainesville, Florida, USA
*Time Irreversibility of Brain Spatio-Temporal Dynamics at Epileptic Seizure Transitions*

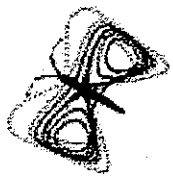
Epileptic seizures occur intermittently as a result of complex dynamical interactions among the epileptogenic focus and brain normal sites [1]. By combining signal processing techniques from the theory of nonlinear dynamics (short-term Lyapunov exponents) and global optimization (binary quadratic form), and applying them to electroencephalograms (EEG), we have shown that epileptic seizures are predictable minutes to hours prior to their occurrence [2]. During this period, critical brain sites that include the focal area progressively exhibit statistically identical maximum rates of information production (chaos), a phenomenon we have called dynamical entrainment. In this communication, we will present evidence that epileptic seizures serve to dynamically reset the epileptic brain, that is to disentrain the critical brain sites that were entrained prior to a seizure. Moreover, we will show that this resetting is irreversible time-wise. If we reverse the arrow of time, resetting at seizure points disappears. Results from the application of the above methodology to long-term (3.6 to 12 days), continuous, 28-channel EEG recordings from 4 epileptic patients with temporal lobe epilepsy will be shown. We expect these findings to aid in the proper characterization, prediction and control of the epileptic transitions [3]. We also expect the proposed methodology to be useful for the investigation of intermittent spatio-temporal state transitions in other complex biological and physical systems.

1. « Fire in the brain », *Discover* magazine, May 2002, pp. 50-53
2. « Quadratic binary programming and dynamical system approach to determine the predictability of epileptic seizures », *J. Combinatorial Optimization*, 5 :9-26, 2001.
3. Supported by NIH (USA).

# Series C

**2pm-4pm Workshop 2: Virtual Worlds, Artificial Societies: the Artist Vision at the Boundary Between Life Sciences and Imagination**
**Organiser**: Mauro Annunziato

This workshop tries to sketch out the state of art of the researches in the artistic field of expressive forms tied to the concepts of artificial life and virtual worlds. A common thread binds these explorations: the theoretical frame of the complexity and emergence. In this way, the life, the mind, the social structures, the dynamics of the language and of the communication, are seen like phenomena of self-organization through evolutionary processes. This context characterizes such artworks for a high degree of autonomy. The artwork can transform itself in time (*generative art*) or can manifest itself like an environment from which not predefined forms emerge (*art of emergence*). In many cases, visitors can interact (*interactive art*) with artificial beings or inhabit virtual worlds. The artist has the task of putting in action a process: to create an environment and the germs of life that will evolve creating shapes that increase their inner structure and complexity with time. The attempt to evoke the mechanisms of life and society through the construction of an artificial life is at the same time a provocation in order to discuss directions of the near future and also a stimulus to re-think the deepest human roots in light of the new philosophical-scientific paradigms. The workshop does not expect to exhaust all the expressive modalities inspired to these concepts, but it represents a good sample of different expressive media: from interactive installations to virtual reality, from genetic architecture to virtual worlds on the web. The aim of the workshop is to contribute to the elaboration of a common territory between art and the science of the complexity. We believe that a cross-fertilization of ideas and interexchange of methods between art and science is possible.



## CONTRIBUTORS

**1) Celestino Soddu, Enrica Colabella and Gabriele Maldonado**
**Generative art is the idea realized as genetic code of artificial objects.**

The generative project is a concept-software that works producing three-dimensional unique and non-repeatable events as possible and manifold expressions of the generating idea identified by the designer as a subjective proposal of a possible world. This Idea / human creative act renders explicit and realizes an unpredictable, amazing and endless expansion of human creativity. This approach opens a new era in design and industrial production: the challenge of a new "naturalness" of the industrial object as a unique and unrepeatable event, mirrors the uniqueness and unrepeatability of man and nature. Argenia is the term that we have coined for this genetic code of artificial ware that, like DNA in nature, identifies

not only an object but a species of objects. Industrial design will no longer be the idea and realization of an object, but the idea of a species of objects and its industrial generation. We have been inspired to a return to the Renaissance cultural approach, capable of combining science and art. We have created ideas formulating a code of the harmony that, as it is born of the history of man and his relationship with nature, identifies and represents the subjective vision of the possible, the imprinting as a designer. The design act changes from forming to transforming, because each form is only one of possible parallel results of an idea.

Celestino Soddu is an architect and Professor in Italian Universities since 1971. Currently he is teaching Generative Design in Milan Polytechnic. In '70 years he was Director of the Audiovisual Centre of the University of Reggio C. and, beginning in 1979, his research is about the dynamic evolution of the environmental and architectural image, designing a sequences of original software. In 1986 he designed the first original software to control the dynamic evolution of the genius loci of an artificial environment. In 1997 he founded and now directs the Generative Design Lab at Milan Polytechnic University and, in 1998, he organized the first Generative Art Conference that continues each subsequent year. Enrica Colabella is an architect and Professor of Generative Design in Milan Polytechnic, since 1975. She uses the new and more advanced tools of communication. She realised architectural projects, movies and video tapes for exhibitions and festivals. She was Professor of Theory and Method of Mass Media Communication in the Accademia di Belle Arti. She works with Celestino Soddu beginning in the years of College.

**2) Christa Sommerer and Laurent Mignonneau**
**Modeling Complex Adaptive Systems and Complexity for Interactive Art**

Several scientific models have simulated Complex Adaptive Systems. These try to model the emergence of complexity within computer-simulated environments inhabited by artificially evolving organisms. My approach is based on the application of complexity and complex adaptive systems to interactive art. With these interactive systems I aim to create dynamic and open-ended image structures that increase in complexity as users interact with them, ideally satisfying some of the key properties of Complex Systems.

Christa Sommerer and Laurent Mignonneau are internationally renowned media artists working in the field of interactive computer installation. They are Researchers and Artistic Directors at the ATR Media Integration and Communications Research Lab in Kyoto, Japan and Associate Professors at the IAMAS Institute of Advanced Media Arts and Sciences in Gifu, Japan. They also hold a position of Visiting Research Fellows at MIT Center for Advanced Visual Studies in Boston USA
.http://www.mic.atr.co.jp/~christa

**3) Mauro Annunziato and Piero Pierucci**
**Emerging Structures in Artificial Societies**

Progress in the scientific understanding and simulation of natural evolutionary mechanisms may be creating the basis for a new stage in evolution: the coming of *artificial beings* and *artificial societies*. Culture itself, aesthetics and intelligence are coming to be seen as the emergent, self-organizing qualities of a collectivity, evolved over time through both genetic and linguistic evolution. This talk traces the art-science experience in the development of hybrid digital worlds, in which societies of artificial beings autonomously evolve their genetics, language, aesthetics and interaction with the humans. The authors discuss their interactive audio-visual art installations and the scientific backstage for the artwork development and the open questions in the artworks itself.

Mauro Annunziato and Piero Pierucci are founders of the *Plancton* media art group. Plancton is an artist-scientist group focalized on interactive installations based on chaos and artificial life to explore the creative potentiality of artificial societies. Their artworks have been exposed in international art-science festivals (Siggraph, Imagina, Alife, Generative Art, Virtuality). Annunziato is the Director of a research laboratory of ENEA (AI, chaos, neural networks, artificial life) and Piero Pierucci directs a laboratory working on voice synthesis and 3D sound modeling. Both are authors of more than hundred scientific publications. Annunziato has been mentioned by NASA-JPL (http://mmp.planetary.org/scien) in 2000 as one of the top 60 artist-scientists selected for the Mars Millennium project. http://www.plancton.com

**4) Juan Romero Cardalda**
**The Hybrid Society**

Creative (and specifically artistic) artificial systems pose a series of specific problems, one of them being the difficulty in finding an adequate quality criterion. In human societies, this assessment is done by means of the interrelation among members of a given culture. Therefore,

one way to tackle the problem would be by modelling a human society or culture. The Hybrid Society (HS) presents itself as an alternative to solve these questions. It constitutes a development framework where different computational models for tasks requiring creativity and social behaviour may be validated at the same time. HS is based on the idea of machines and humans co-existing in a virtual "egalitarian" society. It is opposed to approaches similar to artificial life and to those societies based on co-evolution which constitute purely artificial society models. The aim of HS is to facilitate the design of "social" artificial beings which are capable of developing and assessing new creative products showing a great diversity of complex behaviour. It allows the integration in a single framework of computational models developed by any technique or combination of them, and by any research team, enabling their comparison and collaboration. It also allows the comparison among those computational models and human beings.

Juan Jesús Romero Cardalda is a computer scientist and a musician. He obtained the Ph. D. degree in Computer Science in the University of A Coruña. He co-founded and works at present in the "Creative Computer Group" of RNASA Lab. His present research focuses on the idea of a Hybrid Society, which consists of an egalitarian society composed of creative computers and human beings. In the field of artistic computation, he manages with Colin Johnson, the recent working group in Music and Visual Art inside EVONET, the Network of Excellence of Evolutionary Computation. He also was an editor of Special Issue about "Genetic Algorithms in Visual Art and Music" in Leonardo. Actually he is an assistant teacher in the Faculty of Computer Science in the University of A Coruña (Spain).

**5) Giuseppe Caglioti**
**Ambiguity and symmetry reduction in the emergence of structures and the nucleation of visual thinking**

An analogy is proposed between a) the emergence of structures and properties at the critical state of the dynamic instabilities of natural and artificial systems, and b) the nucleation of the visual thinking in our mind during perception and the process of measurement in quantum mechanics. In this framework, the role of ambiguity and symmetry reduction is presented, focussing on the specific example of the charge transfer spectroscopy of a homonuclear diatomic molecule and the dynamic perception of ambiguity of a modular structure in optical art.

Giuseppe Caglioti is Professor of solid state physics and lecturer of aesthetics, and President of the "Commissione Cultura at the Politecnico di Milano". His interests are now focussed on the technological applications of the results of his research in the fields of the physics of matter and the correlations between natural and human sciences.

## 4pm
## Afternoon Tea and Farewell