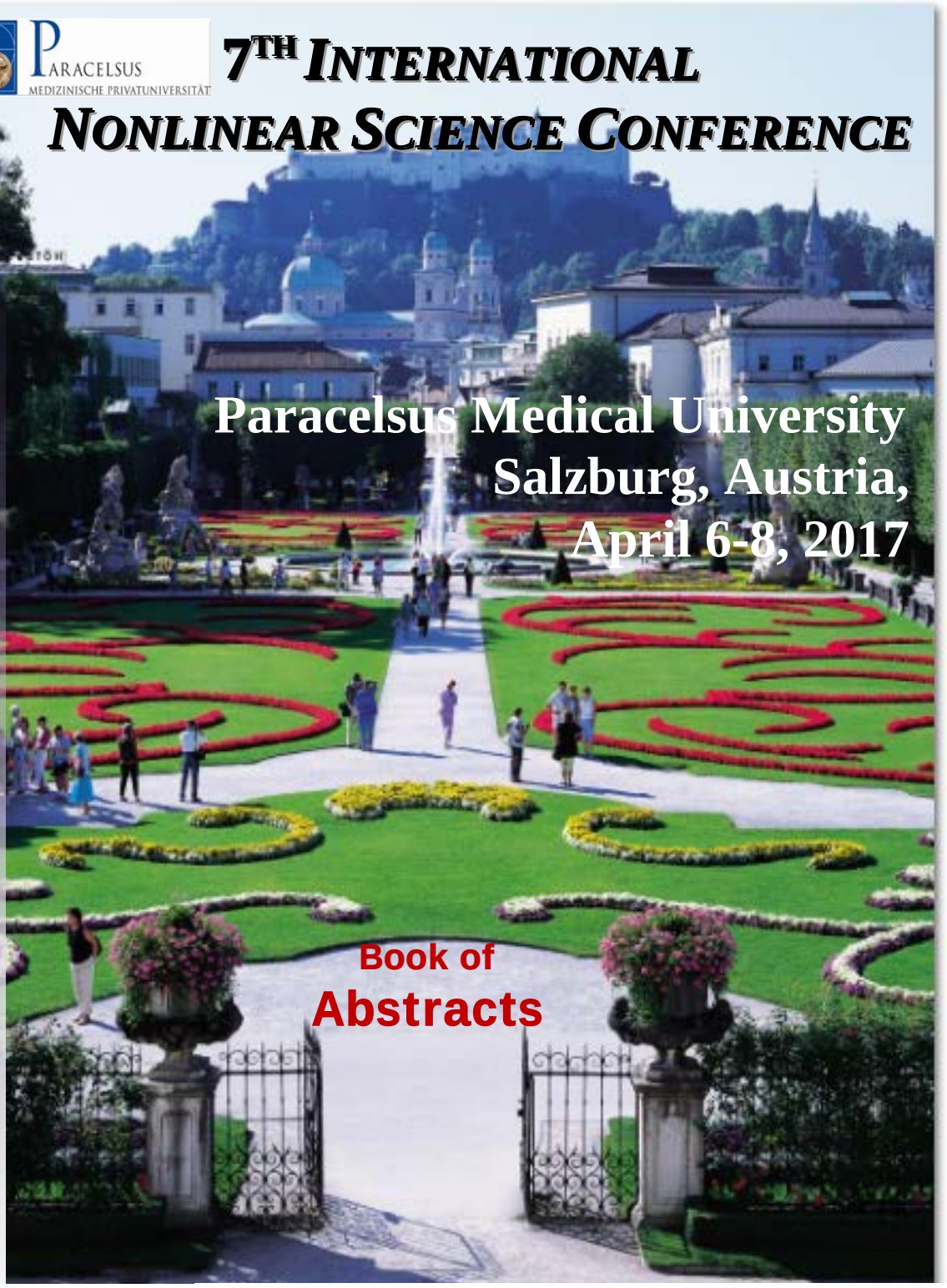
Society for Chaos Theory in Psychology and Life Sciences

PARACELSUS MEDIZINISCHE PRIVATUNIVERSITÄT

7TH INTERNATIONAL NONLINEAR SCIENCE CONFERENCE



Paracelsus Medical University
Salzburg, Austria,
April 6-8, 2017

Book of
Abstracts

Dedicated to the development of nonlinear science worldwide since 1991

PARACELSUS
MEDIZINISCHE PRIVATUNIVERSITÄT

SOCIETY FOR CHAOS THEORY IN
PSYCHOLOGY AND THE LIFE SCIENCES

7th INTERNATIONAL NONLINEAR SCIENCE CONFERENCE

Salzburg, Austria
6th to 8th April, 2017

Venue
Paracelsus Medical University

About the Conference

The Society for Chaos Theory in Psychology and Life Sciences (SCTPLS) is pleased to convene its seventh bi-annual international conference. The International Nonlinear Science Conference (INSC), which is sponsored by SCTPLS in conjunction with a featured university, is the ideal venue for presenting original work applying nonlinear dynamics and related concepts to psychology and the life sciences. For 25 years, the Society and its conferences have been founded on the principles of interdisciplinary work, acknowledging the ubiquity of nonlinear dynamics across the behavioral, social, and life sciences. The conference is typically intimate in size with around 60-70 attendees representing psychology, biology, economics, business, physics, mathematics, and other scholars organized around a common interest in nonlinear dynamics. Attendance is typically broad geographically as well, with membership in SCTPLS representing each of the global continents.

This year brings the 7th INSC to beautiful Salzburg, Austria, a fine destination for culture, tourism, and scientific progress. April 6-8, 2017. Its sponsoring institution is Paracelsus Medical University. –T In this INSC you will find state-of-the-art research work and meet experts in the field, which can provide you the opportunity to start or expand collaborative work. The INSC presents an ideal opportunity for those with ambition to advance their research area via nonlinear dynamics and complexity theory. The program includes prominent keynote speakers and cutting-edge sessions for presentation of symposia, papers, and posters. This Book of Abstracts is the record of all presentations scheduled for this 7th INSC.

Publication Opportunities:

Authors are invited to submit manuscripts based on their presentations to SCTPLS' refereed research journal *Nonlinear Dynamics, Psychology, and Life Sciences*. In addition, the abstracts to the conference will be indexed in PsycEXTRA, produced by the American Psychological Association. A post-conference edition of the abstracts will be available in PDF on the SCTPLS web site (www.societyforchaostheory.org, select CONFERENCES from the main menu). You can also find editions of abstracts from earlier conferences.

Günter Schiepek, *Conference Chair*
7th INSC Chairman

Conference Committee:

Günter Schiepek, Conference Chair, Paracelsus Medical University
Sara Nora Ross, SCTPLS President, Neurotricional Sciences Education Pty. Ltd. and Saybrook University
Stephen Guastello, Marquette University
Dimitrios Stamovlasis, Aristotle University of Thessaloniki

Welcome to the 7th ***International Nonlinear Science Conference***. This conference has been organized by the Society for Chaos Theory in Psychology & Life Sciences, hosted by Paracelsus Medical University in Salzburg. The event reflects a commitment on the part of our organizations to facilitate international collaboration and to encourage the cultivation of scientific partnerships across the globe. We are able to offer you a rich and varied program of presentations, covering a wide range of scholarly disciplines and including theoretical as well as applied approaches. It attests to the international character of our scholarly community that we have presenters from many countries to share their work in nonlinear dynamics, including scholars from the U.S., Eastern and Western Europe as well as Asia. This conference has become part of a long-standing tradition of international scholarly exchange, which has surely strengthened our nonlinear dynamical systems community and the impact of our work.

So, yes, let us continue and strengthen the impact of our work. Let us make no mistake: there has never been a time in our history that needed the holistic, boundary-crossing insights of nonlinear science more than this time, right now. It seems this 21st Century issues the most urgent clarion call to humanity all around the planet to abandon expectations of linear cause and effect, and to wake up to the power of nonlinear assumptions and probabilities.

May we affirm the value of one another's contributions and the good that can come from the work of each, as we listen, learn, and dialogue over these days together. May we think deeply, and make connections between the works presented and the needs of people, organizations, countries, and the planet. Nonlinear complexity is not only boundary-spanning; it is also boundary-breaking. Let us apply its fractal realities to all domains that need these insights!

Dr. Sara Nora Ross, President
Society for Chaos Theory in Psychology and Life Sciences
http://www.societyforchaostheory.org

Dear complexity scientists from all over the world,

The Paracelsus Medical University Salzburg is proud to host the 7*th* *International Nonlinear Science Conference* of the Society for Chaos Theory in Psychology and Life Sciences. Our university is connected to your interests in several ways. First it is evident that psychology plays an important role in medicine, not only because we are confronted with an increasing epidemiology of stress- and behavior-related diseases, but also because of the fact, that mental and social processes (cognition, emotion, behavior) are inextricably connected to biological processes. In consequence, modern medicine has to adopt a bio-psycho-social paradigm. Beyond this and perhaps even more important is the fact that we cannot understand any biological, mental or social phenomena without capturing the structural and dynamic complexity of nonlinear systems.

Thinking and acting in complexity is one of the most important challenges of modern science, not only but also in medicine. Systems and complexity-related competencies prove to be the basic medical competencies in the 21th century. Here we create new insights in the functioning of biological systems like the brain, which is a prototype of a self-organizing system, or of the functioning of medical treatments, like psychotherapy as a self-organizing process. The most interesting phenomena take place at the interfaces, like psycho-immunological or psycho-endocrinal or neuro-cognitive-affective or psycho-social network dynamics. Given this background, a key to understand bio-psycho-social functioning of humans is self-organization. The science of self-organizing dynamic systems is Synergetics, a transdisciplinary and unifying paradigm which plays a central role in modern science.

At the Paracelsus Medical University, applications and developments of Synergetics in the human sciences (psychology, psychotherapy, and brain science) are represented in an excellent way at the Institute of Synergetics and Psychotherapy Research. We are very proud that the founder of Synergetics, the German theoretical physicist Prof. Dr. Dr. h.c. mult. Hermann Haken will come to Salzburg and will open your conference as an outstanding key note speaker. It is a great honor to our university that the 7th International Nonlinear Science Conference takes place in Salzburg. Enjoy the conference and also Salzburg as a city of culture and complexity research.

Univ.-Prof. Dr. Herbert Resch, President
Paracelsus Medical University Salzburg

Dear Conference Attendees,

On the behalf of the conference committee, Sara Nora Ross, Stephen Guastello, Dimitrios Stamovlasis, and me, I would like to welcome you to the Paracelsus Medical University as well as the 7th International Nonlinear Science Conference. We hope that all of you will take advantage of this opportunity to share experiences and intellectual achievements in a synergic environment as in previous years. This year's presentations have been selected from various disciplines: psychology, psychotherapy, systems neuroscience, economy, management, language, sociology, physics, or medicine. Nonlinear sciences paradigms are once more at the basis of all models and applications presented, which helps promote scholarly exchange in a true multidisciplinary environment. In addition, Salzburg is a good place to think in nonlinear and complexity terms. The Paracelsus Medical University and the Christian Doppler University Hospital offer the setting for new developments in theoretical and mathematical modeling of human change dynamics and for producing monitoring systems like the Synergetic Navigation System.

We are very proud that Prof. Dr. Dr. h.c. mult. Hermann Haken, the founder of Synergetics will open the conference by his key note speech. Hermann Haken stimulated and established the transdisciplinary research in complex systems by his groundbreaking new theoretical and methodological pathways like perhaps no other scientist.

Salzburg is a small city which is famous for perhaps the most beautiful kind of dynamic complexity: music. Enjoy your stay here in the central part of Europe, the intellectual and social exchange, and the emergence of new ideas at the 7th International Nonlinear Science Conference.

Günter Schiepek, 7th INSC Chairman
Institute of Synergetics and Psychotherapy Research,
Paracelsus Medical University, Salzburg

KEYNOTE SPEAKERS

Synergetics: Some Basic Concepts and Applications

Hermann Haken
Professor of Theoretical Physics
and Director of the Center of Synergetics,
Stuttgart University, Germany.

Data as Self-organized Patterns on Graphs

Marc-Thorsten Hütt
Professor of Computational Biology Systems
Jacobs University in Bremen

New Perspectives of Computational Modeling

Klaus Manzer
Emeritus Professor of Excellence,
Technical University of Munich

The Contribution of Synergetics and Complexity Science to the Integration of Psychotherapy

Günter Schiepek
Professor of Clinical Psychology
Head of the Institute of Synergetics and
Psychotherapy Research
Paracelsus Medical University Salzburg

Physiological Synchronization and Group Dynamics in Work Teams

Stephen Guastello
Professor of Psychology
Marquette University

Experiential Flow as a Complex Adaptive System: Human Resilience and Psychotherapy

David Pincus,
Associate Professor of Clinical Psychology
Crean College of Health and Behavioral Sciences
Chapman University

Featured Keynote Speakers

Hermann Haken

Synergetics: Some Basic Concepts and Applications

Synergetics is an interdisciplinary field of research dealing with self-organization of complex systems. Self-organization is a process by which the individual components, parts, elements of a system correlate their behavior without an external "instructor." Self-organization ranges from physical systems and devices over biology to psychology and sociology. In spite of the great variety of systems, Synergetics was able to unearth some general principles based on concepts such as order parameters and enslavement. Order parameters characterize macroscopic behavioral patterns that may undergo qualitative changes, often termed phase transitions, leading to new features, e.g., synchronization or chaos. By means of single examples I will illustrate these concepts, and show how they can be applied to psychophysical phenomena such as recognition of ambivalent figures and hybrid images. My approach may have consequences on psychotherapy such as *indirect influencing*, i.e., support of the self-organization of a client, and *strengthening the strongest alternative.*

Bio: Hermann Haken was Professor of Theoretical Physics (1960-1995), and Director of the Center of Synergetics at Stuttgart University, Germany. After his work in Solid State Physics and Laser Theory in 1969, he initiated Synergetics, which has found numerous applications ranging from physics over biology to psychotherapy and information theory. Among his books are:
Haken, H. *Synergetics. Introduction and Advanced Topics*. Berlin: Springer 2004.
Haken, H.; Schiepek, G. *Synergetik in der Pschologie. Selbstorganisation verstehen und gestalten*. Göttingen: Hogrefe 2006, 2nd. Ed.
Haken, H.; Portugali, J. *Information Adaptation: The Interplay between Shannon Information and Semantic Information in Cognition*. Heidelberg: Springer 2015.

Marc-Thorsten Hütt

Data as Self-organized Patterns on Graphs

With the publication of two novel models of random graphs in the late 1990s – small-world graphs and scalefree graphs – 'network science' became a transdisciplinary hype. Indeed, many data analysis problems can be rephrased in the following way: How well does a given (biological, ecological, infrastructural) network match the available (activity, flow, information) data? In Computational Neuroscience, this question is known as the study of SC/FC correlations (i.e., correlations between structural and functional connectivities). In Systems Biology, gene expression patterns are analyzed according to their match to regulatory and metabolic networks. Epidemic diseases can be understood as patterns on air traffic networks. Random walks on graphs can be used to explain the scaling of fluctuations in diverse real-life systems – ranging from river networks to internet traffic. Underlying this comparison of data with network architectures is the idea of considering the data as self-organized patterns on graphs. Following this notion and starting from the theory of spatio-temporal pattern formation one arrives at a novel perspective for analyzing dynamics on networks: by evaluating how the self-organized dynamics are confined by network architecture to a small set of permissible collective states. In this talk I will briefly review this field, starting from investigations of network architectures and then moving to dynamics on

networks and, finally, to patterns on graphs and their applications to data in biology and medicine.

Bio: Marc-Thorsten Hütt received his PhD from Göttingen University in 1997. After research stays in Novosibirsk and Paris he joined an interdisciplinary research group working on circadian rhythms at Darmstadt University. Beween 2001 and 2006 he was an Assistant Professor of Bioinformatics and Theoretical Biology at Darmstadt University. Since 2006 he is a Professor of Computational Systems Biology at Jacobs University in Bremen. His research interests include biological networks, self-organization and spatiotemporal pattern formation. Using simple dynamical models he wants to understand, how network architecture shapes dynamical processes. With his textbooks on Bioinformatics and on Data Analysis in Biology he attempts to bridge the gap between recent theoretical developments and experimental efforts in the life sciences.

Klaus Manzer

New Perspectives of Computational Modeling

The scientific core behind the metaphor "life as machine" is the question of whether processes of life and human intelligence, feeling, and cognition can be modeled, computed and predicted. Modern systems science of complex systems and nonlinear dynamics plays a key role in modeling evolution and the brain. Systems biology designs complex cellular networks reminding us of cellular automata and electronic circuits in engineering science. Synthetic biology constructs new technical systems of life according to these blueprints. Cognitive and humanoid robots become more and more autonomous, interactive, and adaptive, in order to master complex problems and situations. They use artificial neural networks with learning algorithms (machine learning) according to the blueprints of nonlinear brain dynamics. How far can we go to bridge the gap between computational models of the brain and cognitive states in psychology and behavioral sciences? This talk discusses challenges from life science to robotics and artificial intelligence and asks for practical consequences in diagnosis and therapies of human behavior.

Bio: Now an Emeritus of Excellence at the Technical University of Munich, Professor Mainzer's history as a philosopher of science contributes to the foundations and future perspectives of science and technology. He studied mathematics, physics, and philosophy for his doctorate and also habilitation at the University of Münster, which awarded his Ph.D. in 1973. He focuses on the mathematical treatment and computer modeling of science and technology.

He is known as a researcher of complexity with a focus on complex systems in the natural world, science, business, and society, and the paradigms of self-organization, chaos theory, artificial intelligence and artificial life. His research interests delve into computational complexity, cellular automata, neural networks, artificial intelligence (AI), robotics, and big data.

Prior to assuming the Chair of Philosophy and the Theory of Science at Technische Universität München (TUM) and the position of Director of the Carl von Linde Academy in 2008, he was a professor (1981-1988) and prorector (1985-1988) at the University of Konstanz, and a professor and founding director of the Institute for Interdisciplinary Informatics (1988-2008) at the University of Augsburg. He is a member of numerous national and international bodies and academies. From 2012 to 2014 he built up the Munich Center for Science in Technology as founding director. He is the former president of the German Society of Complex Systems and Nonlinear Dynamics and president of the Japanese-German Society of Integrative Science. He is a coeditor, board member of scientific journals, guest-professor, and international author.

Some significant publications: K. Mainzer, *Thinking in Complexity* (Springer: New York 5th edition 2007); K. Mainzer, *Leben als Maschine? Von der Systembiologie zur Robotik und künstlichen Intelligenz* (Mentis: Paderborn 2010); K. Mainzer/L. Chua, *The Universe as Automaton* (Springer: Berlin 2011); K. Mainzer/L. Chua, *Local Activity Principle* (Imperial College Press: London 2013); K. Mainzer, *Künstliche Intelligenz: Wann übernehmen die Maschinen*? (Springer: Berlin 2016); K. Mainzer, *Information: Algorithmus-Wahrscheinlichkeit-Komplexität-Quantenwelt-Leben-Gehirn-Gesellschaft* (Berlin University Press: Berlin 2016)

Günter Schiepek

The Contribution of Synergetics and Complexity Science to the Integration of Psychotherapy

During the last decades, Synergetics together with nonlinear dynamics and complexity science has become an unifying paradigm in psychology and the human sciences. Certainly it is still not the mainstream, but it has stimulated a broad variety of research and theoretical work on neural and mental processes, cognition and emotion, social interaction, how to conceptualize psychotherapy, ideas on the mind-body-interaction, or basic and practice-related research. One important contribution concerns psychotherapy integration. Psychotherapy is still dominated by different schools of thought, a situation which has to be overcome for fruitful progress in this transdiciplinary field. This lecture delineates some criteria for a school-independent psychotherapy, like the availability of a meta-theory for neuronal, mental, and social change processes, an integrative, concrete, and computational theory or model for explaining and simulating change dynamics, criteria for micro-decisions during the ongoing process, tools for real-time monitoring and therapy feedback, methods for client-centered and interpersonal case formulation, a concept for therapist's competencies which can be applied to trainings, or an idea how to bridge the gap between basic research, applied research and practice (practice-based evidence and evidence-based practice). These and other criteria can be fullfilled if the complexity and network dynamics of the involved systems and their dynamics is taken for serious, i.e., self-organization of processes, emergence of new qualities in human development, synchronization and de-synchronization, discontinuous evolution, chaotic dynamics, or critical instabilities as precursors of phase-transions occuring at different time scales and system levels.

Bio: Günter Schiepek is a professor for Clinical Psychology and head of the Institute of Synergetics and Psychotherapy Research at the Paracelsus Medical University Salzburg (Austria) and at the Ludwig Maximilians University Munich (Germany). He is a member of the European Academy of Sciences and Arts, fellow at the Mind Force Institute in Rome, and member of the scientific directory of the German-Japonese Society for Integrative Science. His work is on nonlinear dynamics, self-organization, and complexity science applied to psychotherapy research (process-outcome), neuronal networks, psychotherapy feedback and control, e-MentalHealth, and practice-research relationship. Some of his books: Haken, H. & Schiepek, G. (2006, 2nd. Ed. 2010). *Synergetik in der Psychologie. Selbstorganisation verstehen und gestalten.* Göttingen: Hogrefe. Strunk, G. & Schiepek, G. (2006). *Systemische Psychologie. Einführung in die komplexen Grundlagen menschlichen Verhaltens.* Heidelberg: Spektrum Akademischer Verlag. Schiepek, G. (Ed.) (2003, extended new edition 2011). *Neurobiologie der Psychotherapie.* Stuttgart: Schattauer. Schiepek, G., Eckert, H., Aas, B., Wallot, S. & Wallot, A. (2015). *Integrative Psychotherapy. A Feedback-Driven Dynamic Systems Approach.* Boston, MA: Hogrefe International Publishing.

Stephen Guastello

Physiological Synchronization and Group Dynamics in Work Teams

Emotions in groups can be contagious. When everyone's ups and downs follow closely, we have synchronization. Sync resembles some forms of coordination, such as neuromuscular coordination, where there is a relatively exact or proportional tracking of body sway, hand and head movements, autonomic arousal, or EEG readings between two or more people. This presentation is primarily concerned with emotional arousal within work teams, different types of synchronized time series, their impact on ratings of workload and leadership initiatives, and team-level performance. In one experiment, dyads were monitored as they worked on a vigilance (building security) task; individual measurements of empathy and the speed of presentation of critical stimuli both had an impact on levels of synchronization. In the second experiment, teams of three or four people participated in an emergency response simulation against an opponent. Here we identified drivers and empaths within the group, developed a synchronization coefficient that rendered a single measure of synchronization within the entire group, and explored the connection between group synchronization and team performance.

Bio: Stephen Guastello is a Professor of Psychology at Marquette University in Milwaukee, Wisconsin, USA, where he specializes in Industrial-Organizational Psychology and Human Factors Engineering. He had been developing empirical applications of nonlinear dynamics for more than 30 years. His book-length works include: *Chaos, Catastrophe, and Human Affairs* (1995); *Managing Emergent Phenomena* (2002); *Human Factors Engineering and Ergonomics: A Systems Approach* (2nd edition, 2014); *Chaos, Complexity, and Psychology: The Theory of Nonlinear Dynamical Systems* (2009, co-edited with M. Koopmans & D. Pincus), and *Nonlinear Dynamical Systems Analysis for the Behavioral Sciences Using Real Data* (2011, co-edited with R. Gregson).

David Pincus

Experiential Flow as a Complex Adaptive System: Human Resilience and Psychotherapy

The various channels of human experience: emotion, cognition, behaviors and interpersonal dynamics, are clearly both dynamical and also highly interactive. When taken as such, non-reductionist and non-linear approaches to science are far better equipped to make sense of key questions related to human resilience and psychotherapy process. In particular, measures of entropy; critical transitions, and fractal structure may be used to understand the complementary roles of experiential flexibility and structural integrity in psychosocial health. This address will present a general theory of human biopsychosocial resilience grounded in the concept of *meta-flexibility*: the ability of a complex adaptive system to *flexibly shift its levels of flexibility* in response to shifting flows of information, without getting stuck or disintegrating in the process. Through this theoretical lens, one may understand each general class of nonlinear model (i.e., network, topology, state-space and time-series) as providing a different vantage point into the common features of system resilience: integrity and flexibility. Next, we will cover a sample of basic nonlinear research supporting the relationship between psychosocial health and flexibility in: emotion, cognition, habit, and social dynamics. Finally, we will introduce an integrative-experiential approach to psychotherapy (Experiential Balancing Therapy) that enables clinicians to systematically combine techniques from among the most disparate and historically conflicting schools of psychotherapy: cognitive-behavioral, humanist-experiential, and psychodynamic.

Bio: Dr. David Pincus is an Associate Professor of Clinical Psychology in the Crean College of Health and Behavioral Sciences at Chapman University in Orange, California, USA. He obtained his Ph.D. in Clinical Psychology at Marquette University in Milwaukee Wisconsin and a post-doctoral fellowship through The UC Davis Department of Psychiatry. Dr. Pincus remains active as a clinician, specializing in the treatment of anxiety disorders and family therapy. He is a Past-President of the Society for Chaos Theory in Psychology and Life Sciences, serves as a Review Editor for *Frontiers in Psychology, Psychology for Clinical* Settings, and as a co-editor for the *Imagery and Human Development Series* (Baywood Publishing). Dr. Pincus research focuses on the application of nonlinear dynamical systems theory to a variety of topics in clinical psychology and behavioral medicine including: human resilience, psychopathology, integrative psychotherapy, and pain management. He has published in Journals including: Nonlinear Dynamics, Psychology and Life Sciences, Small Group Research, and Interface Focus (published by the Royal Academy). He is the lead author of: "Imagery for Pain Relief: A Scientifically Grounded Guidebook," and a co-editor of: "Chaos and Complexity in Psychology: The Theory of Nonlinear Dynamical Systems." The common theme of Dr. Pincus's work aims to understand human resilience in a more direct, literal and structural manner than mainstream psychological science. His theoretical, applied and theoretical work aims to understand the complementary roles of network connectivity and flexibility among the various channels of human experience: emotional dynamics, cognition, interpersonal processes, and behavioral flows.

Views of Salzburg

Oral presentations

Can we afford neglecting phenomena which aren't frequent enough to generate statistical populations?

Cristian Andreescu, *Center for Complexity Studies, Bucharest,* **Florin Munteanu**, *Center for Complexity Studies, Bucharest*

Without postulating the existence of a hypothetical informational particle, but based on reasonable evidence and in alignment with the recent studies that target defining the ontological dimension of information and also based on a triad model of information - energy - matter, this paper aims to reveal the extension of the scientific paradigm over less studied phenomena, such as: phenomena with low reproducibility, the influence exerted by the observer upon certain process dynamics and evolution, the non-linear and singularity approaches, and so on. We are looking for new principles to design experiments, and new methods for formulating hypotheses beyond those suggested by the current paradigm. Such studies are primarily focused on the cases where information is the fundamental brick of hierarchical systems, as a means of insuring coherence of the overall complex systems. We are also looking at experiments where we could reveal the emergence of observable structures out of a subsequent hypothetical informational structure. For example, some studies looked at systems with stratified structures, hierarchical in a way where non-obserable effects from a low structural plane (we can call it "micro") to correlate informationally with a higher hierarchical plane (we can call it "macro"), in order for these effects to be directly observable at a macro scale. Besides the call for broadening the scientific paradigm by approaching problems that are loosely or incompletely defined, the paper also points to a series of examples with the hope to open the curiosity to explore a "space" that is common to the thinking and informational structure of reality.

Complexity of brain processes during meditation

Klaus Bærentsen, *Psychology, Aarhus University, Denmark*

As part of our continuing effort to find meaningful ways to characterize brain processes supporting meditation (cf. Bζrentsen et al 2010, Bζrentsen 2011), the complexity of time series representing the activity variations of eight common resting state networks was explored during fingertapping, rest, meditation onset, and 15 minutes of sustained meditation. Fingertapping and meditation onset were scanned using standard on-off block design, whereas resting and sustained meditation were scanned without interruptions. Normalized time series were characterized in terms of fluctuation, distribution, and complexity, using the method suggested in Schiepek and Strunk (2010) and in Haken and Schiepek (2010). Here we present data characterizing the complexity of time series related to the design of the experimental tasks. Results reveal relationships of complexity to phase transitions during the blocked on-off tasks, and the presence of comparable phase transitions during uninterrupted rest and meditation. For comparison, the complexity of time series from scanning of a sphere used for calibration of the scanner is also considered.

Nonlinear dynamics and pattern formation in optimal choice consumer models

Fausto Cavalli, *Catholic University of Sacred Heath of Milan, Italy,* **Ahmad Naimzada**, *University of Milano-Bicocca, Italy*

In this work we consider an optimal choice consumer problem, in which we introduce several significant behavioral aspects of the agents. Our starting point is the classical framework in Benhabib and Day (1981) and, similarly to it, an essential role is played by the dynamical adjustment process, which allows introducing a dependence of the current preferences of the agents on their past behavior. The social interaction among the agents is represented by means of strongly nonlinear functions. This allows modelling, for example, phenomena in which both bandwagon and snob behaviors are simultaneously present (e.g., agents follow a bandwagon behavior if the average consumption is below a certain saturation level, above which their behavior is snob). Suitably modifying the shape of the nonlinear preference functions, we can investigate the influence of agents' heterogeneity. Finally, we take into account the influence of spatial social interactions, in order to study the effects of agents' distribution on the possible diffusion, synchronization and pattern formation of social behaviors. In particular, we consider both local and global spatial interactions, namely each agent can be influenced both by the behavior of each neighboring agent (local interaction) and by the average behavior of all the agents (global interaction). Mostly relying on

computational experiments, we study the effect on the possible resulting spatial configurations of the agents' consumption choices of the prevalence of either the local or the global interaction, focusing in particular on the spatial coexistence of different consumption levels.

Sociology and Complexity. Suicide and Social Integration in Modern Societies: A Reflection on Differentiation and Social Integration Processes from the Perspective of a Non-linear Analysis of Complex Social Systems

Rosalia Condorelli, *Department of Political and Social Sciences, Catania University, Italy*

Can we share even today the same vision of modernity which Durkheim left us by its suicide analysis? Or can society surprise us? Several studies found that beginning the second half of the 20th century suicides in more industrialized western countries do not increase linearly, proportionally as modernization processes increases, as Durkheim's theory leads one to predict. Despite continued individualization process, they found stabilizing or falling suicide rate trends. From this perspective, the insights of complexity theory suggest a redefinition of Parsons' classic concept of social system, articulated around the property of self-maintenance of order rather than on its possible discontinuity and instability, in favour of the analysis of dynamic processes of systems far from equilibrium (or entropy). And in so doing, it provides a new theoretical framing for social change issues and empirical enquiries about it. So, in the frame of nonlinear dynamical system modeling, we formalize the logic of suicide decision-making process responsible for changes at aggregate level in suicide growth rates by a nonlinear differential equation structured in a logistic way, and in so doing we attempt to capture the mechanism underlying the change process in suicide growth rate by hypothesizing that system's dynamics exhibits a restrained increase as expression of an adaptation process to the liquidity of social ties in modern society. By applying a nonlinear logistic to Italian suicide data from 1875 to 2010, results confirm this hypothesis, and afford a reflection on modern society relating the Durkheimian theory with the Halbawach's theory and most current visions of modernity such as the Baumanian one.

Understanding clinical change from a dynamical network perspective: An empirical exploration of dynamic affect-networks in mood disorders

Maartje Eijlander, **Anna Lichtwarck-Aschoff**, **Marieke van Rooij**, *Psychopathology Department, Behavioral Science Institute, Radboud University Nijmegen, The Netherlands;* **Angelique Cramer**, *Universiteit van Amsterdam, The Netherlands* **Günter Schiepek**, *Institute of Synergetics and Psychotherapy Research & Department of Psychosomatics and Inpatient Psychotherapy, Christian Doppler University Hospital, Paracelsus Medical University, Salzburg, Austria*

This study aims to provide an empirically-based understanding of how clinical change treatments work, rather than by application of the network approach to psychopathology. The network approach explains mental disorders as complex, dynamic networks of (causally) related components such as symptoms. Accordingly, clinical change is defined as the reorganization of network architecture, e.g., from an unhealthy to a healthy network. This study contributes by investigating the dynamics of a part of the complex system that may define the wellbeing of patients diagnosed with mood disorders. Because of the perceived burden of daily symptom assessment, this study focuses on affect-networks instead of symptom-networks. The main goal is to see whether the group of patients who (clinically) significantly improve during treatment, and the group of patients who do not show significant improvement differ in their population affect networks. It will be explored whether a higher density in the affect-network, indicating stronger temporal interactions between different types of affect during the first four weeks of treatment, characterizes the non-improver population network. Further analyses will be used to explore whether the degree of individual network density predicts future symptom severity, and therefore clinical change. The time-series data used for the network-analyses are collected by and retrieved from the Synergetic Navigation System (SNS), an online monitoring system developed by G. Schiepek and colleagues and used in clinical practice. The equidistant daily measures collected using SNS are based on the Therapy Process Questionnaire, which was developed by G. Schiepek and colleagues.

About Two Different Dynamical Systems Keeping Track of (Un)Boundedness, with Application To Cognition

Adam Gadomski, *UTP University of Science & Technology, Institute of Maths & Physics,* **Bogdan Lent**, *UTP University of Science & Technology, Faculty of Management*

We address how two different but simple dynamical systems can be used to rationalize a behavior of their more complex, cognition addressing counterparts. First concerns the free fall (System 1) experienced by a material-point. It is one of the examples of motion with g – gravitational acceleration. The time variable assigned to the motion (t) reads: $t=(V-v)/g$; V and v: final and initial values of the point's velocity, respectively. Also, $X=x+(v+V)t/2$ applies, in which X and x – final and initial positions of the material-point ($H=X-x$ – the height H of the free fall), respectively. By performing t reduction in System 1, one provides an 'energetic' pattern, having a quadratic nonlinearity of type V^2. As for the second, the oscillating material-point, attached to a spring of elastic constant k, goes over an isoenergetic trajectory ($E=const.$) of circular type shape. Whereas System 1 contains only one quadratic nonlinearity, V^2, the system with $E=const.$ (System 2) has got two of them (W^2,V^2) for which $W=wX$ *and* $w^2=k/m$ (radial frequency but squared; m – mass) . This is, contrary to the free fall, that the elastic rebound is involved in the corresponding energy $kX^2/2$. In complex cognition systems $t=T+(V-v)/g$ can be envisaged, with T an action-induction (hesitation) time of specific value, with either deterministic (well-shaped individuals) or statistical (loosely determinable – for mental-illness affected) characteristics. Moreover, $T=T(x,X;vV;p)$ would apply (p – external factor), rendering the system energetically non-ideal. A tour toward systematic complexation of Systems 1, 2 can be drawn. An illustrative example of examining a leader behavior, pointing to achieving straightforwardly (free-fall-like) and/or (in)elastically, a certain goal/target, is to be foreseen.

Complexity and the Dynamics of Novel Thinking: Evidence from Short and Long Term Impacts of Musical Skill Learning

Martin Gardiner, *Brown University*

Both our short term longitudinal studies following student progress through early stages of schooling, and longer term longitudinal studies following students from age 7 to age 35 are showing evidence of significant cognitive and social impacts beyond music alone when students receive training that builds specific musical skills. In our data the evidence of impact is strongest in tasks and behavioral situations which demand complex novel thinking rather than repetition of something learned previously. Musical skills often involve novel complex thinking, perhaps especially during skillful sight reading. This capability turns out to be especially strongly linked to many types of impact we study. I hypothesize that students who develop specific musical skills such as advanced sight reading must develop mental capabilities demanded by the music more generally as well. As I will discuss, music skill's relationship to complex novel thinking can then help provide insight into the dynamics of this essential component of highest level human capability.

Fractals in Literature: New Finds

Eystein Glattre, *Veterenary College, NMBU, Oslo, Norway*, **Hɛvard Glattre**, *Codestitcher AS*

By means of the computer-program ZIPFF, recently developed by us, for the first time it is practically possible for literature investigators to utilize American linguist George K. Zipf s (1902-50) two power-laws, the well-known rank-frequency law and the almost forgotten inter-word distance law, in the investigation of corpuses. Thus, ZIPFF makes it possible to study hidden information and fractal properties of a corpus as well as of its words. In this presentation we use Ernest Hemingway's *The Old Man and the Sea* as an example and examine it by means of ZIPFF. We present the novel's rank-frequency histogram and the distribution of the alphas of all words occurring sufficiently often in the novel. This multimodal curve, by us often called a wizard hat, is typical not only of this Hemingway novel, but of all novels we have examined so far. The hat also has several characteristic prominences denoted by us by colors borrowed from physics, for instance, the white and pink peaks, the former consisting of all words with alpha-value around 0.5, mainly function words, and the latter consisting of all words with alpha-value close to 1, mainly lexical words. And since pink words are in the self-organized state of criticality, they must be critical to the shaping of the novel's narrative. We finally show how the wizard hat, by appropriate interpretation, is compatible with the Wernicke-Broca model for language production.

A Logic for Complexty

Jeffrey Goldstein, *Adelphi University*

This paper explores the new logic of complexity that has been emerging out of the transdisciplinary study of complex systems. The term logic is being used here along the lines of *logical* in the following excerpt from the physicist cum biologist Walter Elsasser (one of the first complexity-oriented theoretical biologists): [biology is endowed] with a logical structure quite different from what we are accustomed to in physical science (emphasis added). For Elsasser, the key element of this logical difference had to do with the nature of the fundamental units being studied, whereas for physics the fundamental constituents of matter were particles characterized as homogenous and indistinguishable, a property rendering physics so amenable to mathematical treatment, in biology the fundamental constituents are heterogeneous, a property which seriously curtailed the employment of those mathematical operations at the basis of physics. I allude to Elsasser not to argue for or against his claim but instead to clarify what I mean by logic. This paper represents the culmination of a long-term project aimed at uncovering the new logic of complexity.

Physiological Synchronization and Group Dynamics in Work Teams

Stephen Guastello, *Marquette University*

Emotions in groups can be contagious. When everyone's ups and downs follow closely, we have synchronization. Sync resembles some forms of coordination, such as neuromuscular coordination, where there is a relatively exact or proportional tracking of body sway, hand and head movements, autonomic arousal, or EEG readings between two or more people. This presentation is primarily concerned with emotional arousal within work teams, different types of synchronized time series, their impact on ratings of workload and leadership initiatives, and team-level performance. In one experiment, dyads were monitored as they worked on a vigilance (building security) task; individual measurements of empathy and the speed of presentation of critical stimuli both had an impact on levels of synchronization. In the second experiment, teams of three or four people participated in an emergency response simulation against an opponent. Here we identified drivers and empaths within the group, developed a synchronization coefficient that rendered a single measure of synchronization within the entire group, and explored the connection between group synchronization and team performance.

Turn Taking, Non-Stationarity, and Synchronization in Physiological Time Series

Stephen Guastello, David E. Marra, **Anthony F. Peressini**, **Julian Castro and Michael Equi**,
Marquette University

Many forms of human interaction involve taking turns. A conversation between two people is perhaps the most common example. Other common examples include two-person recreational or gambling games and some types of work activities where the two people perform subtasks on an alternating basis. Turn taking becomes a statistical issue in studies in which physiological data (e.g., autonomic arousal) are collected during the interaction, perhaps for a nonlinear analysis on a neuroergonomics problem. The methodological question thus becomes whether turn taking introduces a source of non-stationarity that could compromise the data analysis by lowering the amount of behavior variance accounted for by a theoretical deterministic model. The objective of this paper is to explore the impact of turn taking on individual time series and, in the case of small experimental groups of research participants, the synchronization of the group as a whole as evidenced by statistical analysis. This study investigated the stationarity of electrodermal time series collected in situations where turn taking in human interactions is involved. The experiment involved seven participants in an emergency response simulation against one opponent. They generated 48 time series across six simulations which were split and re-spliced to separate the team's and the opponent's turns. Significant differences in R^2 coefficients were found for both linear and nonlinear statistical models, but the difference only amounted to 3% of the accuracy of those models. A comparison of synchronization coefficients for the team data indicated stronger synchronization during periods when the team was watching the opponent's actions compared to when they took their own turns. It was concluded that the common focus of attention prevailed against any non-stationarity that was introduced by turn taking.

The Phenomenon of Autogaslighting in the Evolution of Civilization

Jason Hu, *Independent Researcher, Phoenix, AZ*

Inspired by email conversations with Dr. Hermann Haken in 2015-2016, the author makes effort to create a synergy among a number of giant thought leaders: H. Haken of Synergetics, G. Pask of Conversation Theory, E. Jaques of Cognitive Capacity, B. Anderson of Imagined Communities, H. Maturana of Autopoesis, and H. von Foerster of Experimental Epistemology, etc., each shedding lights from a different angle, for a synthetic model to explain the phenomena of the emergence of religions and communities, the emergence of self-organized orders, norms, believes leading to political institutions, and the spreading of such orders/institutions encountering resistance from geographically local constructs i.e. the so-called clash of civilizations. A new conceptual framework of autogaslighting vs. allogaslighting i.e., an ecology of competing constructed realities (beheld by different P-individuals in Paskian term), full of jungle law of ideas (food chains, prey-predator relationships, symbiosis, competition for the same niche, growth, decline and extinction, of a growing population of P-individuals), is presented. If this model can be thoroughly examined and sufficiently discussed during this conference, a new understanding of the evolution of human civilization might be reached and therefore trends of our civilization could be better predicted.

On the Pervasiveness of Long-Range Memory Processes in Daily High School Attendance Rates

Matthijs Koopmans, *Mercy College*

Few educational researchers or practitioners would question that high school attendance is an important mediator in the causal network that is used to explain academic achievement, yet attendance remains under-researched. The New York City Department of Education has created an opportunity to examine the longitudinal trends and dependencies in daily attendance rates as it created a repository of daily attendance rates for all of its schools, starting in 2004. The present analysis examines the dynamical patterns in daily attendance rates over a ten-year period (Sept. 2004 June 2014) in six small high schools and nine large ones. As was done in previous work, this analysis systematically distinguishes short-range, seasonal and long-range dependencies in the data using time series analysis. Seasonal cycles are predictable (here, fluctuation by days of the week), the long-range dependencies indicate cycles that are unpredictable, suggestive of more complex dynamical processes, such as self-similarity, self-organized criticality and scale invariance, features that are difficult to detect by school building personnel, but are important aspects of the systems behavior. Seasonal cycles were found in three of the nine large schools and in all six small ones. Significant long-range dependencies (Hurst exponent) were found in all large schools and all but one of the small ones. The pervasiveness of the long-range processes over and above the seasonal cycles is striking, and points to both the vulnerability and the adaptability of these systems to fluctuations in the exogenous processes that find their expression in daily attendance behavior (e.g., parental support).

Neurorehabilitation Team as Semi-Open Complex System

Olga Maksakova, *Burdenko Neurosurgical Institute*

The work with unconscious patients after acute brain damage, besides specialized knowledge and practical skills, requires a very specific organization. Rehabilitologists deal with fixed patient problems or deficits (motion, speech, cognitive or emotional disorder) usually in outpatient mode. Team-building there means superficial paradigm of management psychology. A linear mode of teamwork fits casual relationships there. We use non-linear mode of teamwork in cases of deep altered states of consciousness (vegetative states, coma, confusion: consciousness mightn't be the goal due to indefinite phenomenon). Rehabilitation team as Semi-open complex system includes the patient as a part. Patient"s response pattern becomes formed not only with brain deficits but questions-stimuli, context, and inquiring person. Team work is sourcing of phenomenology knowledge of patient"s processes and chance to real-time change. Restoration of consciousness is realized by means of build-up of patient's contacts with onr's own body and outward things. Feedback to any minimal movement or vegetative signal of the patient is basic principle. The net of feedbacks with the patient and inter-professional ones builds up the team. Characteristics of team-patient system (TPS) are energy, entropy, and complexity. Impairment of consciousness as the absence of linear contact appears together with a loss of essential functions (low energy), vegetative-visceral fits (excessive energy and low order), motor agitation (excessive energy and excessive order), and etc. Techniques of team work are different in these cases for resulting optimization of the system condition. Complexity rise is a powerful tool for recovering. system self-organization is a key process for awareness

formation. Analysis of complex communication process in TPS may be useful for creation of the general theory of consciousness.

Generalized Multiplicative Model for Assessing Outcome in Psychotherapy: Case Study of Subjective Well-Being

Irina Malkina-Pykh, Research Center for Interdisciplinary Environmental Cooperation of Russian Academy of Sciences

The study presents the performance of generalized multiplicative model (GMultM) for assessing outcome in psychotherapy. GMultM is a flexible nonlinear regression method that is able to predict the impact of common factors (i.e., subjects psychological variables) as well as their changes during psychotherapy on its outcome. This nonlinear model including interaction effects among predictors has a higher explanatory power to predict treatment outcome, compared to any linear model. Also, GMultMs are accurate and interpretable models, compared to full complexity models. Experimental data are used for construction of the GMultM, evaluation of its parameters and validation. GMultM is able to produce nonlinear partial response functions of psychological predictors of different psychological phenomena directly as a result of model s parameters estimation procedure. Case study of rhythmic movement therapy (RMT) for increasing subjective well-being (SWB) is presented. A total of 273 subjects (54 males and 219 females, mean age was 37.3±10.5 years) were selected at random in nonclinical population and assessed with the appropriate surveys and questionnaires. RMT program was proposed to the 105 subjects (24 males, 81 females, mean age 37.6±11.7 years) with very low, low and medium SWB level. Control group was included. GMultM predicts the changes in SWB after RMT intervention satisfactorily and can help to identify the reliable predictors of success.

Neural Connectivity in Default Mode Networks in Subjects with Major Depressive Disorder

Hans Menning, *Private Practive, Zurich, Switzerland*
Günter Schiepek, **Damir Del Monte**, *Paracelsus Medical University*

Individual connectivity patterns between brain regions are like a neurobiological finger print of specific psychiatric disorders. Highly over- or under-synchronized brain networks indicate a dysfunctional adaptation of the brain. Major depressive disorder is associated with an imbalanced, pathological dynamic connectivity pattern within frontoparietal regulation systems. We investigated in a whole-head-EEG study at the Paracelsus Medical University Salzburg 30 depressive patients and 30 matched controls in a pre-post design. The analyses of the resting-state functional connectivity revealed a highly dynamic dysfunctional connectivity pattern in the a priori assumed default mode networks of depressive patients compared to the control group. These findings suggest that depressive patients tend to engage hyperconnectivity networks in favor of internal self-referential rumination (mind-wandering) and at cost of coping with the external world. Similarly, they tend to hypoconnectivity in networks associated with emotion processing and top-down regulation.

Operationalization and Measure of Ambivalence in psychology and social science

Olga Mitina, **Ilya Pluzhnikov,** *Lomonosov Moscow State University, Dept. of Psychology*
Ambivalence is an important concept for understanding dynamics. Two strengths acting in opposite directions could provide specific situations from dynamic stability till destroying in physics and this model could be used in psychology and social science. It is possible to measure ambivalence of people and objects with which people interact. That is why easuring ambivalence is useful for operationalizing NDS studies. Ambivalence is characterized by estimates of intensity (from indifference through dialecticism to pathological ambivalence). Existing models for operationalizing ambivalence were analyzed. All of them realize functions from values of two opposite forces which could be attitudes, motives, affects, and so on. The new model was suggested, which was called parametrized to overcome deficiencies. The general idea of these models was to create a new variable (ambivalence) as function of two variables (two opposite strengths). Two different approaches for measuring ambivalence were suggested. In the first one (called functional) function of values of two opposite strengths is not a goal, but these two variables are independent in nonlinear function which determines results of this ambivalence. So we are interested not in ambivalence itself but in its effects and two strengths are two independent variables which generally determine the effect in a nonlinear way. The third approach called multidimensional allows

considering several pairs of opposite strengths at one time. Ambivalence occurs in many application areas (including clinical, political advertising, personality psychology). Some empirical examples in psychology will be provided.

Using Psychosemantic Approach for Analysis Motivational Dynamics of Movies' Characters (On the base of watching "Rory O"Shea Was Here")

Olga Mitina, **Alexandra Plotnikova,** *Lomonosov Moscow State University, Dept. of Psychology*

The method of revealing how and what general moviegoers perceived and realized during watching the move is presented. We analyze the perception of motivational dynamics which is mostly implicit. Direct questions are unproductive if the respondent is not a professional critic. To identify these underlying representations we use the psychosemantic technique of attribution of motives. The researcher makes a list of motivational constructs which pertain to the main characters and the most significant actions committed by them. Respondents are asked to rate the extent to which a particular motivational construct determines a particular action. Then, using the method of factor analysis the set of motives-variables can be reduced to a few motives-factors. Each act gets the factor scores in the factor space. This way it is possible to determine the extent to which the factor-motive determines this act. Based on the fact that all actions during the movie are performed in a considered (not by chance) order, it is possible to present the motivational dynamics which are implicitly contained in the movie. You can also highlight the actions of the opposite characters and see how the motivational dynamics of these antagonists correlate. We present an example of the analysis of the movie "Rory O"Shea Was Here". 90 participants took part in the research. The following motives-factors were identified: overcoming, altruism, conformity, inferiority. The correlations of dynamics of these motives among three characters will be presented. The characters interchange the motivational energy throughout the movie and the revealed dynamics help to visualize the movie's idea.

Size Doesn't Matter! Stability of Within-Person Variability in Work Motivation Over Different Time Series Lengths

Jose Navarro, **Ana Martvnez**, *University of Barcelona, Spain,***Teresa Rebelo**, *University of Coimbra, Po*rtugal

In recent years, research that considers the gathering of different temporal registers from the same participants has increased considerably in the organizational behavior field. The use of different temporal lengths in these studies can be observed and these studies always find a large amount of variability attributed at within-person level. One question that remains unsettled is whether the length of the time series is related to the variability found in these time series. With the aim of clarifying whether there is any threshold value in which the variability of time series becomes stable, we collect data of work motivation in 85 workers using experience sampling methods. The obtained series varied from 16 to 136 registers. As measures of variability in the time series we used the variance and the mean square successive differences. The results showed that within-participant variability in work motivation is unrelated with time series size (r variance-size = .08, $p > .05$; r mssd-size = .00, $p > .05$). These results are relevant for the field as they show us that with only 15-20 registers per participant we are able to capture all the variability existing in the work motivation dynamic with larger time series being unnecessary.

Predicting Clinical Transition Using Early-Warning Signals

Merlijn Olthof, **Marieke van Rooij**, **Anna Lichtwarck-Aschoff**, *Behavioral Science Institute, Radboud University, Nijmegen,* **Gunder Schiepek**, *Institute for Synergetics and Psychotherapy Research, Paracelsus Medical University, Austria*

Psychotherapy is an effective intervention for various psychopathologies. However, considerable individual differences in outcomes remain. To understand why, we need to focus on individual processes of clinical change. The present study aims to investigate change processes in clients with various psychopathologies, using synergetics as a framework for the study of change. Time series data of the therapeutic processes of these clients is available from the Synergetic Navigation System (SNS; Schiepek et al., 2016), an online monitoring system. Synergetics suggests that clinical transitions, such as sudden jumps in problem intensity during a psychotherapeutic process, can be understood as phase transitions from one attractor state to another. This leads to the hypothesis that clinical transitions can be predicted by early-warning signals (catastrophe flags) present in time series data of daily process evaluations. Predictive early-warning signals can enrich our understanding of individual differences

in psychotherapeutic success and the process of change throughout the course of treatment. Additionally, these new insights may be relevant for clinical practice as it informs clinicians about how to personalize treatment by specifying when intervention efforts might be most effective. The presentation will cover some first results as well as an discussion of theoretical and practical considerations regarding the topic.

Path Dependent Coordination of Expectations in Asset Pricing Experiments: A Behavioral Explanation

Nicolo Pecora, **Anna Agliari**, *Catholic University, Piacenza,* **Cars Hommes**, *University of Amsterdam*

In the learning-to-forecast laboratory experiments in Hommes et al. (2005), three different types of aggregate asset price behavior were observed: monotonic convergence to the stable fundamental steady state, dampened price oscillations, and permanent price fluctuations. We present a simple behavioral 2-type heuristics switching model explaining individual as well as aggregate behavior in the experiment. Based on relative performance, boundedly rational agents switch between a simple trend following and an anchor and adjustment heuristic that differ in how much weight is given to the long run average price level. The nonlinear switching model exhibits path dependence through co-existence of a locally stable fundamental steady state and a stable (quasi-)periodic orbit, created via a so-called Chenciner bifurcation. Depending on initial states, agents coordinate individual expectations either on a stable fundamental steady state path or on almost self-fulfilling persistent price fluctuations around the fundamental steady state. We illustrate these results by model simulations, and also rigorously establish path-dependence and co-existence of a locally stable fundamental steady state and stable periodic or quasi-periodic orbits by mathematical bifurcation analysis as a generic feature of our nonlinear behavioral switching model.

Timescales of Neural Codes in Cognitive Systems

Annemarie Peltzer-Karpf, *Cognitive Science Unit, English Department, Graz University*

This paper strives to integrate cognitive neuroscience and linguistics, triggered by a striking report by Pallier, Devauchelle & Dehaene (2011) on the first quantitative measure of the brain computing syntactic structures as opposed to mere word-lists. Topical is the hierarchical binding (merging) of single words to form larger phrases and sentences along with redefining Broca's area as a region with internal functional specializations. We report on the efforts taken to study this operation in isolation. The discussion is staged at the interfaces of two distinct systems: the conceptual intentional (semantic) system and the sensory motor (articulation, auditory or visual perception) system. Considering the many layered structure of language we need a neural coding scheme in which complementary information is represented in different frequency components or temporal scales of neural population activity. A central mechanism to consider is multiplexed processing which is staged along spatial scales in the visual and the auditory domain. The dynamic flow observed in current cognitive neuroscience provides a clearer view of multistability at the cost of having to get hold of turbulences, fluctuations and changing degrees of order and stability. Focusing on the temporal coding of superimposed connection patterns and multiplexing we have a workable key for the simultaneous handling of distinct frequency scales operating in the cortex and in language. In addition the chaotic itinerancy proposed by Kaneko and Tsuda (2003) can help to disentangle emerging cortical dynamics. We try to show how neural recordings and computational approaches begin to elucidate how interactions between local neural population activity and large-scale dynamics shape cognitive functions and verbal behavior.

Interpersonal Adaptation in Teacher-Student Interactions

Helena Pennings, *Educational Sciences, Utrecht University*

How real-time classroom interactions in 35 secondary education classes unfold in time was observed to study to which extent teacher and class behaviors in interaction interpersonally adapt to each other; to which extent do students follow the teacher's behavior? We used Sadler's joystick method to observe interpersonal teacher and student behavior, in terms of agency and communion (Sadler, Ethier, Gunn, Duong, & Woody, 2009) during the first 10 minutes of the lesson. We used spectral analysis to identify cyclical patterns in each individual teacher-class interaction. To determine the degree of synchronization between teacher and class behavior, we calculated coherence and phase (Warner, 1998). In the presentation, I will explain how each step of pre-

whitening the time-series data informs us on the quality of the interactions. I will compare the results of one teacher (Teacher-class A) with the overall results. The focus lies on linear trends, cross-correlations, detrending the data, the rhythmicity, coherence, phase, and residual fluctuations. For example, for Teacher-class A coherence values were .65 for communion and .78 for agency, indicating a considerable degree of synchronicity between interpersonal teacher and class behavior. Teacher-class A's phase values were -.01 for communion and .46 for agency. These values show that the teacher only slightly tends to follow the students in communal behavior and leads the students in agentic behavior. Further analysis of the coherence and phase values of the 35 teacher showed that differences in coherence and phase are related to the quality of the teacher interpersonal style.

The Dynamics of the Systems with Nonlinear Pairwise Interactions: Theoretical Background

Yuri Pykh, *Research Center for Interdisciplinary Environmental Cooperation of Russian Academy of Sciences*

In this study we combine the three universalisms – pairwise interactions concept, dynamical systems theory and relative entropy analysis – to develop a theory of entropy issues. We introduce two hypotheses concerning the structure and types properties of the system's entities interactions (including biological networks and social interactions models) and derive generalized replicator dynamic equations. Then we construct energy-like and entropy-like Lyapunov-Meyer functions (LMF) for these equations. We show that energy-like LMF contains no information about the equilibrium of the system and is a substantial generalization of the Fisher's fundamental theorem of natural selection. If there is nontrivial equilibrium point for generalized replicator system then we construct entropy-like LMF for this system and prove that it is a relative entropy function or the function of information divergence. We prove that negative relative entropy is a convex function for a probability space and receive new distance measure between two probability distributions. We also use Legendre-Donkin-Fenchel transformation for dual coordinates. As result we establish the set of next important links: nonlinear pairwise interaction -> generalized Fisher (replicator) equations -> Lyapunov-Meyer functions -> relative entropy -> distance measure -> LDF-transformation -> duality. In particular it follows from these links that nonlinear pairwise interaction is the origin of all known entropy functions.

A Cusp Catastrophe Model for Satisfaction, Conflict, and Conflict Handling Strategies in Teams

Teresa Rebelo, Paulo Renato Lourenço, *Faculty of Psychology and Education Sciences, University of Coimbra,* **Isabel Dimas,** *GOVCOPP, ESTGA, University of Aveiro,* **Margarida Pinheiro,** *Faculty of Psychology and Education Sciences, University of Coimbra*

Teams are now a structuring feature in organizations, and conflict, recognized as an inevitable phenomenon, has become an area of research interest. While literature shows contradictory results regarding the impact of conflict on teams, the strategies used to manage them have shown they can help to explain the differentiated effects of the conflict situations. Adopting a nonlinear dynamical system perspective, this research tests a cusp catastrophe model for explaining team members' satisfaction. In this model, the conflict type is the asymmetry variable and conflict handling strategies the bifurcation. The sample is made up of 44 project workgroups, and data were collected at two moments (project half-time and end). Using the dynamic difference equation modeling approach, the results suggest that the cusp model is superior to the pre/post linear model when the bifurcation variables are passive strategies (avoiding and obliging), whereas is not for active strategies (integrating and dominating). Thus, the findings show a tendency for a nonlinear effect of passive strategies on members' satisfaction. In this way, this study contributes to the small group research literature by presenting passive conflict handling strategies in a bifurcation role, which suggests that beyond a certain threshold of the use of avoiding or obliging strategies, teams might oscillate between two attractors, the modes of high and low members' satisfaction.

From Metaphor to Method: Chaotic Itinerancy and Creative Problem Solving

Diane Rosen, *State University of New York*

Despite extensive research on creative thinking, underlying processes remain little understood. By way of metaphorical understanding, however, aimless wandering has represented transformative creative dynamics across millennia and cultures: from ancient

Taoism, to Greek myths like Odysseus eponymous journey, to folktales of itinerant, boundary-crossing tricksters – all pluripotent, unpredictable agents of change. In complexity theory, this archetypal paradigm aligns effectively with chaotic itinerancy (CI), a class of transient motion in high-dimensional dynamical systems, where autonomously-excited trajectories produce regions of order and disorder (quasi-attractors), and emergent new order retains traces of destabilized origin attractors (attractor ruins). Freeman and Tsuda, among others, suggest that such correlated transitions may underlie generation of internal images, imagination, creativity, and problem solving in various fields. This paper draws on metaphorical itinerancy and chaotic itinerant dynamics to propose a method for enhanced creative problem solving across disciplines. First, wandering is briefly discussed as transformational trope. Creative thinking is then considered through the lens of CI, in particular: an expanded field of play for "I don't know," the intermediate phase during which transient ideas form and collapse prior to spontaneous emergence of a new structure/solution; and percolation of ideas based on instability, bifurcation, and self-organization. Finally, examples from my studio art practice illustrate a transitory dynamics-based approach to exploring idea fragments, perceptions, and memory in a chaotic deterministic manner, strategies intended to disrupt conventional meaning-maintenance and destabilize the familiar to render it strange. Figuratively and literally, dis-solving is seen as the key to solving creative problems.

Seeing Physiological Transitions in NeuroPhysics Therapy: Therapeutic Dynamics of Cascading Recursions and Hypothesized Relations to Epigenetic Change Mechanisms

Sara Nora Ross, *Neurotricional Sciences Education Pty. Ltd.; Saybrook University,* **Ken Ware,**
NeuroPhysics Therapy Institute & Research Centre

We continue the project to elaborate our hypothesis about the body's genius to self-organize its healing from many disorders and diseases when using NeuroPhysics Therapy. Cascades of macro-level fractal transition patterns in the body's kinetic motions during the mild-resistance exercise therapy are easily observed. Micro-level transition data align across concurrent bioelectrical time signals (EEG, ECG, EMG) and infrared thermography (IRT) during the therapy. From those data, we can take fractal neurophysiology as a given. IRT movies, shown during this presentation, bring concrete meaning to the abstract notion of cascading recursions. Such recursions are the dynamic vehicles of fractal physiology. We trace hypothesized recursions through J. G. Miller's map of decider subsystems and behavioral epigenetics' analyses of epigenomic modifications of chemical compounds. These are known to impact gene function, protein production, and human health, including autoimmune diseases. NeuroPhysics Therapy has been effective with various autoimmune and nervous system diseases and injuries. This application of cascading recursion analysis through macro and micro decider subsystem levels down to the epigenomic level deepens the hypothesis about the body's genius to self-organize its healing.

On Practical Consequences of the Nonlinear Dynamic Systems Approach: A New Technology for Process Feedback

Günter Schiepek, Benjamin Aas, Helmut Schoeller,
Research Institute of Synergetics and Psychotherapy Paracelsus Medical University, Salzburg

The practical consequences of complexity science / nonlinear dynamics and of common factors research in psychotherapy are far reaching. The role of interventions, treatment techniques, or manual adherence is weakened, whereas nonstationarity (e.g., sudden changes), unpredictability, and complex dynamics (e.g., chaos) has been corroborated. One consequence is a continuous high-frequency monitoring of change dynamics. By this, long-term prediction is replaced by an early-warning system of dynamic features (crises, critical instability, order transitions), and the focus on linear interventions (instructive interaction) is replaced by a continuous cooperative self-control (autocatalytic feedback). In this presentation, the functions of the internet-based Synergetic Navigation System (SNS) are shown. A case study is used to illustrate these features, e.g., the diagram assistant (nonlinear time series analysis, analysis of dynamic complexity, complexity resonance diagrams, recurrence plots, dynamic synchronization pattern analysis), user management, questionnaire editor, traffic light functions, and social interaction monitoring.

Possibilities of Interdisciplinary Analysis for Human Group Dynamics

Jesus Mario Serna, *University of Paris 7, Denis-Diderot, USPC, Center for Research in Psychoanalysis, Medicine and Society*, **Mark McCann**, *University of Glasgow, UK*, **Andrew Christian**, *NASA Langley Research Center, USA*, **Danilo Liuzzi,** *University of Milan, Milan, Italy*, **Gaetano Dato**, *University of Trieste, Italy*, **Justin Williams**, *University of North Texas, USA*, **Lorraine Sugar**, *University of Toronto, Department of Civil Engin*eering, **Sina Tafazoli,** *Princeton University, USA*

There are still considerable breaches between purely qualitative and quantitative approaches in many working models for group dynamics in psychology and social sciences. We argue that an interdisciplinary approach may help bridge these gaps towards more integrative models. We ran a discussion group based on the Operative Group Model (OGM), using a complex systems approach to reinterpret its dynamics, applying network theory and thematic discourse analysis (DA). Finally, we consider the potential advantages of performing an acoustic analysis on the audio recordings from the group sessions. To our knowledge, this integrative approach has never been applied in the context of an OGM. In this study we provide two main levels of analysis: the participants' personal and group experience, and the experimentation and analysis methods aspect. For the former, we gather data from group theory in psychology, psychoanalysis, the OGM, and the participants' feedback. We then use DA and a bipartite graph identifying weighted thematic nodes as a research framework. Finally we explore possible ways to incorporate an acoustic analysis, notably implementing a Hidden Markov Model (HMM). The goal is to identify appropriate interdisciplinary models to analyze human group dynamics with both quantitative and qualitative methods. We present some preliminary results from overlapping data that might pinpoint movements towards group cohesion. We then discuss further considerations on the analysis framework and future applications. Finally we consider the advantages of implementing the OGM to foster meaningful interdisciplinary dialogue in research groups, notably to overcome communication difficulties between researchers and enhance collaboration.

Nonlinear Dynamical Interaction Patterns in a Discourse Analysis: Shedding Light into the Black Box

Dimitrios Stamovlasis, *Aristotle University of Thessaloniki*

Focusing on some ontological aspects of group functioning one may recognize that the dynamics are more than a metaphor and acknowledge that a different from the traditional methodological framework is needed for a more profound investigation. Interactions among participants in a collaborative setting give rise to an outcome that is not explicably understood as resulting merely from the individual actions, because it emerges from a complex dynamical process and it can be understood only in an evolutionary context (Stamovlasis, 2016). This paper presents and exemplifies the application of nonlinear dynamics and complexity framework to the study of learning-in-groups studies focusing on science education. A discourse analysis is carried out by orbital decomposition analysis (ODA), a method designed for data that comprise categorical time series. Fundamental concepts, such as entropy, self-organization and inverse power law distribution are used to explicate the dynamical characteristics along with the implementation of measures, such as Shannon entropy, topological entropy, dimensionality, and Lyapunov exponent. The experimental setting was designed for the participants to be free to interact without a predetermined scenario, thus contributing to a brain-storming process, which was found to possess dynamical characteristics. The dynamical process was depicted on the above-mentioned indices and on a cusp catastrophe structure revealed in a pre-post analysis encounter for learning outcomes as a function of some individual differences. The nonlinear analysis sheds light into an educational process, which thus far has been treated as a black box. It demonstrates how NDS changes our view on methodological and epistemological issues in learning science research. Implications for educational theory and practice are also discussed.

Dispositional Dynamical Systems: Theory, Modeling and Implications for Research

William Sulis, *McMaster University, Ontario*

In psychology and psychiatry one is faced with complex systems whose dynamics are often driven by contextual factors. These factors manifest over multiple spatial and temporal scales. In some cases, context is mediated through chemical agents

neurotransmitters, neuropeptides, hormones, neuroimmunohumoral factors, pheromones, and the like. The presence of these chemical agents induces changes in the parameters governing the dynamics of the system, thus altering the functionality expressed by the system. For example, in the lobster stomatogastric ganglion, hormonal factors change the firing patterns of different neurons in the ganglion. In social insect such as ants, the presence of pheromones may shift the large scale task behaviour of an ant, for example from nest worker to forager or warrior. Such systems are termed dispositional dynamical systems. Unlike parametric control theory, dispositional control aims to steer a system towards manifesting different salient functionality relevant to particular contexts. These context dependent or dispositional systems pose serious problems for researchers attempting to study them using common- place linear correlational, statistical, or time series methods. To explore these situations further, a simple model involving two dispositionally coupled logistic maps is studied. The model is studied through its time series and analytically through a study of its attractor basin structure.

Transient Induced Global Response Synchronization: Dispositional Cellular Automata

William Sulis, *McMaster University, Ontario*

Synchronization has a long history in physics where it refers to the phase locking of identical oscillators. This notion has been applied in biology to such widely varying phenomena as the flashing of fireflies and the binding problem in the brain. The relationship between neural activity and the behaviour of the organism is complex and still poorly understood. There have been attempts to explain this using the notion of synchronization, but the participating neurons are fungible, their activity transient and stochastic, and their dynamics highly variable. In spite of this, the behaviour of the organism may be quite robust. The phenomenon of transient induced global response synchronization (TIGoRS) has been used to explain the emergence of stable responses at the global level in spite of marked variability at the local level. TIGoRS is present when an external stimulus to a complex system causes the system's responses to cluster closely in state space. In some models a 10% input sample can result in a concordance of outputs of more than 90%. This occurs even though the underlying system dynamics is time varying and inhomogeneous across the system. Previous work has shown that TIGoRS is a ubiquitous phenomenon among complex systems. The ability of complex systems exhibiting TIGoRS to stably parse environmental transients into salient units to which they stably respond led to the notion of Sulis machines which emergently generate a primitive linguistic structure through their dynamics. This paper reviews the notion of TIGoRS and its expression in several complex systems models including driven cellular automata, cocktail party and dispositional cellular automata.

Cyber-Systemic Approaches from a Viewpoint of Clinical Psychology Transdisciplinary Perspectives

Felix Tretter, *Bertalanffy Center for the Study of Systems Science, Vienna*

In German psychology, in the 1980s, Norbert Bischof used circuits and simple algorithms for modelling the Oedipus conflict. In addition, Dietrich Doerner presented an AI model of the mind. In this context, Günter Schiepek and colleagues, connected to systemic family therapy, triggered systemic clinical psychology (Schiepek et al. 1992). At that time, only qualitative modelling with boxes and arrows and semi-quantitative simulations was possible (idiographic modelling). Later, by using real time monitoring Schiepek could apply tools for analysis of complex data sets in the context of mathematical theories of nonlinear systems (TNLS). However, still there are conceptual gaps between TNLS, practice and intradisciplinary theories of clinical sciences of the mind (CSM; clinical psychology, psychiatry, psychosomatics). Here it is assumed that Hermann Haken's theory of Synergetics with concepts like order parameter and control parameter that already is adapted to some clinical theoretical frameworks (e.g. cognitive behaviour therapy) by Günter Schiepek, Wolfgang Tschacher and others, can provide a connecting conceptual framework that bridges from systems science to neuroscience (Tretter et al. 2010; Systems Neuropsychiatry), psychoanalysis, theoretical psychopathology (Werner Janzarik's structure dynamics), new phenomenology (referring to Kurt Lewin's field theoretical ecological psychology) and late computational psychology/ psychiatry. The presentation will show inter- and transdisciplinary correspondence of central constructs that might be essential for integrative theories in CSM (Kotchoubey et al. 2016; Integrative Methodology). Examples from addiction disorders are used (An der Heiden et al. 1998).

Contingencies in Operators of Diagonal Evolution

Irina Trofimova, *McMaster University, Ontario*

The phenomena of vertical and horizontal emergence are analysed in terms of their contingent interactions resulting in diagonal evolution. The concept of the zone of proximate development and an application to iterative map techniques are discussed. These theoretical components use 12 operators that could be linked to functionality of elements composing complex systems. These operators act in at least three different directions of evolution making a division into levels of organization rather conditional. The presentation attempts to describe the contingencies of relationships between operators of diagonal evolution using recently developed formal notations.

Dynamic Causal Modeling: A Non-Linear Approach on Modeling Brain Connectivity

Kathrin Viol, *LMU Munich, Germany*, **Günter Schiepek**, *Paracelsus Medical University, Austria*

Dynamic Causal Modeling (DCM) has become a popular method to analyze connectivity between brain regions, mainly due to its easy-to-use implementation in the software SPM. This presentation aims to explain the non-linear approach used in these models and will illustrate its application on fMRI data from a study of the psychotherapy process. Brain function depends on interactions among specialized brain regions. These regions are connected and allow for neuronal information processing by forming distributed and recurrent networks (integration/connectivity). Changes in connectivity are important for development, learning, perception and adaptive response thus all the components for successful psychotherapy. Dynamic Causal Modeling is one of the few approaches in modeling connectivity that accounts for its dynamic and non-linear nature. Since states of the brain evolve continuously in time, the dynamic nature seems obvious, but is still neglected in other models (e.g., SEM). Moreover, the brain depends on non-linear phenomena for much of its characteristic behavior. DCM is the only (widely used) model to respect this non-linear character and is able to reproduce the complex behaviour observed. DCMs are designed as classical input-state-output-systems, with perturbations of the input allowing to estimate parameters for the connectivity. This approach does not treat the brain as a black box but constructs a neuronal model of interacting regions or nodes, i.e. treats the brain as a deterministic non-linear dynamic system. The strength of the approach is demonstrated on fMRI data from a study of the psychotherapy process. Patients were scanned three times during inpatient therapy. With DCM, we show that psychotherapy was able to change the strengths of connectivity between brain regions compared to controls.

Emotional-Cognitive Regulation and Critical Instabilities of Affective Experiencing and Cognitive Mastery in Psychotherapy Diaries: Preliminary Results

Catalin Zaharia, *Sigmund Freud University*, **Omar C.G. Gelo**, *University of Salento, Sigmund Freud University*, **Erhard Mergenthaler**, *University of Ulm*, **Günter Schiepek**, *Institute of Synergetics and Psychotherapy Research, Paracelsus Medical University, University klinikum/Christian Doppler Klinik*

According to a dynamic systems (DS) approach to psychotherapy (Gelo & Salvatore, 2016), the disorganization of the therapeutic process is a necessary though not sufficient condition for clinical change to take place. In the present paper we focus on client's *affective experiencing and cognitive mastery*, whose combination produces different patterns of emotional-cognitive regulation (Mergenthaler, 1996, 2008). Aim of this preliminary study is to see to what extent affective experiencing and cognitive mastery might show different degrees of critical instability in different patterns of emotional-cognitive regulation. Participants were N = 30 clients with heterogeneous diagnoses treated in an inpatient psychotherapeutic setting. Clients wrote daily diaries about their daily life including the treatment. A computerized-text analysis was run on the diaries in order to assess (a) affective experiencing and cognitive mastery (operationalized respectively as emotional tone [ET] and abstraction [AB]) and patterns of emotional-cognitive regulation (operationalized as emotional-abstraction patterns [EAPs]). Critical instability was operationalized as dynamic complexity over time, which was then calculated for ET and AB. We expect that the dynamic complexity of both ET and AB will be higher in the EAP characterized by high ET and AB compared to the other EPAs. Results will be discussed with regard of psychotherapy practice and research.

Symposia and Panel Discussion

Symposium I

Discussant: *Valery Galkin*

The Analog of Heisenberg Uncertainty Principle in Biology and Psychology for Description of Complex Homeostatic Systems

Eskov V.M., *Surgut State Universit,* **Eskov V.V.,** *Surgut State University,* **Vochmina U.V.,** *Samara State University***, Filatova D.Y.** *Surgut State University*

It was experimentally shown in that the state vector x = x(t) = (x1, x2, , xm) of a complex biological system exhibits specific dynamics in the phase space of states R_m ($1 \le m \le \infty$), which is usually not stable in terms of the statistical distribution function. Similar results were obtained in the theory of deterministic chaos. Typical examples of a system s state vector are records of R-R intervals, tremor, tapping, myograms, EEG, etc. Experiments show that the description of complex biological systems by deterministic or statistical models faces difficulties. The instability is explained by the lack of steady modes; moreover, distribution functions and other statistical characteristics of samples describing the dynamics of biological systems are essentially not replicable. A description of complex biological systems based on simulation the dynamics of chaotic systems is proposed. For homeostatic biosystem, we define the concept of a quasi-attractor, inside which the state vector moves chaotically. Methods for quantitative description of the chaotic dynamics of complex systems are proposed. The quasi-attractor is the intersection, in the given m-dimensional space of all parallelepipeds Q, of all realizations of a random variable χ

What Does It Mean: Voluntary or Involuntary Movements

Zimin M. I., Zinchenco U. P., *Moscow State University,* **Khadarzev A. A.,** *Tula State University,* **Filatov M. A.**, *Surgut State University*

Last year, 2016, was 120 years since the birth of N.A. Bernstein. And now in 2017 we celebrate the 100th birthday of I.R. Prigogine. To the present time Bernsteinian hypotheses of "repetition without repetition" has not been studied. Quantitative description of these experimental results is now performed on the basis of construction of matrices of pairwise comparisons of samples, under conditions of multiple repetitions of a motion. The quantitative results show differences between voluntary (tapping) and involuntary (postural tremor) movements. It is proven that from the standpoint of chaotic assessment there aren't significant differences between these movements. New methods were presented for calculating human psychophysiological parameters. The new concept of Eskov-Zinchenko effect was presented, which demonstrates the chaotic kaleidoscope of statistical distribution functions f(x) of the obtained samples, the spectral densities of signals and their autocorrelation A(t). The role of consciousness is being discussed in organizing various types of movement. It is proven that the alleged involuntary movements (tremor) and voluntary movements (tapping) differ little from each other. From the standpoint of the stochastic, these two types of motion are chaotic in fact, because of statistical distribution function f(x) changes randomly. The new theory of chaos-self-organization suggests methods of calculation of matrices of pairwise comparisons of samples that provide a clear distinction between tremor and tapping, i.e., between spontaneous and voluntary movements. Voluntariness itself, i.e., increasing the role of consciousness in movements, is performed by increase in percentage of stochastics to compare consecutive samples of tremorogramm and tappingramm subjects. It represents quantitatively the effect Eskov-Zinchenko in evaluation not only of movement, but also in implementation of regulation of various functional systems that provide homeostasis.

Symposium II

Discussant: Valery M. Eskov

N.A. Bernstein Hypothesis and Eskov-Zinchenko Effect in the Description of Chaotic Dynamics of Homeostatic Biosystems (Complexity)

Olga Filatova, *Surgut State University,* **Zimin M. I.,** *Moscow State University,* **Bazhenova A.E., & Poskina T. Y.**, *Surgut State University*

The registration of tremor was performed in two groups of subjects (15 women in each group) with different physical fitness at rest and at a static load of 300 g. Each subject has been tested 15 times (number

of series N=15) in both states (with physical loads and without) and each series contained 15 samples (n=15) of tremorogramm measurements (500 elements in each sample, registered coordinates x1(t) of the finger position relative to eddy current sensor) of the finger. Using non-parametric Wilcoxon test of each series of experiment a pairwise comparison was made forming 15 tables in which the results of calculation of pairwise comparison matrix (15x15) for tremorogramms are presented. In this case, tremorogramms showed the global statistical instability of the samples (their statistical distribution functions f(x)) as in state of rest and under physical load. The samples obtained in one experiment cannot be arbitrarily repeated in the next experiment (similar to homeostasis). This represents a quantitative measure of Eskov-Zinchenko effect in the analysis of randomly varying statistical distribution functions of samples of tremorogramms. The average number of hits random pairs of samples (<k>) and standard deviation σ were calculated for all 15 matrices without load and under the impact of physical load (300 g), which showed an increase almost in twice in the number k of pairs of matching samples of tremorogramms at conditions of a static load. It was revealed changes in number k of matches for arbitrary pairs of samples in a resting state: non athletes 2,93 and athletes 2,13.

Evolution of Homeostasis as Aging Dynamics of Cardio-Vascular System Parameters

Olga Filatova, **Diana Filatova**, **Julia Bashkatova**, & **Grigorenko, V.V**., *Surgut State University*

The problems of homeostasis interpretation are presented in connection with the theory of chaos-self organization. The chaotic behavior of stochastic functional cardio intervals examples when the parameters of quasiattractors of cardio-vascular systems decrease with aging increasing. The aging evolution of biological systems is studied as example of changing the cardio-vascular parameters and values of the quasi-attractors and Shannon entropy of female and male of three age groups of indigenous and alien population of Ugra. Parameters xi of the cardio-vascular system of the three age groups of ranged limiting volume VG of the phase space of states, which are defined as quasi-attractor. According to the Native Women's aborigines quasi-attractor parameters the population of Ugra build models Ferhlyust-Pearl. A woman and man who is not aborigines changes its parameters of quasi-attractors as a parabolic relationship with a minimum average age. Now we present a real evolution of biosystems (transition from one stable state to another). We present common criteria for estimation of pathological or normal state of human body. Numerical examples of such evolution are also presented.

The Homeostasis and Evolution of Complex Biosystems and Thermodynamics of Non-Equilibrium Systems of I.R. Prigogine

Valey, M. Eskov and Valery V. Eskov, *Surgut State University, Russia*

Now we celebrate 100th anniversary birthday of I.R. Prigogine (25th January 2017), who left a lot of fundamental issues to address in modern biology, medicine, ecology, and psychology. These issues are reduced to the new understanding of homeostasis and evolution of complex living systems. The laws of thermodynamics cannot be applied to living homeostatic systems at the system level of organization, although it works on a molecular level. At the same time we cannot use the laws of thermodynamics of non-equilibrium systems. For homeostatic (living) systems, the theorem of Glansdorff-Prigogine about the minimum gain of the entropy P = dE/dt in the area (neighborhood) where the entropy of E is maximum (equilibrium points) does not apply. Moreover, in the borders of thermodynamics doesn't apply the concept of equilibrium to biomedical systems. Any parameters xi homeostasis system (third type systems complexity) demonstrate the absence of stationary regimes (dx/dt=0) and the absence of statistical stability of static distribution functions obtained in a row (in the general homeostasis) samples of xi. In the transition from one homeostasis (functional status) to another, the values of the Shannon entropy of E may be different. At the same time, biosystems affect energy and actually changing their own functional status. Shannon entropy is a weak marker of homeostasis for electroecephalograms and electromyograms. Therefore, it is not repeated motions, such as tremor. There is effect of Eskov-Zinchenko, when all the statistical functions are continually changing, and the parameters of quasi-attractors (in one homeostasis) remain unchanged. Physics of living (homeostatic) systems has another law of behavior of the state vector x (t) in the FSS.

Symposium III

Modeling Psychotherapy as a Nonlinear Dynamic System

Helmut Johannes Schoeller, **Kathrin Viol**, **Günter Schiepek**, *Institute of Synergetics and Psychotherapy Research, Paracelsus Medical University, Salzburg, Austria*

Background and Aims: The conceptual interpretation of psychotherapeutic process and outcome as manifestation of nonlinear complex system-dynamics can be denoted as meta-model for the synergetic investigation of psychotherapy. This novel perspective provides a basis for recent research and guided a number of investigations in the past. Its influence is growing, because firstly its theoretical foundations can elucidate central characteristics of human change processes. Secondly time-series of central state-factors, gained from psychotherapeutic processes using the Synergetic Navigation System (SNS) for psychotherapy-monitoring make the case for the applicability of the meta-model. As an important ingredient to clarify questions arising from the meta-model we made a stab at constructing a mathematical model, trying to simulate the psychotherapeutic process. The target of our work is aimed firstly to proof the fundamental applicability of the meta-model by using methods of complexity sciences. In the case of positive findings it will be possible to secondly compare its emergent dynamics for explanation and interpretation of observed clinical processes. Framework and Methods: Starting from central psychological and psychotherapeutic expertise about the client-therapist-system, common factors and other topics a nonlinear dynamic system model with variables inherent functional interdependencies was constructed. The model integrates five variables (intensity of emotions, problem intensity, motivation to change, insight and new perspectives, therapeutic success) into a set of five coupled nonlinear difference equations. Variables act as order-parameters and serve as surrogates for psychological states of the client, corresponding to a subset of factors (subscales) of the so-called Therapy Process Questionnaire (TPQ), which is used in the daily-routine-practice of psychotherapy monitoring. Considering that human functional behavior is modulated by personal traits and social factors, four appropriate control-parameters (working alliance and quality of the therapeutic relationship, cognitive competencies for mentalization and emotion regulation, behavioral resources and skills for problem-solving, and motivation to change/self-efficacy) were created, which are integral and modulating part of the models nonlinear equations. One of it (working alliance) does correspond to a factor of the TPQ too. The model was implemented as a set of VBA-Scripts in Microsoft-Excel 7.0, routines and results were tested against an implementation in Matlab (R2016a Ver. 9.0.0.341360, 64 Bit). Additional Functions to simulate drifts of control-parameters, to apply varying intensities of dynamical- and measurement-noise, to simulate punctuate interventions were implemented. Most recently we created a tool for the simulation of reverse (state-based) trait-dynamics, modeling the feedback of changing states on the magnitude of personal and social traits, which in turn influences the model-variables functional characteristics. Single simulation-runs do result in a set of five time-series, reflecting the virtual dynamics of the variables and four additional series, corresponding to changes of the control-parameters. The display of the time-series was supplemented by additional functions for phase-space-embedding (producing and visualizing attractors) and the generation of bifurcation-diagrams. Results: Using our model we could demonstrate, that its representation of a general psychotherapy system is capable to generate plausible time series for the dynamical variables and features. The overall trends in the mean values of the variables E, P, M, I, and S in relation to drifting control-parameters is plausible from the psychological point of view. The analysis shows, that shaping architecture and models functional characteristics on the microscopic level by some detailed psychological knowledge, does result in complex behavior on the macroscopic level, which correspond to time-series of real psychotherapy. The model creates phase transition-like phenomena, bi- or multi-stability under the influence of noise or interventions. It is sensitive to initial conditions and small aberrations by fluctuations or external input (butterfly effect) and shows sensibility of the dynamic patterns on parameter drift. The model produces multiple types of dynamics, as fixed-point-behavior and simple or more complex cyclical patterns. Near transitions-points the model emerges characteristic slowdown. But most important, the system is able to create chaotic dynamics! Specifically simulations comprising drifting control-parameters revealed an important quality of nonlinear systems dynamic concerning the recovery of the actual system-state after disturbance. While in computational reality the system has time to re-stabilize, in reality disturbances may and do occur on every time step. This lack of recovery due to consecutive adaption makes a distinct difference resulting in chaos-like dynamics. Most of these features are predicted by both chaos theory and synergetics and correspond to empirical findings.

Conclusions and Implications: The model contributes to the development of an integrative conceptualization of psychotherapy. It refers to the knowledge on common factors and other psychological topics like motivation, emotion regulation, and cognitive processing. In the field, chaotic system behavior demands technologies of real-time monitoring reporting on the nonlinear features of the ongoing process (e.g., its stability or instability) and a client-centered continuous cooperative process control. Furthermore, restricted predictability and spontaneous changes challenge the usefulness of manuals or other predefined programs. Detailed results of the models simulations raise new questions and issues for further research. In particular the relationship between functional behavior on the one hand and noise, random interventions and changing parameters on the other hand has to be investigated. In addition the strategy to prove the validity of the meta-models central assumption, that psychotherapeutic process and outcome can be interpreted as manifestation of nonlinear complex system-dynamics, has to be supplemented by further quantitative research. Real time-series and their characteristics have to be transferred into both, an appropriate architecture and an entire functionality comprising accurate parameterization of the synergetic model of psychotherapy.

Symposium IV

Turning Points: Biopsychosocial Pattern Formation and Pattern Breaking in Psychotherapeutic Processes

David Pincus, *Psychology, Chapman University,* **Omar CG Gello**, *University of Salento, Italy, Sigmund Freud University, Austria,* **Giulio de Felice**, *Sapienza University of Rome and Italian University of London,* **Günter Schiepek,** *Research Institute of Synergetics and Psychotherapy Paracelsus Medical University,* **Gloria Lagetto**, *University of Salento, Italy;* **Franco F.Orsucci**, *University College of London and Italian University of London,* **Marcello Gallucci**, *University of Milano-Bicocca, Italy,* **Alessandro Giuliani**, *Italian National Institute of Health, Rome;* **Enrico Ciavolino**, *University of Salento, Italy*

Discussant: **Günter Schiepek,** *Research Institute of Synergetics and Psychotherapy, Paracelsus Medical University Salzburg, Austria*

Verbal Pattern Formation and Treatment Outcome in Psychotherapy: A Preliminary Study

Omar CG Gello, *University of Salento, Italy, Sigmund Freud University, Austria,* **Gloria Lagetto**, *University of Salento, Italy,* **Fiorella Leopizzi**, *University of Salento, Italy,* **Marcello Gallucci**, *University of Milano-Bicocca, Italy,* **Enrico Ciavolino**, *University of Salento, Italy*

According to a dynamic systems approach to psychotherapy, the therapeutic process: (a) is characterized by self-organization, that is, it shows an increase of order over time. This latter is mediated by pattern formation over time (pattern formation hypothesis); (b) existing patterns must be disrupted in order for new patterns to emerge (transformative pattern formation hypothesis) (Gelo & Salvatore, 2016). In the present study, we investigate pattern formation at a verbal level taking place in the discourse between client and therapist. We expect that verbal pattern formation (VPF): (1) will present a stronger overall linear increase in good outcome cases than in poor outcome ones (pattern formation hypothesis); (2) VPF will present a quadratic (i.e., U-shaped) time course in good outcome cases, while it will not in poor outcome ones. The sample was comprised by respectively six good outcome and six poor outcome cases of experiential therapy for depression. Speech production was assessed by means of the Therapeutic Cycle Model (Mergenthaler, 1996). VPF was operationalized by means of a measure of order derived from information theory (Shannon & Weaver, 1949). It was possible to partially confirm both hypotheses. The findings, implications for research and clinical practice are discussed.

A Markovian Formalization of Physiological Variables in Psychodynamic Psychotherapy Evinces A Quantum-Like Structure

Giulio de Felice, *Sapienza University of Rome and Italian University of London,* **Franco F. Orsucci**, *University College of London and Italian University of London,* **Alessandro Giuliani**, *Italian National Institute of Health, Rome*

Aim: we investigated the evolution of galvanic skin response and heart rate variability pertaining to therapist and patient in a brief psychodynamic psychotherapy (i.e. 16 sessions). The main aim of the study is to explore (if any) the turning points (i.e. phase transitions) that lead to a good psycho-therapeutic outcome. Furthermore, the authors will explore the connection between the mentioned physiological variables and the clinical narratives occurring in those specific stages of the

psychotherapeutic process. Method: we recorded the galvanic skin response, heart rate variability and the clinical narratives of therapist and patient in 16 sessions of a brief psychodynamic psychotherapy. Each session was then transcribed (i.e. clinical narratives) and sampled at 2hz (i.e. physiological variables). We studied the evolution of physiological variables by means of the principal component analysis, the symbolic dynamic (i.e. k-means clustering) and two additional measures: the correlation structure persistence and the correlation structure variability. We then compared the results with the clinical narratives. Results: The principal component analysis showed three main components: the first describing the relationship between patient and therapist, the second describing the patient independent behavior, the third describing the therapist independent Behaviour. From the symbolic dynamic emerged a non-ergodic networks in which the nervous central system acts as an external control over the transitions between different states. The correlation structure persistence and variability demonstrate two different turning points in the psychotherapeutic process, the first in session 8 and the second in session 15. Conclusions: the study represents a substantial progress in the psychotherapy research literature. It shows the evolution of physiological variables in a brief psychodynamic psychotherapy showing for the first time in our scientific domain their quantum-like trend at the relationship level (i.e., first component). In other words it demonstrates the presence of a resonating physiological dynamic between patient and therapist. Finally, the two turning points elicited from the correlation structure correspond to fundamental switches in the clinical narratives concerning the main patient anxieties.

Discontinuous Patterns of Brain Activation During Psychotherapy

Schiepek, **Viol**, **Schoeller**, **Aas, Kronbichler**, **Kastinger**, *Research Institute of Synergetics and Psychotherapy Paracelsus Medical University*

Strongly connected and synchronized to the mental level, self-organization should also take place at the brain level. In a study with patients suffering from obsessive-compulsive disorder (OCD), repeated fMRI scans were realized during a period of inpatient psychotherapy (2-4 months). The stimulation paradigm used neutral, disgusting, and individually recorded OCD-symptom-provoking pictures to test the changing activation of OCD-relevant brain networks. Considerably larger neural changes in OCD-related brain areas (cingulate cortex/supplementary motor cortex, bilateral dorsolateral prefrontal cortex, bilateral insula, bilateral parietal cortex, cuneus) were observed during critical phases (critical instabilities and pattern transitions) than during non-critical phases of the psychotherapy or compared to the interscan-intervals of healthy controls. An actual study extended the paradigm concerning the number of fMRI scans during hospital stay and by including a resting state period of 10 minutes at each fMRI scan. Changes in the effective connectivity of neural networks were analyzed by the hypothesis-driven method of Dynamic Causal Modeling. The analysis of functional connectivity patterns and their changes refers to a full brain model of 66 cortical and subcortical structures (structural connectivity data from Diffusion Tensor Imaging, DTI) and cross-correlates all functional connectivity (FC[t]) matrices produced by a running window over each resting state period. By this method of Functional Connectivity Dynamics matrizes, the non-stationarity of brain dynamics (pattern transitions) is reflected within each resting state, and at another time scale also between resting states realized in the fMRI scans during the course of the therapies.

Systemic Binds: The Key Concept for Integrative Psychotherapy

David Pincus, *Department of Psychology, Crean College of Health and Behavioral Sciences, Chapman University, USA*

Double binds are situations in which a person is trapped by a conflicting message, where the act of conforming to some interpersonal demand becomes self-negating. For example, the statement: Well, I still love you! during a heated conflict is potentially binding in that: (a) if it is accepted then it opens the door to the possibility that this ongoing love is in jeopardy; (b) if it is rejected then one is forced to escalate the conflict. This type of, damned if you do, damned if you don t social dilemma served as a key organizing concept for the early systemic psycho-therapies from the 1960 s and 70 s. However, along with these early systems approaches, the concept has faded from influence in mainstream contemporary psychotherapies. Basic research demonstrating the complex and interactive nature of self and interper-sonal experience may extend the notion of binds beyond the interpersonal context, to the additional experiential channels of: cognition, emotion, behavior, and self-relations. This broader understanding of binds may then be used to identify a common etiology underlying the various forms of neurotic psychopath-ology. Binds may also be used as a common strategic target across the vast array of contemporary

psychotherapeutic approaches, including cognitive-behavioral, emotion-focused, and psychodynamic.

Panel Discussion

Nonlinear Dynamical Systems and Psychotherapy: Scientific and Practical Concerns

David Pincus, *Dept. of Psychology, Chapman University*, **Günter Schiepek,** *Research Institute of Synergetics and Psychotherapy Paracelsus Medical University*, **Omar CG Gello**, *University of Salento, Italy, Sigmund Freud University, Austria,* **Giulio de Felice**, *Sapienza University of Rome and Italian, University of London*

Traditional psychotherapy research has been grounded in the medical or disease models, which are based in the scientific philosophies of elementism, linearity, and reductionism. As such, psychotherapy research since the 1950 s has been focused on using: clinical trials, linear statistics, and simple pre-post designs. As a result, psychotherapy has become one of the best supported and most investigated procedures in all of modern medicine, and at the same time one of the most mysterious. Indeed, the consensus among experts in psychotherapy research are that: (1) Approach makes little contribution to outcomes, and all approaches are more or less equivalent (i.e., the Do-Do effect); (2) No single factor makes a large and substantial contribution to outcomes (i.e., greater than 30% of the variance); and (3) Less is often more, with levels of training, experience, numbers, frequency and length of sessions having little to no consistent impact on patient outcomes. Of great scientific and also practical concern, the linear-reductionistic paradigm has driven the process of overwhelming proliferation of different approaches to psychotherapy, well over 400 and growing. The topic to be explored within this discussion will be the benefits and challenges to using a nonlinear dynamical systems (NDS) paradigm to better inform the science and practice of psychotherapy. The NDS paradigm is inherently interactive, nonlinear, and holistic, allowing for investigators to examine the mechanisms of psychotherapeutic change without the ill-fitting assumption that a single, uni-directional and proportional cause occurs at a single point in time. Each of the panelists has spent their scientific careers in pioneering approaches to understanding the self-organizing processes underlying how psychotherapy works. Günter Scheipek, for example, has carried out many dozens of studies over the course of nearly four decades using synergetic models to demonstrate that critical transitions in neurological and experiential processes predict better psychotherapeutic outcomes. Among a wide array of theoretical and empirical developments, Omar CG Gelo has developed and tested sophisticated approaches to measure the construction of meaning within psychotherapy sessions, using automated approaches to content analysis and a variety of network-Markovian models that are capable of measuring changes to semantic flow across therapy sessions. Giulio de Felice has done similar work, as well as making contributions to understanding the role of therapist-patient sync phenomena, and the role of critical shifts in arousal levels within and across sessions. Finally, David Pincus has contributed to basic research aimed at measuring fractal patterns that may underlie biopsychosocial resilience, as well as applied work aimed at translating NDS research results for use in practice.

The panel will be exploring topics around the following questions:

1) Which are the main empirical results regarding a dynamic systems (DS) approach to psychotherapy?
2) Which are the main methodological challenges?
3) Why nonlinear dynamical systems? What may be gained over and above traditional approaches to psychotherapy research?
4) What are the most important empirical results that may be immediately useful to psychotherapists?
5) What are the most important theoretical concepts for researchers and psychotherapists to consider in moving the field forward?

POSTERS

Irreversibility and Intentional Characteristics of Tracked Data From Self Assessments

Alexandru Caragea, Catalin Zaharia,, *Center for Complexity Studies, Bucharest, Romania*

The internet-based technology offers new ways to gather and use self-assessment information regarding the evolution of state descriptors relevant for clinical or developmental research. But self-assessment processes imply the intervention of feedback and feedforward components and nonlinear coupling factors to the history of the measured/described states. These ask for considering such aspects of “the lived history” (as irreversibility and desirability) into psychological and psychiatric research aimed to

develop “early warning systems” for phase transitions in human self-organization processes. In our paper, we focus on applying this conception to discuss the case of self-assessments made by clients in ongoing therapeutic or development processes. The measures to identify nonstationary phenomena and critical instabilities in short and coarse-grained time series. Those phenomena were proposed by Gunter Schiepek and Guido Strunk in their paper: The identification of the main fluctuations and phase transitions in a nutshell term and coarse-grained time series a method for the real-time monitoring of human change process.

Anxiety and the Enhanced Complexity of Adolescent Boys' Everyday Life Heart Rate

Aina Fiol-Veny, Alejandro De la Torre-Luque. Maria Balle, Xavier Bornas, *University of the Balearic Islands, Spain*

Rationale: Women show greater vagal activity compared to men. If reduced vagal activity is associated with anxiety disorders (AD), why women have consistently higher prevalence rates of AD? As adolescence embraces the age of onset of many AD, this study aimed at analyzing the vagal activity of adolescent boys and girls (with high or low anxiety) to test the hypothesis that, at that age, girls show lower vagal activity compared to boys, and therefore girls could be more vulnerable to the development of AD. Methods: Four groups were set up according to gender and anxiety symptomatology: high-anxious girls (n = 24) and boys (n = 25), and low-anxious girls (n = 22) and boys (n = 24). Their cardiac functioning was recorded while they performed regular school activities. In addition to time- and frequency-domain measures, long-term scaling exponents and entropy were calculated. A series of two-way (gender and anxiety) MANOVAs were performed. Results: No interaction effects between gender and anxiety were obtained, but between subjects effects were observed for each factor independently. Highly anxious participants had more reduced vagal activity than the low-anxious group. Regarding gender, boys showed greater vagal activity, higher long-term scaling exponents, and more entropy than girls. Discussion: The results support the hypothesis that the heart rate of adolescent boys, irrespective of their anxiety level, show greater vagal activity and complexity than the heart rate of their female counterparts. Adolescent girls, therefore, could be more physiologically vulnerable to the development of AD.

Nonlinear changes in Cardiovascular and Psychomotor Systems while Performing Fitts Tapping Tasks

Matilda Nikolic, **Ana Prorokovic, Andrea Tokic**, *University of Zadar, Croatia*

Previous studies have shown that physiological systems have linear and nonlinear characteristics of temporal changes. However, there are few studies that examined the nonlinear dynamic of the psychophysiological systems under the influence of workload, and even less frequent are those which have followed parallel changes in several different systems. Therefore, the aim of this research was to check whether the changes in the workload cause the same/similar changes in two psychophysiological systems, psychomotor and cardiovascular. The study included 40 participants, who performed psychomotor Fitts tapping tasks (2, 4, 6 bits). These tasks were chosen due to the fact that their workloads can be precisely expressed quantitatively. An electronic version of Fitts tapping tasks was used which allowed recording of intertap intervals. While performing the tasks cardiovascular activity was also recorded. Values of Lyapunov exponents for three workload levels within both systems were positive which implies that they were chaotic. When it comes to the complexity of the systems (correlation dimension) it can be said that the psychomotor system was more complex than cardiovascular. Workload increase led to a reduction of psychomotor system complexity while the same trend was obtained for cardiovascular system, but the differences were not significant. Index of determinism was equal for two systems. This parameter was stable for psychomotor system through different workloads but not for the cardiovascular system. Generally, it can be said that the workload level affected changes in the nonlinear dynamics of the cardiovascular and psychomotor system in different manners.

A Big Data Study on How Zipf’s Law Governs Multiplex Emotion-Associated Words

Takuma Takehara, *Doshisha University,* **Fumio Ochiai**, *Tezukayama University,* **Naoto Suzuki**, *Doshisha University,* **Toshio Shibata**, *Hokusei Gakuen University,* **Kunio Mizuno**, *Tezukayama University,* **Toru Tazumi**, *Bunkyo University,* **Takayuki Ishikawa**, *Utsunomiya University,* **Takanobu Baba**, *Otemon Gakuin University,* **Tokihiro Ogawa**, *National Research Institute of Police Science*

According to our previous study on emotion-associated words (EAWs), the appearance-frequency distribution of EAWs was governed by Zipf"s law, as the slopes of the regression lines for each emotional cue word reached approximately -1.0. However, the previous study had approximately 1,400 participants, which indicates a small sample size. Thus, in the current study, we asked more than 5,000 participants to make the first-order association and write it down in the single noun that came to their mind in response to nine emotional cue words (Happiness, Excitement, Calmness, Relaxation, Surprise, Anger, Disgust, Fear, and Sadness). Subsequently, we asked them to make second- and third-order associations and write them down in the single noun, resulting in 128,484 responses in total. Similar to the previous study, we identified Zipf"s law in the appearance-frequency distribution for the first-, second-, and third-order associations, suggesting that EAWs had a clear regularity, were scale invariant, and were influenced by unification/diversification principles. Moreover, the diversity of the EAWs was found enhanced for the third-order association compared to the first-order one. These findings might provide a better understanding f the structure and role structure of EAWs.

The Effects of Shift Work on Nonlinear Aspects of Cardiovascular Dynamics

Andrea Tokic, **Ljiljana Gregov, Matilda Nikolic,**
University of Zadar

Since shift work is considered as a risk factor for health problems due to the continuous desynchronization and resynchronization of circadian rhythms, the aim of this study was to determine whether shift work (and different length of this work) affects nonlinear aspects of cardiovascular dynamics in healthy shift workers. The study included 48 nurses divided in two groups (24 nurses in each) of equal age and length of service. One group worked in a three-shift rotation system and the other (control) worked only the day shift. On the basis of length of service, the groups were divided into three comparable subgroups with eight participants: 1-10, 11-20 and 21-30 years of service. Cardiac activity (R-R intervals) was monitored continuously during sleep using the Data Logging System. Results showed that shift workers with up to 10 years of service had higher values of correlation dimension than the equivalent group of day workers, but shift workers with more than 10 years of service had lower values of correlation dimension than comparable groups of day workers. All shift workers, regardless of length of service, had significantly higher indexes of determinism than day workers, but index of determinism slightly enlarged with increase of years of services. Generally, it seems that shift work has a negative impact on cardiovascular dynamics from the very beginning, and nonlinear parameters of cardiovascular dynamics can be potential predictors of health problems in the future.