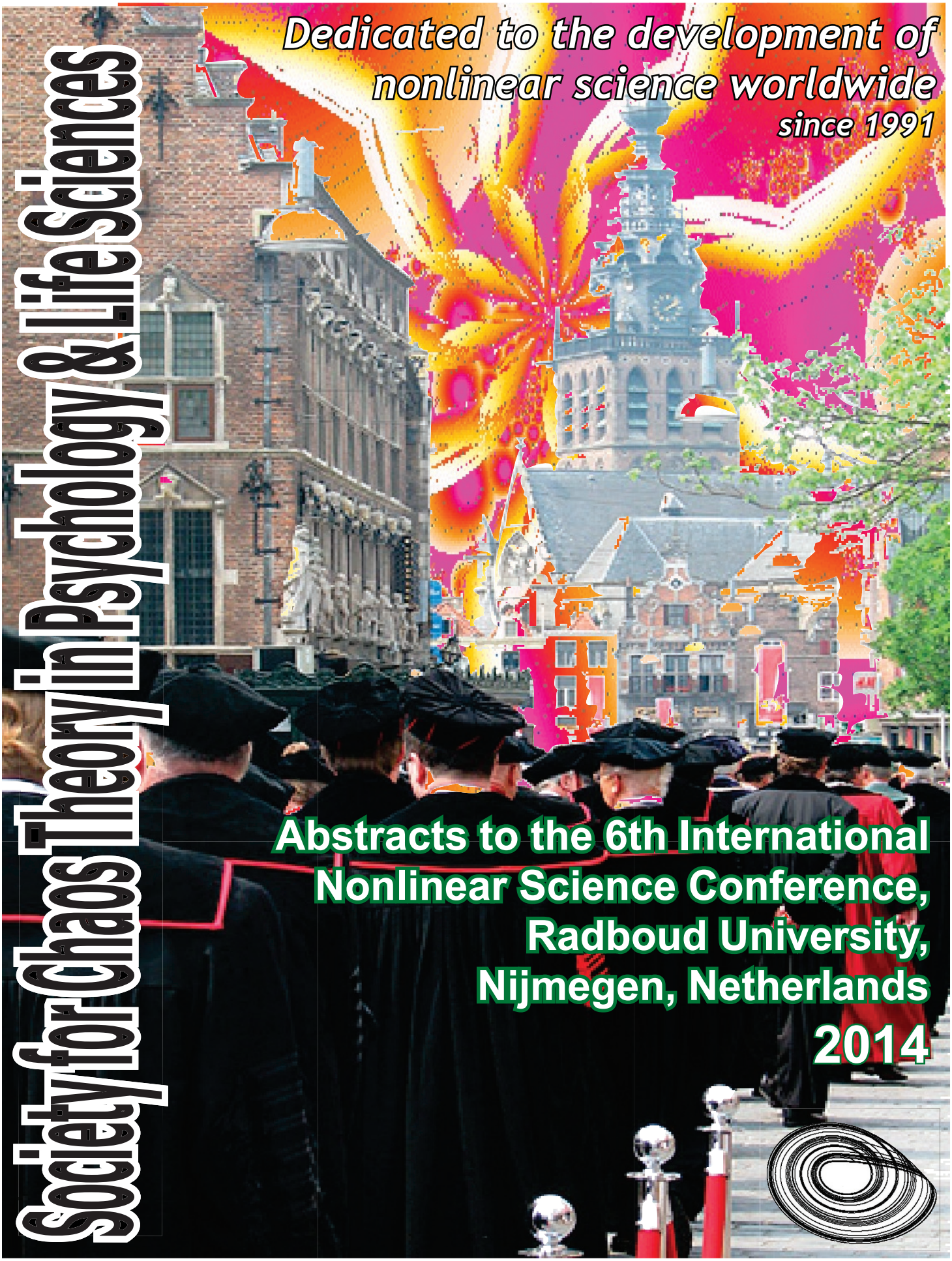
Society for Chaos Theory in Psychology & Life Sciences
Dedicated to the development of nonlinear science worldwide since 1991
Abstracts to the 6th International Nonlinear Science Conference, Radboud University, Nijmegen, Netherlands 2014

Society for Chaos Theory in Psychology and Life Sciences

6TH INTERNATIONAL NONLINEAR SCIENCE CONFERENCE

The Behavioral Science Institute of the
Faculty of Social Sciences Radboud University,
Nijmegen, Netherlands
March 20-22, 2014

Conference Program & Abstracts

Venue

Radboud University,
Nijmegen, Netherlands

Society for Chaos Theory in Psychology & Life Sciences

(SCTPLS)

& Radboud University

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

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Welcome to the ***6th International Nonlinear Science Conference***. This conference has been organized by the Society for Chaos Theory in Psychology and Life in conjunction with Radboud University. 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 or presentations, covering a wide range of scholarly disciplines, including theoretical as well as applied approaches. It attests to the international character of our scholarly community that we have presenters from many countries to share their work in nonlinear dynamics, including scholars from the U.S., Eastern and Western Europe as well as Asia. 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.

A. Steven Dietz, President of Society for Chaos Theory and Life Sciences
http://www.societyforchaostheory.org

Dear Conference Attendees,
On the behalf of the conference committee, I would like to welcome you to the Radbound University Nijmegen as well as the 6th 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, presentations are from various disciplines: psychology, economy, management, language, sociology, physics, informatics, ecology, and medicine. This small, intimate group that we seem to be able to get together at each of the preceding INSC's provides for excellent discussions and insights from disciplines one usually does not get acquainted with. I wish you all wonderful days at our campus, Nijmegen, and perhaps other parts of Netherlands.

Anna Bosman, *PhD,* Chair, 6th INSC 2014
Faculty of Social Sciences, Radboud University

Featured Keynote Speakers:

Karl Friston

"Free *Energy, the Brain, and Life as We Know it*"

How much about our interaction with – and experience of – our world can be deduced from basic principles? This talk reviews recent attempts to understand the self-organized behaviour of embodied agents, like ourselves, as satisfying basic imperatives for sustained exchanges with the environment. In brief, one simple driving force appears to explain many aspects of action and perception. This driving force is the minimization of surprise or prediction error. In the context of perception, this corresponds to Bayes-optimal predictive coding that suppresses exteroceptive prediction errors. In the context of action, motor reflexes can be seen as suppressing proprioceptive prediction errors. We will look at some of the phenomena that emerge from this scheme, such as hierarchical message passing in the brain and the perceptual inference that ensues. I hope to illustrate these points using simple simulations of perception, action and action observation.

Karl Friston is a theoretical neuroscientist and authority on brain imaging. He invented statistical parametric mapping (SPM), voxel-based morphometry (VBM) and dynamic causal modeling (DCM). These contributions were motivated by schizophrenia research and theoretical studies of value-learning – formulated as the dysconnection hypothesis of schizophrenia. Mathematical contributions include variational Laplacian procedures and generalized filtering for hierarchical Bayesian model inversion. Friston currently works on models of functional integration in the human brain and the principles that underlie neuronal interactions. His main contribution to theoretical neurobiology is a free-energy principle for action and perception (active inference). Friston received the first Young Investigators Award in Human Brain Mapping (1996) and was elected a Fellow of the Academy of Medical Sciences(1999). In 2000 he was President of the international Organization of Human Brain Mapping. In 2003 he was awarded the Minerva Golden Brain Award and was elected a Fellow of the Royal Society in 2006. In 2008 he received a Medal, Collège de France and an Honorary Doctorate from the University of York in 2011. He became of Fellow of the Society of Biology in 2012 and received the Weldon Memorial prize and Medal in 2013 for contributions to mathematical biology.

Peter C.M. Molenaar

"*Recursive Estimation for Nonergodic Stochastic Dynamic Systems*"

Ergodic theory is shown to have fundamental consequences for the statistical analysis of psychological processes, the most important of which is the necessity to focus on intra-individual variation in order to obtain valid results for processes that are heterogeneous across subjects and/or across time and place. Innovative recursive estimation techniques are presented which appropriately accommodate such heterogeneity. Examples presented include a) nonlinear oscillators undergoing bifurcations in human movement research; b) stochastic generalization of catastrophe theory in applications to cognitive development; c) bilinear connectivity modeling of fMRI BOLD series in neuro-cognition; d) estimation of subject-specific heritabilities in the context of nonlinear epigenetics; e) recursive estimation of Lyapunov coefficients of chaotic time series. In closing, some general issues in stochastic bifurcation analysis are addressed.

Peter C.M. Molenaar is distinguished professor of Human Development at Penn State University in the US. The general theme of his work concerns the application of mathematical theories to solve substantive psychological issues. One concerns the application of mathematical singularity theory (in particular catastrophe theory) to solve the longstanding debate about the reality of developmental stage transitions. Another theme relates to the application of nonlinear multivariate statistical signal analysis techniques to solve the problem of mapping theoretical models of cognitive information-processing onto dynamically interacting EEG/MEG neural sources embedded in spatio-temporally coherent backgrounds. Adaptation and extension of these techniques to connectivity mapping based on fMRI BOLD time series. Another central theme of prof. Molenaar's work is mathematical-statistical ergodic theory to study the relationships between intra-individual (idiographic) analyses and inter-individual (nomothetic) analyses of psychological processes. He has proven, based on the classical ergodic theorems, that for nonstationary processes such as learning and developmental processes it is necessary to focus on intra-individual variation (person-specific time series analysis). He has also done work on advanced multivariate analysis techniques in quantitative genetics and developmental psychology, the application of adaptive resonance theory (ART neural networks) to study the effects of nonlinear epigenetical processes and use of mathematical biological models of self-organization. One of the more recent topics relates to the application of engineering control techniques to optimally guide psychological and disease processes of individual subjects in real time, that is, real-time optimal treatment of individual patients with type-1 diabetes and asthma under normal living conditions.

Nijmegen, Netherlands



COMMUNICATIONS AND ORAL PRESENTATIONS BY ALPHABETIC ORDER

Neurodynamics model based on synaptic weights

Gaetano Liborio Aiello, *University of Palermo, Italy*

Random Cellular Automata are elective models of brain dynamics. They are based either on mere locality or on a random distribution of the interacting cells. A model is here proposed, which operates on a wiring scheme as it may result from cytoskeleton dynamics and axon guidance cues (Aiello, GL, Romano, V, Percolation Model of Axon Guidance, Proc. ESANN 2013, pp.65-70). Each cell is allowed up to N interactions with any others, chosen at random. With n(i, j) the number of axonal links from cell i to cell j, the ratio n(i, j)/N is taken as the *weight* w(i,j)of the synapse (i, j). The event triggering the cell ON/OFF response is related to the amount of synaptic input the i-th cell receives from the active cells in its receptive field, i.e., $W(i)=\Sigma_k\ a(k)w(i,k)$, where w is the weight of the synapse, and $a_k(t)=0,1$ the state of the cell. The "arousal" function that determines the activation of the cell, has a probabilistic component that allows spontaneous activation as well. Similarly, a "depression" function allows spontaneous de-activation. The population dynamics varies from chaos to autistic behavior through phase transitions induced by changes in the degree of connectivity.

Dispersion of response times in normal and dyslexic children

Anna Bosman, Radboud University, Nijmegen
Jay Holden, University of Cincinnati, USA,
Maarten L. Wijnants, Radboud University, Nijmegen
van Rooij M., University of Twente, Enschede

A better understanding of how word recognition comes to appear fluent promises to shed light on prominent failures to develop cognitive competencies. Some researchers believe that a stable performance on a genuine task indicates skilled performance, others rather point to the importance of a healthy degree of variation. The starting point of this presentation is that reading performance is both organized and variable. Although the bulk of standard statistical analyses are frustrated by the presence of structure in trial-to-trial variation, mixtures of non-Gaussian distributions make use of this apparent paradox. It is shown that response time distributions may indicate system behaviour at the edge of stabile versus flexible performance in an optimal balance, and are indicative of additive versus multiplicative effects. This postulate was corroborated by a recent study that revealed clearer log-normal distributions in more fluent reading, while dyslexic readers predominantly showed power-law distributions. Interestingly, dyslexic readers also revealed predominant power-law distributions in a variety of tasks that do not include word recognition. Since comorbidity has consistently been associated with a poorer prognosis and greater demands for professional help, unravelling the causality of comorbidity ranks among the top priorities in dyslexia research. The observation that dyslexic children fall out on so many different tasks and modalities is not strange from a complex systems perspective, since it does not assume specific component deficiencies to malfunction, but much more general reductions of system interactions.

Multi-stability of perceptual and conceptual responses in goal-directed imitation: an extended developmental perspective

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Background: Development can be conceived as a temporal process in a complex dynamic system consisting of many components which interact with each other as well as with the environment over time (van Geert 2009). Order parameters emerging through bifurcation in the course of development may still remain available for response selection in adults. Aim & Framework: Here we compare imitation of hand movements in Iranian adults with those of Iranian children from 4.5 11 year of age in the framework of goal-directed imitation (GOADI, Wohlschläger et al., 2003). Responses were elicited under a variety of spatial perspectives and amount of exposure in three goal-directed imitation tasks: hand-to-ear, hand-near-ear, and cup-grasping. Method & Samples: Tasks were conducted on 165 Iranian children (81 female) and 22 Iranian adults (12 female). Participants were supposed to imitate 8 uni- and bi-manual ipsi- and contra-lateral hand movements of the experimenter. *Results & Conclusion*: Children showed a clear developmental trajectory from perceptual mirroring of the goal location to conceptual matching considering the correspondence between the model s and the subject s hand. In comparison, adults also mostly matched observed movements, however, retained a significant amount of the developmentally earlier mirroring response, in particular females. This can be seen as evidence for multi-stability, where earlier solutions do not get lost but may still compete with developmentally later emerging ones, here, mirroring and matching. Whatever factors determine their selection may differ in children and adults cognitive-developmental but also social, gender, politeness, or aesthetic reasons.

Musical skill, brain remodelling, self-organization and learning

Martin Gardiner, *Brown University, RI, USA*

This paper continues to develop Brain Engagement theory (Gardiner, 2008). Data from longitudinal studies to be discussed include results from an ongoing study in Cambridge, MA of students who start singing skill training in kindergarten or dirst grade and then show superior progress in reading and math compared to peers in the same district after controlling for poverty, and learning disability. This and other of our evidence of musical skill learning affecting cognitive, social and personal learning beyond the domains of musical skill itself appear to suggest something like transfer from musical to other learning. But what exactly is transferred from musical learning to some other domain such as mathematics is often unclear. I propose and discuss that what is transferred in the learning we study is not brain engagement for pieces of well-developed skill but rather takes place at the level of strategy addressing and affecting how the brain models its own engagement. This approach to modeling can help to explain our and other recent data.

Music performance, brain remodeling, and self-organization

Martin Gardiner, *Brown University, RI, USA*

This paper continues to develop Brain Engagement theory (Gardiner, 2008). Musical performance will be used to illustrate how quickly and profoundly a musician can change from one interpretation to another in performing the same music. The flexibility with which such performance shifts can take place raises important questions about how capability for skillful performance is stored in the brain and how flexible modification takes place. I propose and discuss that such changes involve important rapid changes in self-organization that quickly change how the brain models and organizes its engagement producing the musical performance. This approach to modeling has broader implications concerning learning.

Catastrophe models for cognitive workload and fatigue in n-back tasks

Stephen J. Guastello, *Marquette University*, **Reiter K**., **Timm P., Shircel A**., **Shaline J., Nyffeler, Fabisch M**., & **Krumholz M**., *Marquette University, Milwaukee, USA*

N-back tasks require the individual to keep a short stream of information in short-term memory and match a new stimulus to one that appeared one or more steps previously. N-back tasks place a heavy load on working memory, and thus make good candidates for studying cognitive workload and fatigue (CWLF). This study extended previous work on CWLF, which separated the two phenomena with two cusp catastrophe models and an experimental design that captures the features of both models. Participants were 113 undergraduates who completed 2-back and 3-back tasks with both auditory and visual stimuli simultaneously. The visual stimuli were either basic geometric shapes or cartoon faces. The auditory stimuli were spoken letters of the alphabet. Tasks were preceded by several measures hypothesized to be related to cognitive elasticity and compensatory abilities. The NASA TLX ratings of subjective workload were completed afterwards. The adjusted R^2 was .980 for the workload model, which indicated a nearly perfect prediction with five bifurcation (elasticity versus rigidity) effects: algebra flexibility, TLX performance, effort, and frustration; psychosocial measures of inflexibility and monitoring. There were also two cognitive load effects (asymmetry): 2 vs. 3-back and TLX temporal demands. The adjusted R^2 was .454 for the fatigue model, which contained two bifurcation variables indicated amount of work done, and algebra flexibility as the compensatory ability variable. Both cusp models were stronger than the next best linear alternative model. No differences were determined for geometric shapes versus cartoon faces. The study made an important step forward by uncovering an apparently complete model for workload, finding the role of subjective workload in the context of performance dynamics, and finding CWLF dynamics in yet another type of memory-intensive task.

A flow network of uncertainty and stability to describe children s learning in a prediction task

Heidi Kloos, *University of Cincinnati, OH, USA*
Castillo R., *Universidad de Talca, Chile*

A complete theory of human behavior must capture both its randomness apparent in strong context dependence of behavior, as well as the stability of behavior, apparent in the surprising resistance to changes in some circumstances. Recent advances in complexity science have made important discoveries towards such a theory, emphasizing the idea that skilled behavior seeks to balance overly regular tendencies with tendencies that are overly random. The hallmark of these efforts is the idea of self-organized criticality, the state of a system poised towards maximally adaptive behavior. In the current paper, we expand these efforts, looking for a new measure to capture the balance between order and disorder, one that can be applied to small data sets of categorical performance. The proposed measure borrows ideas from information theory, previously applied to the stability of energy flow in an ecosystem. Specifically, we modified a measure of uncertainty (derived from joint probabilities of events), as well as a measure of robustness (derived from conditional probabilities), to track changes in behavior. The behavior of interest is a series of predictions about how objects would sink in water. Using data from this problem-

solving task administered to children and adults, we describe ways in which the measures of uncertainty and robustness track relative stability of behavior. Results are promising, opening the possibility for studying the trade-off between randomness and stability in children's reasoning.

An alternate paradigm for understanding the emergence and growth of languages

Malcolm Lowe, *Independent researcher, Charlotte, USA*

This paper challenges the traditional belief in linguistics that languages evolve from other languages and offers instead an alternate paradigm grounded in complex systems theory. Since it was first recognized that widely separated languages in time and space can share strong similarities in their lexicons, morphology and sound correspondences, it has been widely assumed that such similarities must be due to common descent. On the basis of this a priori assumption, and using the comparative method, comparative linguists have built elaborate phylogenetic trees of genetically-related languages, many of which languages are reconstructed (and therefore completely unattested) proto-languages. But given that common origin is not the only possible explanation for the evident similarities between languages, this entire theoretical edifice rests on highly questionable foundations. Viewed from the perspective of complex systems theory, the tendency of languages to exhibit similar lexical, morphological and sound correspondences is explained not by a common ancestor but by the fact that there is a universality to the way sound and meaning unfold in languages (or meaning systems) over time. In other words, although language systems may start at the same place, and develop along similar lines, they ultimately grow apart and create completely different languages. Known colloquially in chaos theory as the butterfly effect, this phenomenon was first observed by Edward Lorenz in the context of a computer simulation of the development of two separate weather systems which, although starting from virtually the same point, came to represent completely different weather patterns over the longer term. This paper argues that this alternate paradigm not only fits the empirical evidence better than the traditional paradigm, but also opens up a path to understanding how languages came into being in the first place, something which the current paradigm has conspicuously failed to do.

Learning in monopolies with delayed price information

Akio Matsumoto, *Chuo University, Tokyo, Japan*
Szidarovsky F., *University of Pécs, Hungary*

We call the intercept of the price function with the vertical axis the maximum price and the slope of the price function the marginal price. In this paper it is assumed that a monopoly has full information about the marginal price and its own cost function but is uncertain on the maximum price. However, by repeated interaction with the market, the obtained price observations give a basis for an adaptive learning process of the maximum price. It is also assumed that the price observations have fixed delays, so the learning process can be described by a delayed differential equation. In the cases of one or two delays, the asymptotic behavior of the resulting dynamic process is examined, stability conditions are derived and the occurrence of Hopf bifurcation is shown at the critical values. It is also shown that the nonlinear learning process can generate complex dynamics when the steady state is locally unstable and the delay is long enough.

Work group competition and performance dynamics

Ugo Merlone, *University of Torino, Italy*
Dal Forno A., *University of Torino, Italy*

In Economics relations between market structure and economic performance have been studied extensively. Several authors criticized monopoly. For example, Arrow showed that the incentive to innovate is greater under competition than under monopoly. This view is not new, as more than two centuries ago Hadely observed the tendency of monopolies to retard the introduction of industrial improvements. On the contrary, according to this author, competition has an important function as a stimulus to efficiency. For these reasons practitioners, consultants, and even academics have long advocated bringing the market inside the firm and therefore increasing internal competition. We consider a work group supervised by a manager who uses internal competition to increase productivity. We assume that, up to a certain level, work group performance increases as the result of internal competition, thereafter it decreases. From our model we obtain a piecewise linear map which describes the dynamics of interaction. The map is analyzed and the results can be interpreted in terms of the Blake-Mouton (1964) managerial grid theory.

Teamwork: Teams as a complex solution to manage uncertainty

Jose Navarro, *University of Barcelona, Spain*
Narayan S., *University of Barcelona, Spain*

Introduction: Nowadays work-groups are considered as a good example of complex systems, which have complex, adaptive behaviours (e.g. Arrow, McGrath & Berdahl, 2000). On the other hand, complexity science has proposed general behavioural rules for complex systems. One of these rules is the interplay between the system complexity and environmental uncertainty. At this point, when uncertainty increases more complexity is necessary to cope with it. Proposal: We will present a theoretical framework to

understand the complexity-uncertainty interplay in work-groups. Work-groups as systems (i.e. composed by members in interaction) can be analysed regarding their level of complexity (e.g. their level of interdependence among members). Work-groups are also interacting with some environments and here is critical the tasks that the group has to do. These group-tasks can be characterised as more or less uncertain. A critical interaction between work-group complexity and group-tasks uncertainty is proposed as the key point to understand the emergence of teams: to cope with high uncertainty tasks work-groups should work with high levels of interdependence in order to be effective. Therefore, team forms emerge as the natural way to cope with the environment in an adaptive manner. Previous research about non-linear and chaotic behaviour in effective teams (e.g. Cheng & Van de Ven, 1996; Ramos-Villagrasa et al., 2012) can be revisited using this approach. Implications: Work-groups processes and group-tasks can be integrated in a more general socio-technical approach. Now work-groups can be analysed considering their levels of complexity (i.e. interdependence among members), and the environment can be analysed considering its level of uncertainty (i.e. group-tasks uncertainty).

A dynamic systems account of language attrition

Annemarie Peltzer-Karpf, *University of Graz, Austria*
Trettenbrein, P.C., *University of Graz, Austria*

In the last decades, linguists have successfully employed Dynamic Systems Theory (DST) in the description of processes of cognitive growth and development (see Hohenberger & Peltzer-Karpf, 2009 for a recent example). Whilst this research has largely been concerned with language acquisition and initial development, little attention has been paid to the inverse process that is attrition of a speaker's L1, or L2, and/or L3. We propose that the study of language attrition calls for the application of DST in order to enhance the scope of theoretical descriptions and allow for a better understanding of associated phenomena. Within the context of a DST description, language attrition serves as an umbrella term for a variety of involved processes triggered by different mechanisms and factors that alter the current state of a complex linguistic system already in place. As linguistic data of any form ultimately has to be represented neuronally, susceptibility to attrition depends on connection strength between neurons and their likelihood of firing, both expressed using the concept of an activation threshold (AT) level. Increases (and decreases) of AT levels for linguistic data can thus be understood as alterations (processes of attraction or repulsion) of the current system that result from changes of neuronal structure. These changes then, in turn, largely result from environment or time-dependant variables such as, for example, frequency of use and brain plasticity. Hence, when studying language attrition we can observe a non-linear dynamic system's gradual retreat into chaos.

Considering verbs as dynamic systems: The neurobiological mechanism behind the self-organisation of meaning and time

David Rail, *Neurology, Private Practice, Sydney, Australia*

Verbs are arguably the most complex and important of Neurobiological entities. They function as the highest semantic and syntactic node of sentences (Wildgen 1994). Verbs are pivotal in the organisation of thought and language (Pinker 2007). The verb s semantic function is based on the interaction between: Simulation and Event Structure Templates that integrate somatic and psychological influences into temporal constructs (Kemmerer & Gonzalez-Castillo 2010) (Levin 1993) (Pustejovsky 1991). Verbs are unique among dynamic systems because time itself is instrumental for the function of the verb in the development of meaning. Time and meaning bootstrap one another. The self-organisation of time and meaning is key to an understanding of verb function and more broadly language itself. Despite understanding of the key parameters governing verb function we lack an overriding Neurobiological Mechanism (NBM) explaining how the self-organisation of meaning and time leads to that function. We model the verb enabling us to derive NBM through a macro-micro commutation (circular causality). The macro determinant consists of the Action Representation System (ARS) - Simulation, Intentionality and Verbalisation (Grezes & Decety 2001) (Meltzoff & Decety 2003). The micro component stems from co-dependency between Time and Meaning. We propose that the commutation self-organises to criticality (metastability) (Kelso 2012) as the child s verbal proficiency advances to the adult level. We define the verb through deriving the asymptotic form of the commutation functioning at criticality. We discuss the significance of this form in terms of each of its key variables, especially intentionality; perception and the interdependency between meaning and time.

The complexity of good primary care psychology

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Derksen, J.J.L., *Free University Brussels, Belgium and Radboud University Nijmegen, the Netherlands*

Warren Weaver wrote in 1948 an article about Science and complexity. This article addresses the subjects of simplicity, disorganized complexity and organized complexity. With organized complexity he meant problems with a sizable number of factors which are interrelated into an organic whole but cannot be handled with statistical techniques. He gave us scientists a mission: Science must, over 50 years, learn to deal

with problems of organized complexity. It is now 2014, more than sixty-five years later. What is the current state of affairs when it comes to problems of organized complexity within primary care psychology? Most research is still done with basic statistical techniques and the complex reality is more than ever reduced to measurable indicators. The same seems to be the case when it comes to the valuation of good care. Ethical diversity is ignored by ethical monism leaving no space for the dynamics of ethical pluralism. Recognition of the complexity of primary care psychology and striving for ethical pluralism is one step towards Weavers mission. An example will be given how the foundations of primary care psychology can be based on the principles of complexity science. Organized complexity most therefore be taken into account as well as the acceptance of uncertainty and limited knowledge. A pleasant side effect is that the gap between theory and practice can this way be narrowed down**.**

An experimental study of Schelling's asymmetric coordination game

Hirokazu Takizawa, *Chuo University, Japan*
Kawagoe T., *Future University Hakodate, Japan*
Matsubae T., *Chuo University, Japan*

This paper reports experimental results on the asymmetric coordination game described in Schelling fs Strategy of Conflict. There are three players, A, B, and C, who simultaneously choose from the set of possible permutations of letters, A, B and C. The payoff structure is asymmetric; the payoffs are ranked according to the order of letters appearing in the coordinated choice. For example, if they all choose CAB, player C earns 3, A 2 and B 1. There has been no systematic experiment on this game. Comparing the rate of coordination success in the game above with those in another game, where the letters A, B, C are replaced by meaningless symbols: #, *, and $, we identified the focal point effect as predicted by Schelling. In our experiment, however, we had the subjects repeat the game with the same group members to see what happens dynamically. They were informed of the other members' choices after each round. It is found that most subjects tend not to stick to the choices with which they have first succeeded in coordination. Rather each subject tries to reach coordination where he/she can earn the most, although such attempt usually leads to a coordination failure. Remarkably, some groups succeed in dynamic coordination; they changed the coordinating choice by rotating the letters in the order of ABC, BCA, CAB so that each member could get almost the same average payoffs. The goodness of fit of a model based on the reinforcement learning is examined.

Complexity in identity: Exploring nonlinear development of commitments

Mandy A.E. van der Gaag, *University of Groningen, the Netherlands*
Kunnen S., *University of Groningen, the Netherlands*

Identity can be defined as a macro-level psychological constructs concerning commitments of oneself in relation to the world, which includes beliefs, interests and goals in different domains of life (Bosma & Kunnen, 2001). There has been a lot of research that demonstrates correlations between identity and different variables like personality, wellbeing etc. (Meeus, 2011). However, research concerning micro-level, real-time processes that underlie identity development is rare and research concerning the connection between micro and macro level even more so (Lichtwarck-Aschoff, van Geert, Bosma & Kunnen, 2008). We attempt to elaborate this research by applying the framework of complex dynamic systems to identity development. A property of a complex system is interconnectedness of different time-scales, macro-level phenomena emerge from micro-level interactions, and the macro-level phenomena constrain the micro-level interactions (Kunnen, 2012). When applied to identity development, a new perspective emerges where daily experiences in a certain context interact with the strength of commitment towards the context, which interacts with the quality and strength of beliefs, interest and goals. A theoretical model will be presented, including some preliminary results from our empirical study: an intensive, longitudinal study among first year students where participants report important experiences and their level of commitment weekly, for 30 weeks. We will show different patterns of nonlinear commitment development and how dynamics are influenced by experiences. We will also show how macro-level identity constructs, as measured by an extensive identity interview (GIDS-r, Bosma, Kunnen en van der Gaag, 2012), constrain micro-level interactions between experiences and commitment strength.

Delay discounting explained with a two-attractor nonlinear model

Marieke van Rooij, *University of Twente, Department of Human Media Interaction, Enschede, the* Netherlands
Michael Richardson, *University of Cincinnati, Center for Cognition, Action, and Perception, Cincinnati, OH, USA*

Delay discounting refers to the well-known phenomenon that individuals discount the value of future gains compared to similar immediate gains. A large body of research addresses the hyperbolic relationship between immediate and delayed rewards, but the reason for this discounting is less well understood. In this paper, we argue that delay discounting may be better understood within a nonlinear framework and present empirical data from a two-choice discounting task. In previous

work, we demonstrated nonlinear phenomena in human decision making behaviour under uncertainty using a risky choice task, suggesting that the dynamics of decision making are difficult to capture using conventional linear models. A nonlinear dynamical model was therefore proposed that models risky strategy changes using two different attractors emerging through a bifurcation in the underlying decision system. The model is adapted to model delay discounting and predicts catastrophe flags related to multistability in choices between immediate and delayed gains. We present data from 72 participants from the University of Cincinnati indicating their preferences between immediate and delayed gains, demonstrating as predicted, hysteresis, reversed hysteresis, and critical slowing down. The implications of using dynamical models for explaining the nonlinear complexities of human decision making are discussed, as well as the degree to which the theory of nonlinear dynamics systems might offer an alternative framework for understanding the human decision making process.

Dyadic synchronization in a therapeutic relationship

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Heijligers C., *Radboud University Nijmegen, the Netherlands*
Anna M.T. Bosman, *Radboud University Nijmegen, the Netherlands*

This research project consists of a therapeutic relationship between a client and a therapist. The relationship is regarded as a complex system in which co-regulation between client and therapist and a delicate balance between synchrony and variability are the means of a specific treatment to enhance development. Although communication should be regarded as a continuous process, discrete states in the interaction between client and therapist are recorded and coded. An example of such a state is the gaze direction of the participants. The two coded time series are analysed by CRQA. The information of the Recurrence Plot and the Lag Profile gives insight in the dyad as a system with respect to recurrent patterns of interaction and who is leading the system. Questions for discussion are how to analyse four time series of four participants, three clients and one therapist involved in a therapeutic group setting and how to reveal the underlying process of co-regulation.

Do Wii sync while cooperating? An investigation of interpersonal postural sway

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Bosman A.M.T., *Radboud University Nijmegen, the Netherlands*
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In the present study we examined whether interpersonal synchronization of postural sway occurs while cooperating. The participants were 8 13 year olds, who performed a tangram task. They did this three times for 10 minutes, each time trying to finish as many tangram puzzles as possible. The first and third time they did it individually, while the second time they performed the task as a dyad. Thus, the second time they performed the task they had the opportunity to cooperate. Postural sway was measured with the use of two Wii Balance Boards, both set at a recording rate of 100 Hz. In order to find out whether interpersonal synchrony occurred and whether or not it had an effect on task performance, the data were analyzed with the use of two nonlinear methods, namely (Cross) Recurrence Quantification and Detrended Fluctuation Analysis. These analyses were performed after down sampling the data to 10 Hz. The results from these analyses, as well as their implications and directions for further research, will be discussed.

Real-time processing: the dynamics of productive and receptive lexical knowledge in the first and second language

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de Bot K., *University of Groningen, the Netherlands*
Plat R., *University of Groningen, the Netherlands*
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The present study was designed to determine whether variability patterns in four lexical processing tasks correspond to random variability or whether the patterns have a specific structure that is associated with self-organization of complex systems, that is to say pink noise. Nineteen Dutch second language learners of English performed four lexical processing reaction time tasks that differed with respect to modality (reception vs. production) and language (first language (L1) vs. second language (L2)). The degree to which pink noise is present in the four tasks reveals how late bilinguals are able to coordinate their behavior in the two languages and across the two modalities. The findings reveal more pronounced patterns of pink noise in the receptive tasks than in the productive tasks and somewhat more pronounced pink noise in the L1 tasks than in the L2 tasks. Although the differences in variability patterns in the two modalities can be explained by different task demands, the differences between the L1 and the L2 tasks suggest that the participants show more coordinated behavior

in the L1. Furthermore, the presence of pink noise in these lexical tasks is not easily explained by component-dominant models of language. This suggests that language processing is more adequately explained by interaction dominance than by traditional modular approaches.

Can children walk and think at the same time? Exploring the developmental trajectory to cognitive complexity in a dual-task paradigm

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This paper presents experimental work conducted with 43 children (4-12 years) to investigate changes in complexity of cognitive task performance carried out with a motor task. In adults, motor tasks take priority in sustained complexity when a second task is added. In contrast, cognitive tasks lose complexity in a dual-task paradigm. The current study examined the developmental trajectory of this pattern. Children completed a 10-minute cognitive task (repeated time estimation) and a 10-minute motor task (walking on a treadmill). The repeated time estimation required a button press every time the child thought a target time interval of 0.4 seconds had passed. In one case, the cognitive and motor tasks were carried out separately (single-task estimation; single-task walk), and in the second case, they were carried out concurrently (dual-task estimation; dual-task walk). The variability of the obtained trial series was submitted to Detrended Fluctuation Analysis to obtain a measure of complexity in the form of the Hurst exponent. Results show a characteristic increase in complexity for both time estimation and walking as age increased as long as the tasks were performed independently. However, this developmental trajectory disappeared in the dual-task condition: Complexity remained unchanged across age when children had to perform time estimation while walking. The results indicate that the functional reorganization of cognitive dynamics observed in adults is similar to what was found with children. However, different from adults, the motor task did not have priority over the cognitive task.

The Ware K. health trigger neurophysics therapeutic process produces unprecended recovery from a long term spinal cord injury

Ken Ware, *International NeuroPhysics Functional Performance Institute, Arundel, Queensland, Australia*

A world renowned para-Olympian and adventurer began Ware K Health Trigger Therapy (formally referred to as Ware K. Tremor Therapy (see web-pages below); on the 16th -20th of May, 2013, to treat long term shoulder ailments that were interfering with his preparation for elite competition. The patient was also hoping that the therapy would aid in alleviating his long-term chronic pain. However, in the very early stages of applying the therapeutic process, unexpected neural dynamics began to emerge in the lower limbs, whilst the patient performed upper limb exercises, in accordance with the parameters of this therapy. The surprisingly unexpected neural activity increased in velocity and intensity and was observed as bilaterally consistent between the left and right lower limbs and was in synchronicity with upper body neural dynamics, despite the patients highly recorded long term T12 lesion associated paralyses. This inspired efforts to then do other exercises to determine the de nova functional capacity of the lower limbs, in consideration to what was documented in the patients medical records. It was evident that this therapy had stimulated and activated post lesion sensory motor (ascending, descending) neural pathways that were already reconnected. This lead to the patient being able to take his first unassisted steps in 25 years, only 4 days from when he began this therapy. There are no records in the literature or otherwise of any person with similar long or short term spinal cord lesion impairment, achieving such dramatic functional improvements in time scales anywhere near what this patient accomplished as a direct result of the therapy. The long-term chronic pain the patient has suffered from being also nonexistent as well. Attempts to replicate these results with patients with more significant lesions of the spinal cord have also produced unprecedented results.
http://f1000.com/posters/browse/summary/1093372)
http://www.youtube.com/watch?v=c1vQ2D1XF7c.

Evidence of Ephaptic communication in the nervous system as observed in EMG data obtained from a Tetraplegic during Ware K Health Trigger Process Therapy

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Ephaptic Communication, (Ross, Ware 2013) or, non-synaptic communication within the nervous system, is now being vigorously studied by teams of Neuroscientists around the globe. There are diverse motives for Neuroscientists to shift their energy and resources towards the study of endogenous brain fields and neat nervous system structures and functions, seeking evidence of ephaptic coupling of neurons (see web-page below). However time scales and fluidness of global, self-organizing, health triggering chaotic neural dynamics, that emerge in clients systems during Ware K therapy, provide strong evidence that ephaptic communication/coupling is intrinsic, manifesting in the creative evolution of the very observable global nervous systems dynamics during the therapeutic process. A constant of this therapy is the client s systems unrestrained motor responses to applied mild sensory stimuli. The neural dynamics that emerge over time, maybe likened to flocks of birds or schools of fish, flying or swimming in unison, where

there are no central governors. . For validation purposes, when we took simultaneous emg samples from the left and right side trapezes, abdominals and leg adductors of a tetraplegic, as he performed upper limb exercises in the prescribed manner, the time series very clearly portrayed, that when notable activity occurred in the trapezes, that there was a simultaneous mirroring of this activity in the abdominals and adductors. The Spinal cord lesion did not interrupt global communication within the parameters of the this therapeutic process, suggesting strongly that the nervous system, given the right initial conditions, can communicate ephapticly or in ways yet to be fully understood, describable and manageable. Dramatic improvements in functions and senses below the lesion were accomplished in less than 18 hrs of this therapy.
(http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3780359/
http://www.ncbi.nlm.nih.gov/pubmed/10408593*)*

SYMPOSIA

Recurrence Quantification Analysis: Theory & Applications

Chair: **Cox, Ralf**

Bosman, A.M.T., Hasselman, F. Lichtwarck-Aschoff, A., Radstaak, B., Wijnants, M.L. van Dijk, *Radboud University Nijmegen, the Netherlands*

The temporal structure of behaviour contains a rich source of information about its dynamic organization, origins, and development. This information is essential for unravelling how people's actions are synchronized with those of other people, for example in social interaction, or how they are coordinated in a specific task, for example during problem solving. In addition, it provides a framework for conceptualizing and understanding how behaviour emerges and develops from the interaction of body, brain and environment. Thoroughly studying behaviour as it unfolds over time by means of (nonlinear) time-series analysis, it is possible to reveal such information. In this symposium an informal introduction and demonstration will be given of a particular nonlinear time-series technique, called recurrence quantification analysis (RQA). It affords a quantification of the prominent features of the dynamical organization underlying overt behaviour, such as its complexity, stability, and flexibility. This technique can reveal relations between behavioural variables on different timescales, which are inaccessible to traditional central tendency measures and correlational or lag-sequential methods. Over the past decade, RQA has seen several convincing applications in various research areas of psychology, as will be shown in this symposium. Sandwiched between two methodological presentations, a number of applications of RQA will be discussed covering intersections between behavioural science, cognitive science, and psychopathology.

The dynamics of mother-infant coordinative behaviour (Cox & van Dijk). A methodological introduction of (Cross-) RQA will be given for continuous as well nominal and categorical variables. Focus will be on the background and main features of the technique, the kinds of insights it can provide, and on its advantages above traditional measures (more than on a rigorous treatment of all the details of the analysis). The first application will entail the analysis of mother-infant speech, or, to be more specific, the use of holophrasic, combinatory or syntactic utterances. The aim is to distinguish different patterns of behaviour, characterizing the changing ways in which infant and caregiver attune to each other over time. The results show a more flexible interaction pattern emerging over time.

Dynamical principles of coordination in complex systems (Wijnants). Over recent decades it has become clear that meaningful temporal patterns of variability can be found in any repeated performance, and that their relative presence is experimentally controllable. As will be argued, dynamical patterns as quantified by RQA and well-coordinated system behaviour go hand in hand. First, results from a precision aiming study are discussed to show that variation of movement times becomes less random and more patterned with motor learning. Next, results from a word naming study are discussed in which dyslexic and non- dyslexic word-naming performance in beginning readers are investigated. It was observed that RQA measures differentiate reliably between dyslexic and average response times and correlate strongly with the severity of the reading impairment. The second part of the talk will focus on the broader discrepancy among mainstream cognitive science and the full implications of these findings

Fighting AN: A non-linear case-exploration of a client-therapist text message interaction (Radstaak & Bosman). A complex systems perspective was adopted for the longitudinal, exploratory non-linear analysis of a text-message conversation between a female with severe restricting type anorexia nervosa (AN) and her therapist. A priori, we argued that a rigid maintenance of recurrent behavioural structures could be indicative for a system's pathology (Miller, 1978). Hence, the text messages were analysed for the presence of recurrent structures by means of RQA. The results yielded higher levels of recurrent behaviour by the client compared to the therapist. Moreover, higher levels of recurrent behaviour were negatively associated with the client's weight

A characteristic destabilization profile in parent-child interactions associated with treatment efficacy for aggressive children (Lichtwarck-Aschoff)
This study examined profiles of change in repeated mother-child interactions over the course of a 12 week treatment period for childhood aggression. The aim was to investigate whether it was possible to detect the characteristic profile of change, typical for phase transitions, over the course of treatment, and whether this profile was associated with positive treatment outcomes. Using a novel application of RQA for categorical time series, entropy values were computed for six repeated real-time observations of each mother-child dyad. Subsequent latent class growth curve

analysis on the sequences of entropy values revealed two distinct classes of dyads, with one class showing a clear peak in entropy over the six measurement points. The latent class membership variables showed a significant systematic relationship with observed dyad improvement (as rated by clinicians). The class with the peak in entropy over the sessions consisted largely of treatment improvers. Hence, this study revealed a treatment-related destabilization pattern in real-time behaviours that was related to better treatment outcomes.

Applications of recurrence-based analyses in the social and life sciences: pitfalls, challenges and potential (Hasselman) (Cross-)RQA, central to the contributions in this symposium, is one of many techniques introduced into the analytic toolbox of the social and life sciences that allow for a quantification of nonlinear dynamics of human performance and physiology. The potential of nonlinear tools is widely recognised, Bravi et al. (2011) note in their evaluation of 70(!) different variability analyses that the challenges for the field are to develop a shared vocabulary and increase coherence between results of different studies and the techniques that were used. In this talk I will discuss the pitfalls and challenges that arise when interpreting the outcomes of nonlinear time series analyses based on human performance (e.g., differences between the dynamics of categorical, discrete, and continuous variables). More importantly, I will sketch the potential for developing a more general analytic framework when one tries to resolve these challenges. I will use (C)RQA as an example analytic framework to illustrate these issues, but this is by no means a case in point. I will argue it is specifically the recurrence based analysis of time series that holds the potential to bridge the gap between the methods developed to study complex networks (e.g., Donner et al., 2011), fractal structures (e.g. Webber, 2012) and Generalised (non)Linear Models.

Recent advances in the empirical study of dynamical processes in education

Chair: **Koopmans M.,** *Mercy College, New York, USA*
Pennings H., Brekelmans M. & van Tartwijk J., *Utrecht University, the Netherlands*
van Steenbeek H. & van Geert P., *University of Groningen, the Netherlands*
Stamovlasis D., *Aristotle University of Thessaloniki, Greece*

As a field of inquiry, education has been slower to catch on to nonlinear dynamical systems approaches than other disciplines, such as psychology, econometrics and theoretical biology. However, recent progress in the field includes significant and path-breaking empirical work to study the dynamical underpinnings of the educational process. This symposium aims to present some of the most recent advances in this area.

Pennings et al. examine whether real-time interpersonal teacher behavior is related to the teacher-student relationship. The study conceptualizes interpersonal behavior in terms of Agency and Communion, and utilizes State Space Grid (SSG) analyses to examine the differences in attractors and variability in real-time interpersonal behavior between teachers and students. Teachers were found to be clearly distinct in terms of their SSG profiles: the correspondence between the location of the attractors in the SSG and the blend of Agency and Communion characterized the teachers interpersonal profiles. Regarding structure, higher variability was observed in real-time behavior for teachers with interpersonal profiles characterized by lower levels of Agency and Communion.

Steenbeek and van Geert observe and analyze long-term and short-term learning-teaching trajectories successful as well as unsuccessful ones as emergent and dynamic phenomena resulting from the interactions in the entire educational context, in particular the interaction between students and teachers, viewed as processes of intertwining self-, other- and co-regulation. The first part of this paper presents an example of an empirical study of a math learning-teaching trajectory in a 9-year old boy with an emotional behavioral disorder. The second part discusses the dynamic modeling of learning-teaching trajectories. The short-term dynamics is described by a dyadic agent-based model, the long-term dynamics by a network of interacting variables encompassing concerns, evaluations, actions and action effects (such as learning) in students and teachers.

Stamovlasis applies a Cusp catastrophe model to explain students academic achievement as a function of cognitive variables, such as, information processing capacity, field dependence-independence, logical thinking and convergent/divergent thinking, and affective ones, such as attitudes toward learning. It was shown that some of the above variables, which do not demonstrate consistent behavior within linear models, are acting as bifurcations within catastrophe models. These striking discontinuities cannot be picked up by traditional linear and logistic regression models, attesting to the importance and potential of catastrophe approaches in education.

Koopmans utilizes a nonlinear time series approach to examine short term and long-term dependencies in the daily attendance rates in five urban schools over a seven-year period. While school attendance is a critical mediator to school success, it is rarely investigated longitudinally. This study reveals a strong cyclical pattern (weekly) in all five schools, and evidence for self-organized criticality in one of the five. Implications of the findings from all four studies for educational practice and for future educational research are discussed.

Process monitoring and multi-level nonlinear dynamics in psychotherapy: Converging Results from SNS technology and psychotherapy-research

*.**Schiepek, Günter,** Paracelsus Medical University, Salzburg, Austria.* **Aas, B.**, *Ludwig-Maximilians-University, Munich, Germany*)

This symposium outlines some essential features of practice and basic research on psycho-therapy-related systems. One of these features is the application of methods for the identification of structures and dynamics of complex systems, the other is a multi-level approach to social, mental (cognitive and affective), and brain dynamics in patients with obsessive compulsive disorder. A third feature of systemic research is the integration of nomothetic and idiographic as well as quantitative and qualitative approaches.

We will present an internet-based method for the monitoring of change processes, which allows for data-mining (by repeated self-ratings) and visualization of the resulting time series and analysis of these using nonlinear and systemic techniques. The visualized non-linear and non-stationary patterns of change are communicated to patients and therapists during the ongoing therapy or counselling process. By this additional, data-driven feedback loops are introduced to the system. Standardized questionnaires for process and outcome monitoring as well as idiographic questionnaires, which are tailored to the client can be used. Individualized questionnaires are related to the components of the system, which is reconstructed by the method of the idiographic systems modelling.

In the last years several inpatient and day treatment centers have used the Synergetic Navigation System (SNS) as an internet-based monitoring and feedback technology. Patients are administered to daily self-ratings by using a standardized process questionnaire. Here we report on the results from more than 500 cases whose time series realized chaotic dynamics (method: cross Lyapunov exponents) as well as critical instabilities and order transitions during the change process. In a subsample we demonstrated therapeutic effects of the SNS application (e.g. Increased emotional experiencing in chronic drug dependent patients).

A recently published research project (Schiepek et al. 2013) used this internet-based process monitoring (called Synergetic Navigation System, SNS) to identify order transitions in self-organizing human systems. In parallel, evolving brain patterns of the client are monitored by repeated fMRI scans. Results show that therapeutic order-transitions correspond to specific transitions of neuronal patterns. In an ongoing research project, we extend this paradigm onto the specific systemic qualities of the evolving brain, mirrored by functional and effective connectivity as well as synchronization patterns of neuronal networks.

The theory of self-organizing complex systems predicts that successful therapies of OCD are characterized by discontinuous order-transitions at three synchronized levels of systems functioning: a) subjective experience, b) neuronal activity, and c) processes of gene-expression. On the cognitive and emotional level, we assess the dynamics of the therapeutic process of OCD-patients by daily self-ratings implemented and standard use at the Christian Doppler Klinik at Salzburg. Patients with OCD appear to have maladaptive neuronal activity in specific brain regions. To assess whether changes on the level of subjective experience coincide with changes in neuronal activity during the course of a 3-4 month therapy-program, OCD patients are administered to repeated fMRI scans while being exposed to neutral and symptom-specific stimuli. Additionally, these are compared to a control group of healthy subjects.

On the third level of gene-expression, we are planning to assess whether the above mentioned changes in subjective experience and neuronal activity also correlate with factors that have earlier been identified to be connected with neuronal plasticity. Through blood tests we will investigate the levels of specific proteins (CREB- and BDNF) that have been linked with synaptic redistribution, the biological process underlying learning processes.

This research contributes to a better understanding of the multiple processes underlying OCD by identifying typical patterns in the course of a psychotherapy that can be used to better adjust and improve the therapeutic process. Furthermore the results underline the notion that psychological phenomena can best be understood with a paradigm that takes an multi-level approach, integrating concepts of complex system theory, synergetics and chaos-theory. Our symposium presents an applied, internet-monitoring tool (3) and empirical results from finished and ongoing psychotherapy-research (1), after laying a theoretical background of our work (2).

Nonlinear dynamics in psychopathology and psychotherapy

Chair: **Tschacher W.,**
Ramseyer F., *University of Bern, Switzerland*
Pincus D., *Chapman University, USA,*
Bornas X., *University of the Balearic Islands, Spain*
Eberle K., *University of California, Irvine, USA*
Balle M., *University of the Balearic Islands, Spain*
Kupper Z., *University of Bern, Switzerland*
Walther S., *University of Bern, Switzerland*
Sandman C.A., *University of California, Irvine, USA*

STUDY 1 *Psychotic disorganization is linked to disorganized movement patterns*
Disordered communication is a core problem in schizophrenia patients' everyday functioning. The Bern group has worked on systems-based measures of nonverbal behavior that evaluate embodied social interaction. We conducted projects addressing nonverbal behavior in role-plays with

schizophrenia patients (378 role-play scenes involving 27 outpatients) and in actigraphic data (100 patients). The projects and analyses were based on previous work on psychotherapy process and social-psychological studies of healthy dyads in conversation. Here we focus on the results relevant to schizophrenia. Nonverbal behavior in role-plays was assessed objectively using a video-based algorithm (Motion Energy Analysis, MEA) developed in our group. MEA allows quantifying the synchrony of social interaction. In healthy dyads, synchrony predicts the affective pleasantness of conversations. In schizophrenia patients, lower nonverbal synchrony was associated with symptoms (negative symptoms, conceptual disorganization, lack of insight), patients' verbal memory and self-evaluation of competence. Thus, synchrony yielded an objective and sensitive marker of the severity of patients' problems. In the actigraphic timeseries of patients' everyday behavior, the autocorrelation structure of movement was linked to symptom profiles of patients. Generally, less temporal structure and predictability was found in patients with higher symptom loads. In conclusion, both results on movement patterns point to deficits in important, usually unconscious, capacities that regulate social interaction and are connected with the satisfaction with social exchange. These analyses therefore provide novel insights in the relationships between psychotic symptoms and movement.

STUDY 2 *Movement synchrony in psychotherapy: The coordination of hand movements is associated with session outcome*

Previous work has shown that nonverbal behavior was associated with both session-level outcome and global outcome in psychotherapy. Nonverbal synchrony here the coordination between patient's and psychotherapist's movement behavior is a facet of nonverbal behavior that has recently been studied with MEA. The present study aimed to replicate and extend these findings by using direct acquisition of movement data. In this single-case analysis, we measured patient's and therapist's hand and arm movements with a high-resolution accelerometric measurement system (Vitaport). In addition to these behavioral data, both patient and therapist provided session-level ratings of various factors relevant to the psychotherapy process, which were assessed with post-session questionnaires. The coordination of hand movements in (N=20) sessions of this dyadic psychotherapy was positively associated with progress reported in post-session questionnaires. Sessions with high progress were characterized by high movement coordination. Thus, accelerometric data of this therapy dyad confirmed previous findings gained through video analyses: The coordination of nonverbal behavior shown by patient and therapist was an indicator of successful work within sessions. This replication study showed that nonverbal synchrony embodies important aspects of the alliance. Its assessment and quantification may provide therapists important additional information on processes that usually occur outside conscious awareness, but that nevertheless importantly influence various aspects of the therapy dyad.

STUDY 3 *The role of self-injury in behavioral flexibility and resilience*

Severe and persistent self-injurious behavior (SIB) is notoriously difficult to understand and to treat. The current study of the group at Chapman University / University of California used self-organization theory to investigate the possible relationship between SIB and changing levels of behavioral flexibility. Data consisted of categorical time-series of sequential behaviors from individuals with developmental disabilities and severe SIB. Orbital Decomposition was used to analyze each series for measures of structure and entropy. Overall, results showed evidence for self-organization in behavior patterns. Second, series including SIB were on average more flexible than those without SIB; while, higher numbers of SIB events (perseveration) were associated with higher behavioral rigidity and structural disintegration. Finally, there was evidence that behavioral flexibility almost always shifts reliably after a discrete bout of SIB, either increasing or decreasing in complexity. Altogether, these results may provide a deeper and more theoretically grounded understanding of the function of SIB beyond the traditional behavioral paradigm involving simple stimulus-response or response-consequence relations. Instead, some behaviors, such as SIB, may serve a resilience-making function as more global regulators of behavioral flexibility and coherence.

STUDY 4 *Allometric control of daily mood and anxiety fluctuations*

Despite some efforts to investigate the dynamics of mood in patients with affective disorders, daily mood fluctuations in healthy people are still poorly understood. In this study of the Spanish group, allometric aggregation was applied to time series of self-reported mood and anxiety data to test the hypothesis that those fluctuations are under allometric control. Similarly to physiological systems like heart beating, instead of a single set point for mood (heart dynamics) we should find a distribution of values, all of which are accessible to the affective (cardiovascular) system. Thirty-two undergraduate students (21 women) reported mood and anxiety scores three times per day along 45 days through the Internet. A surrogate data analysis was performed to demonstrate that the scaling h values from the empirical series were statistically different from the h = 0.5 value from the randomized time series. The ! mean scaling exponent for the mood time series was h = 0.7415 (SD = 0.11) and for the anxiety time series h = 0.7964 (SD = 0.097). The surrogate data analysis confirmed the fractal properties of the self-reported time series, thus lending support to the hypothesis of allometric control of daily mood and anxiety. The clinical usefulness of these results for the diagnosis and treatment of mood disorders is discussed. Specifically, those results suggest that trying to regularize mood fluctuations may not be an appropriate clinical aim, as some degree of irregularity seems to be not only normal but adaptive and necessary.

POSTERS

Heart rate fractal properties and vagal tone are related to attentional orienting

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Resting cardiac vagal tone has been associated with emotion regulation (ER) and also with several attentional processes but the use of nonlinear measures to study the complex output of the cardiac system is still scarce in the field of ER and attentional functioning. According to Posner and Petersen s (1990) model of attention there are three major attentional networks: alerting, orienting, and executive control. This study aimed to analyze how the complexity of heart rate and cardiac vagal tone relates to the functioning of these networks. Fractal-like properties (scaling exponents through detrended fluctuation analysis and fractal dimension) and sample entropy were calculated on 5-min long resting heart rate time series from a sample of healthy university students and staff members (n = 106). Attentional functioning was measured through the Attentional Network Test for Interactions (Callejas, Lupiañez, & Tudela, 2004). Significantly positive correlations were found between enhanced attentional orienting and the fractal dimension and entropy of heart rate as well as with vagal tone. These results are in agreement with Thayer and Lane s model of ER as far as a link is suggested between vagal tone and attention modulation. Nonlinear measures extend this prediction to other cardiac features.

Fractal coordination in sports: A demonstration of temporal structures in rowing performance

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Resting cardiac vagal tone Within the domain of motor control and learning, it has been suggested that the continuous interactions between system components (e.g., muscles, joints, neurons, etc.) give rise to a coherent temporal structure of behavior, spanning multiple time scales (e.g., Wijnants, Bosman, Hasselman, Cox, & Van Orden, 2009). This pink noise pattern differs from random variation over time (i.e., white noise), and would be more apparent when the system behavior is healthy or better trained (Wijnants et al., 2009). In the current study, we examined whether temporal structures of performance in rowing, a sport in which continuous coordination is crucial, could be characterized as non-random (i.e., more pink). Moreover, we explored whether the temporal structure of high-level rowers was closer to pink noise, than the temporal structure of medium-level rowers. Four high-level and 5 medium-level rowers performed 550 strokes on a rowing ergometer. Using force sensors, we measured the movement times from force peak to force peak. Detrended fluctuation analysis revealed that the structure of the time series of the movement times differed from a random pattern for each rower. In addition, the temporal structure was closer to pink noise for the high-level rowers than for the medium-level rowers. These results provide the first insights into temporal structures of sport performance, and suggest that variation should not be discarded in research on sport performance. Rather, it could provide crucial information about the quality of coordinated movements.

A nested time-scale model of self-esteem

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In this presentation, a self-organization (SOSE) model of self-esteem is presented. Our model suggests that self-esteem is a self-organizing phenomenon that exists on various time-scales, where the ontology of state self-esteem and trait self-esteem, as well as the relationship between state and trait self-esteem, depend on bottom-up processes of self-organization. Specifically, we suggest that state self-esteem self-organizes out of a real-time network of self-related experiences on the micro level, and that trait self-esteem self-organizes out of the iterative development of state self-esteem at the macro level. Trait self-esteem, in this sense, is conceptualized as an emergent temporal structure that can be defined as a collection of attractor states. Our model suggests that strong emergent attractor states (where the system is relatively resistant against external perturbations) will constrain the degrees of freedom (i.e. the variability) of lower-order state self-esteem. In a preliminary study, we tested our SOSE model with regards to adolescent self-esteem (N = 13) in the context of real-life parent-child interactions. Observational data was coded in a multivariate and time-serial manner and analyzed using Kohonen's Self-organizing Maps (to measure the self-organization of trait self-esteem attractors), State Space Grids (to measure the level of top-down constraint), and Monte Carlo analyses (to test group differences). We found that the real-time dynamics between adolescents' trait and state self-esteem during parent-child interaction fall into two significantly different profiles ($p = 0.04$), both of which are explained by the SOSE model. In profile 1, strong trait self-esteem attractors (for which lower-order variability at the state self-esteem level is relatively more resistant to contextual perturbations, i.e., significant changes in the simultaneous parental emotional-behavioral expressions) constrain simultaneous state self-esteem variability. In profile 2, weak trait self-esteem attractors (for which lower-order variability at the state self-esteem level is relatively less resistant to

contextual perturbations), exhibited relatively less constraint on simultaneous state self-esteem variability.

The fractal dynamics of grieving processes

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Inspired by the research on self-esteem by Delignières et al. (2004), this study explores whether grieving processes are characterized by fractal dynamics. Partners in close relationships can be seen as systems that are 'coupled' on different levels, for example with regard to physiological and psychological self-regulation. An involuntarily life transition, like becoming widowed, disrupts the complex interactions, of which intimate partners provided each other. From this point of view, it can be assumed that the transition to widowhood alters the state of a system by means of self-organization processes. To shed light on this possibility, data were analyzed from two widows, who filled in dairies for al least 512 consecutive days, of which four dimensions were scored three times a day. All measured dimensions represent physical, mental and social domains of subjective wellbeing that are affected by grieving after the loss of a loved one. The obtained time series were analyzed with fractal analyses, and revealed the presence of fractal 1/f dynamics. This result suggests that grieving is a complex process poised between flexibility and rigidity.

Modeling work teams performance through catastrophe theory: The roles of past performance, performance expectations and team demography diversity

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Researchers have found empirical support for the pertinence of examining work groups as complex adaptive systems (Guastello, 2010; Ramos-Villagrasa, Navarro, & Garcia-Izquierdo, 2012). Team performance is defined as the extent to each work groups achieve formally and previously established goals or standards (Hackman, 1986). Empirical work on team performance suggests that what individuals expect in terms of their immediate and long term performance influences how they will perform in the future (Schippers, Homan & van Knippenberg, 2012). Furthermore, literature as regarded the role of team diversity characteristic in terms of the homogeneity versus heterogeneity of team members task experience and age (van Knippenberg, De Dreu & Homan. 2004). Participants were 1041 teams (4539 individuals) enrolled in a 5 weeks management competition (the Global Management Chalendge®). Data collection was done between 2010 and 2013 and hypotheses testing was done using R's Cusp Package for cusp catastrophe models fitting using maximum likelihood (Grasman, van der Maas & Wagenmakers, 2009). According with the R2, AICc and BIC indices, the cusp model fits the data better. Ours findings support the growing empirical evidence that work groups performance can be better understood through nonlinear dynamical systems theory. More specifically, this study contributes to the study of work groups as complex adaptive systems because it shows that a) cusp catastrophe modeling describes work group performance better than linear approaches, and b) by offering additional empirical support to the role of past performance, performance expectations and demographic diversity in work groups performance.

Nonlinear dynamics of discrete and repeated movement tasks

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For the purpose of developing nonlinear dynamics analysis of discrete movements we have studied 12 adult subjects reaching round obstacles to a set of five targets located on a planar surface. The subjects' movements followed sequences summarised as Constant, involving repeated movements to a particular target, Intercalated in which movements to a particular target were separated by movement to another target and Random. These sequences permitted systematic variation in the cognitive and physical demands on the subjects during reaching. Movement sequence data was also available for re-assortment reach-by-reach following collection. The kinematics of movement in 3D were captured from a reflective marker placed on the middle phalanx of each subject s right index finger (four cameras, 120 Hz). Direction of pointing was specified by x (M-L), y (A-P) and z (vertical) coordinate trajectories. Maximum Lyapunov exponents were calculated on average for equivalent movements for x, y and z trajectories to be respectively 0.65, 0.59, 1.45 (Constant); 1.25, 1.31, 1.46 (Intercalated); 1.48, 1.47, 1.66 (Random). Simple statistical analysis yielded significant differences: x and y, Constant vs. Intercalated or Random, $p < 0.01$; z, Constant or Intercalated vs. Random, $p = 0.06$. Data processing methods will be given in detail in the presentation.

Learning culture and affective well-being at work: Does the individual growth need matter for this relationship?

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In the literature on organizational learning and learning organizations, it quickly becomes clear that culture is a key concept. In fact, organizational culture is mainly conceived as an essential condition to facilitate and support learning in organizations and, consequently, as an important feature in

order to achieve organizational performance. In addition, a large amount of research has been centred on its impact on performance issues, and the relationship of this kind of culture with other outcomes has been, to some extent, neglected. In this scope, the present research aims i) to assess the impact that a learning context, (that is to say, organizations with a learning culture), has on persons, namely in terms of their affective well-being at work; and inspired by the Hackman and Oldhams' job characteristics model, ii) to understand the role of individual growth need strength in this relationship. This study has a sample of 145 public service workers. The OLC scale (Rebelo & Gomes, 2011) was used to measure the orientation of organizational culture towards learning, affective well-being at work with the JWAS (Katwick, Spector, Fox, and Kelloway, 2000), and the individual growth need strength with a six item-scale derived from section six of JDS (Hackman and Oldham, 1974). The use of STAR models (Structured Additive Regression models) for analysing data suggests a nonlinear effect of these variables on well-being, revealing that medium values of learning culture and individual growth need lead to higher values of affective well-being. In short, the main findings hold the idea that an organizational learning culture tend to generate positive outcomes on workers, although the strength of its impact is affected by person's willingness to learn in a non-linear way.