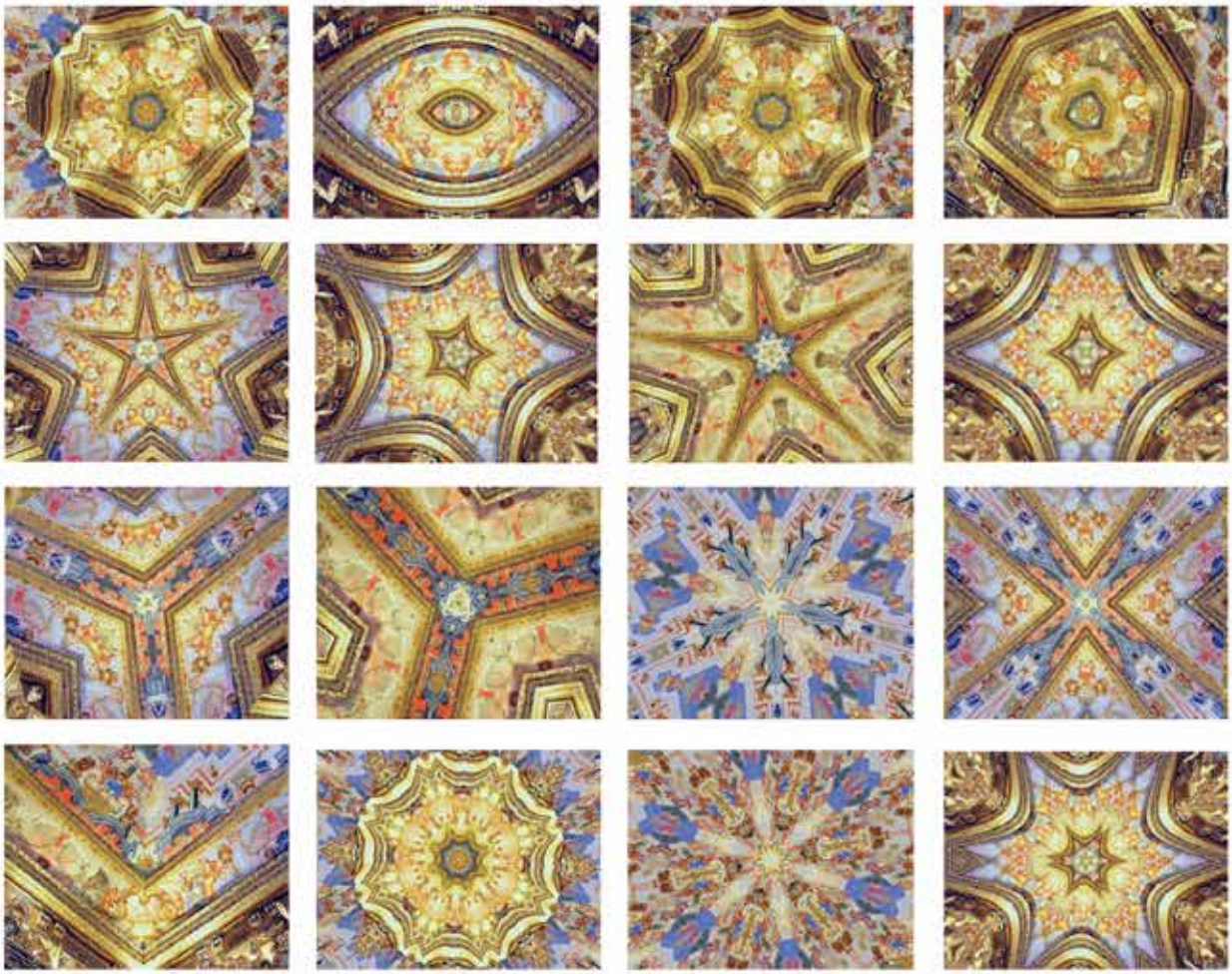
8th INTERNATIONAL NONLINEAR SCIENCE CONFERENCE



28-30 MARCH

Society for Chaos Theory in Psychology and Life Sciences 2019

UNIVERSIDADE D COIMBRA

INSC

CÂMARA MUNICIPAL COIMBRA

8th International Nonlinear Science Conference

Book of Abstracts

Coimbra, Portugal, March 28-30, 2019

FACULDADE DE PSICOLOGIA E DE CIÊNCIAS DA EDUCAÇÃO
UNIVERSIDADE D COIMBRA

Dedicated to the development of nonlinear science worldwide since 1991

About the 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 23 years, the Society and its conferences have been founded in 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 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. The program includes prominent keynote speakers, workshops, symposia, individual sessions, and posters presentations. This year brings the 8th INSC to beautiful Coimbra, Portugal. The dates for the conference were set for March 28-30, 2019, and our sponsoring institution is the Faculty of Psychology and Education Sciences, University of Coimbra – a fine destination for culture, tourism, and scientific progress. The presentation schedule along with all program details and other announcements are posted. In this INSC, you will find state-of –the–art research work and meet the most experts in the field, which can provide you the opportunity to start original collaborative work. The INSC presents an ideal opportunity for someone just starting in the field, with ambition to advance his research area via nonlinear dynamics and complexity theory.

Publication Opportunities:

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

Conference Committee:

Teresa Rebelo, University of Coimbra, Conference Chair
David Schuldberg, SCTPLS President
Stephen Guastello, Marquette University,
Dimitrios Stamovlasis, Aristotle University
Paulo Renato Lourenço, University of Coimbra
Isabel Dimas, University of Aveiro

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

Welcome to the 8th ***International Nonlinear Science Conference***. This conference has been organized by the Society for Chaos Theory in Psychology & Life Sciences, hosted by University of Coimbra. This 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 offering 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 and researchers from Eastern and Western Europe, the U.S., as well as Asia. This conference has become part of a long-standing tradition of international scholarly exchange, which has strengthened our nonlinear dynamical systems community and increased the impact of our work.

David Schuldberg, President
Society for Chaos Theory in Psychology and Life Sciences
http://www.societyforchaostheory.org

Dear Conference Attendees,

On the behalf of the conference committee, David Schuldberg, Stephen Guastello, Dimitrios Stamovlasis, Paulo Renato Lourenço, Isabel Dimas and me, I would like to welcome you to the University of Coimbra as well as to the 8th 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, Coimbra is a nice place to think in nonlinear and complexity terms. It is known as "the city of students" due its university, one of the oldest in Europe. Enjoy your stay here, in the southwest part of Europe, the intellectual and social exchange, and the emergence of new ideas at the 8th International Nonlinear Science Conference.

Teresa Rebelo, *Conference Chair*,
Faculty of Psychology and Education Sciences
University of Coimbra

KEYNOTE SPEAKERS

How work motivation changes in the short and long term

José Navarro
University of Barcelona, Spain

Self-regulation, variability, and big change: A regime for all seasons

David Schuldberg
University of Montana, Missoula, USA

Synchrony and Embodiment -Empirical Hypotheses derived from Synergetics

Wolfgang Tschacher
University Hospital of Psychiatry and Psychotherapy,
University of Bern, Switzerland

Featured Keynote Speakers:

José Navarro

How work motivation changes in the short and long term

On average, an adult spends one-third of their life at work in western cultures. For this reason, work is a crucial source of human well-being. However, our motivation at work is not always the same but changes from time to time and at different time scales; at short-term if we consider days or weeks, and long-term as well if we consider years and decades. Recent literature has started to pay attention to these changes proposing different psychological mechanisms. In this lecture, I will focus on these changes and the mechanisms involved. At long-term, I will explore how work motivation changes are due to changes in expectancies, personal values, and vocational interests among others. All of these changes can be considered as a natural consequence of a more general process of maturity. At short-term, the picture that research is showing us is clearly more interesting from the point of view of the complexity science; at short-term (i.e., hours, days or weeks), work motivation behaves non-linearly, presenting continuous ups and downs independently of the task the worker is doing. The mechanisms involved in these changes remain unclear; however, the most likely explanation for these changes is the emotions that work and labor relationship produces continuously. Emotions at work are volatile and their non-linear dynamics can be considered as the main determinant in work motivation changes. At this point, asking about the dynamic nature of emotions and motivations at work moves us to ask also about the possible functions of these continuous changes as an adaptive response to interacting with the working environment.

Bio: José Navarro, PhD, is an associate professor at the University of Barcelona, Spain. His research activity is about work motivation as a dynamic process that evolves chaotically over time, and the interplay between team processes and team tasks as a critical influence on team effectiveness. His research has been published in prominent journals such as *Nonlinear Dynamics, Psychology, and Life Sciences*, *Journal of Organizational Behavior*, *Human Relations*, *Journal of Happiness Studies*, *European Journal of Work and Organizational Psychology*, or *Small Group Research*. He belongs to the Society for Chaos Theory in Psychology and Life Sciences.

David Schuldberg

Self-regulation, variability, and big change: A regime for all seasons

This talk discusses three potential features of the behavior of dynamical systems, especially nonlinear ones: Self-regulation, variability, and discontinuous change. **Self-regulation.** For much of my professional career I have been interested in negative feedback processes, as these have formed an image and touchstone for understanding well-functioning biological systems. **Variability.** We have long known that self-regulative systems fluctuate and sometimes exhibit complex – in fact, chaotic – behavior while still maintaining a bounded and life-maintaining biological regime (thank you, Ari Goldberger). **Sudden change.** How does so-called "discontinuous" or "qualitative" change occur, in psychotherapy, spirituality, and political consciousness? How can we characterize it? Those studying nonlinear dynamical systems and their behavior (for example Steve Guastello) have long been interested in catastrophes, bifurcations, surprise, and qualitatively different behavioral regimes. This talk discusses these three cases in the context of modeling well-known as well as yet to be discovered phenomena in psychology and neurosciences. The methodological issue of choosing one's level of analysis and magnification in this work is emphasized, as well as discovering the precursors of "regime change" in these systems.

Bio: David Schuldberg is a professor in the Department of Psychology at the University of Montana – Missoula (Montana) and serves as Director of Evaluation for the UM National Native Children's Trauma Center. He is currently both President and President-elect of the Society for Chaos Theory in Psychology and Life Sciences (SCTPLS). He received his B.A. in Psychology and Social Relations from Harvard University in 1973 and his M.A. and Ph.D. (1981) in Clinical Psychology from the University of California, Berkeley. He joined the faculty of The University of Montana in 1984; he was a visiting Professor in the University of Florence (Italy) Professor di Chiara Fama ("clear fame") program in 2006. At UM he teaches undergraduate and graduate Psychology courses, supervises graduate students in their clinical work and research, and pursues several lines of research. His research areas include both severe mental illness and positive psychological and physical health, including medical outcomes; serious mental disorders (including the Eating Disorders and PTSD); nonlinear dynamical systems and chaos models of psychological processes, especially using time series data; creativity; psychological assessment and program evaluation; integration of Behavioral Health in Primary Care; and, rural and rural minority health services.

Wolfgang Tschacher

Synchrony and Embodiment-Empirical Hypotheses derived from Synergetics

Current research in psychology increasingly showed that, and how, social and psychotherapeutic interaction is grounded in posture, body motion, gesture, prosody, and physiology – in short, in the bodies of individuals interacting. It was found that patients and therapists spontaneously synchronize their movements and even their physiological responses during psychotherapy. This nonverbal synchrony has been linked to better therapeutic outcomes and generally to prosocial attitudes. Mental and communicative processes are thus embodied in movement patterns and physiological synchrony. I view such processes as examples of self-organization dynamics that can be modeled in the framework of Hermann Haken's synergetics. We developed statistical methods to detect synchrony based on time series with high sampling rates, and to establish effect sizes of this phenomenon using surrogate tests. I will also demonstrate how we can visualize the underlying attractor landscapes on the basis of such time series.

Bio: Wolfgang Tschacher was born in Stuttgart, Germany, studied psychology at Tübingen University where he received his Ph.D. in 1990. Psychotherapy training in systemic therapy at the Institute of Family Therapy, Munich. Habilitation in psychology and Venia legendi 1996 at University of Bern, Switzerland, professorship in 2002. He currently works at the University Hospital of Psychiatry, where he founded the department of psychotherapy research. His main interests are in quantitative psychotherapy research, time-series methods and experimental psychopathology, with an emphasis on dynamical systems, complexity science, embodied cognition, and phenomena of cognitive self-organization. Organizer of the series of 'Herbstakademie' conferences on systems theory in psychology. For a list of publications and conference information, see www.exp.unibe.ch or www.embodiment.ch

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Oral presentations

Yuji **Aruka**, *Chuo University, Japan*

Identifying market performances with redundancies and a deeper logic of complexity motivated by Turing' s rule selection

In Cook(2004), the cellular automaton of Rule 110 is well known as a complete Turing machine in the sense that any calculation or computer program can be simulated using this automaton. On the other hand, in the lineage of Wolfram s A new kind of science , we are interested in the properties of Class 1-4 on interactive cellular automaton (ICA): Cellular automata (CA) can be classified according to the complexity and information produced by the behavior of the CA pattern: Class 1: Fixed; all cells converge to a constant black or white set Class 2: Periodic; repeats the same pattern, like a loop Class 3: Chaotic; pseudo-random Class 4: Complex local structures; exhibits behaviors of both class 2 and class 3; likely to support universal computation (Carvalho 2011). In particular, the property of Class 4 may be described as follows: Nearly all initial patterns evolve into structures that interact in complex and interesting ways, with the formation of local structures that are able to survive for long periods of time. The rule 110 proves itself to reproduce such structures. Much more interestingly, Wolfram s group has also discovered these from the behaviors of Fully Random Iterated Cellular Automata (FRICA) with multiple rules. Thus, we can detect some critical conditions that may make a certain local structure collapse by changing a selection of the rules. This new observation may bring us a new perspective, at least, a useful hint, on how to measure the market performances. Because we can regard a market performance as one similar to the property of Class 4. Here we replace the rule with the strategy. In the field of market transaction, usually, participating agents will behave by following their own strategy to either ask or bit. Given the participating set of agents to implement their own strategy, then, the market system will run under any allocation of strategy configuration that is always exposed to an internally or externally changing environment. It is noted that there is not always secured the equality of ask and bit any time but also some unsettled balance incurred even in the realization of a contract. Hence there are something like redundancies in the market. Hence, we can say that the market field is always affected by randomness and redundancies. It is already verified by U-Mart, our unique market simulator, that a specifically selected strategy configuration in Aruka et.al (2018) could always internally generate any price time series that coincides with a given spot price time series whatever its pattern is extrapolated. This special configuration may be regarded as a core structure locally generated during the market transaction procedure on one hand. On the other hand, we can measure any divergence from the special reference. Under the idea of Class 4, we will be able to grope for identifying market performances with redundancies and a deeper logic of complexity

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Xavier **Bornas,** *University of the* Balearic Islands, Spain
Margalida Caimari-Ferragut, *U. of the* Balearic Islands
Josep Roman-Juan, *University of the* Balearic Islands
Aina Fiol-Veny, *University of the* Balearic Islands
Maria Balle, *University of the* Balearic Islands

How far has your heart travelled? Introducing a simple measure of the heart system trajectories in state space

This paper introduces a new measure to evaluate heart output from a dynamical systems approach. The measure is based on the time delay technique for two-dimensional state space reconstruction from time series of interbeat intervals. The system"s trajectories within this space are dynamically depicted and the mean distance, as well as the total distance travelled by the system, are calculated in pixels. All this is done through a LiveCode© program and several examples will be presented at the Conference. Preliminary data from adolescents with highly positive emotional regulation (HPER) style (n=10) and adolescents with highly negative (HNER) style (n=10) who underwent a protocol of stress induction based on the Trier Social Stress Test show the usefulness of the new metrics to distinguish the dynamical behavior of the heart systems from these groups. The HPER group showed greater flexibility across experimental conditions (baseline, anticipation, exposure, and recovery) ($F(3,16)=6.89$, $p=.003$, partial $\eta 2=.56$) than the HNER group ($F(3,16)=1.27$, $p>.10$). The total distance and the mean distance in the HPER group were longer than in the HNER group at both baseline and recovery conditions, i.e. at rest. In addition, the new measures outperformed other complexity measures (e.g. Higuchi"s fractal dimension and sample entropy). As to the physiological meaning of the new measure a correlational analysis revealed that the associations with traditional HRV measures were equal in both groups. However, HRV and complexity seem to be associated in adolescents with HPER style but not in those with HNER style. The new measure adds to the existing tools for a more thorough understanding of the complex regulation of the heart.

José Manuel **Caballero-Caballero**, *Resident Medical Intern, La Paz Universitary Hospital, Madrid, Spain*

M. Victoria Caballero-Pintado, *Murcia University, Faculty of Economics and Business*

Manuel Ruiz Marín, *Cartagena Polytechnic University*

Symbolic Recurrence Rate to Detect Atrial Fibrillation

Symbolic Recurrence Rate to detect atrial fibrillation Atrial fibrillation (AF) is an abnormal rhythm of the heart that is felt as an irregular heartbeat or pulse. This disease is the most common sustained cardiac arrhythmia and increases the risk of heart failure and other heart complications. Paroxysmal AF (PAF) is defined as an intermittent AF that terminates spontaneously o with intervention in less than seven days. In this work we present a new tool, namely symbolic correlation integral, for AF detection in RR intervals time series. This method is based on symbolic analysis. This kind of analysis may reveal physiological properties of AF and contain important information that can be used to discriminate PAF and no-PAF. To obtain the symbolic time series we consider the time series of RR intervals embedded in an m-dimensional space. Next, we define the symbolization map which transforms the embedded time series in a sequence of symbols. The set of symbols is the ensemble of all the permutations of length m that represent ordinal patterns, and the symbolization map assigns every element of embedded m-dimensional time series, namely m-history, to a permutation that sort out from the smallest to the greatest the entries of this vector. Two m-histories are symbolic recurrence states to a symbol when by the symbolization map have the same image. Then we define he Symbolic Recurrence Rate (SRR) to a symbol as the probability of symbolic recurrence states to this symbol. We have calculated SRR by using moving windows procedure to RR interval time series, with the aim of identifying the most important changes in the dynamics of RR interval time series from a subject. This study is based on data from PhysioNet MIT-BIH Atrial Fibrillation Database (https://physionet.org/physiobank/database/afdb/) and MIT-BIH Normal Sinus Rhythm Database (https://physionet.org/physiobank/database/nsrdb/).

Margalida **Caimari-Ferragut** *U. of the Balearic* Islands

Josep Roman-Juan, *University of the* Balearic Islands

Maria Balle, *University of the Balearic Islands*

Xavier Bornas, *University of the Balearic Islands*

Aina Fiol-Veny, *University of the Balearic Islands*

Using State Space Grids to study father- and mother-adolescents interactions: does flexibility depend on the child's level of risk for anxiety disorders?

Many anxiety disorders (AD) emerge during adolescence, where parents-adolescent interactions are crucial and may be influenced by temperamental traits and anxiety symptoms. Most research studied these children s and parent s psychological variables separately and with static measures such as questionnaires. This approach misses the interrelated and contextually specific emotions that children and parents experience during day-to-day interactions. The Nonlinear Dynamic Systems (NDS) theory considers parent-child interactions as complex dyadic systems evolving in time. To explore whether parent-child interactions involving at risk for AD adolescents were different from those involving low or no-risk adolescents, we used the state space grid (SSD) method. This method provides a visual representation of the dyad"s trajectories along the selected episode; parent"s emotional states (5 in this study, see below) are located along the y axis and the 5 adolescent"s emotional states along the x axis, so that a grid of 5 by 5 states (i.e. 25 cells) can be reconstructed. Then several quantitative measures are calculated (e.g. the number of visits to one specific cell or region) that give information about the system"s flexibility, the attractors" strength, etc. The main hypothesis of this study was that interactions involving at-risk adolescents would be less flexible than interactions where the child was not at risk. In addition gender differences were examined. Sixty-eight father-adolescent dyads and fifty-three mother-adolescent dyads (mean age of adolescents was 14.21 years, SD= 0.706) were videotaped during two (positive and negative content) episodes of ten minute s interaction, separately and counterbalanced. Videotapes were coded through the Simple Affect Coding System. The combination of facial expression, voice tone and physical cues resulted in five categories: neutral (NE), distress (DI), Anger-Disgust (ADi), validation (VE), and positive affect (PA). Coding was continuous and therefore a mark was made each time that one of the interacting persons shift from one state to another one. The GridWare software was used to analyze all this information. The resulting quantitative indices were then exported to SPSS for statistical analysis. Results reported here concern the region AD-DI (four cells) in the SSG. Interactions involving mothers. No differences between groups of risk for AD were seen during negative episodes. Positive episodes involving

low-risk adolescents revealed longer mean duration in the region and mean duration per visit than interactions involving no-risk adolescents (p=.016 and p=.033 respectively). No differences were found between boys and girls. Interactions involving fathers. No differences between groups of risk for AD were seen during positive episodes. Negative episodes involving high-risk adolescents revealed more events (p=.028), more region duration (p=.007) and larger region range (p=.023) than interactions involving low-risk adolescent. Regarding gender, no differences were found between boys and girls during positive episodes. In negative interactions, return time (a measure of the attractor"s strength) was shorter in interactions with girls than with boys (p=.039). These results lend partial support to our main hypothesis (i.e. interactions involving at-risk adolescents are less flexible than interactions with no-risk adolescents) but show that flexibility depends also on the context and the gender of the interacting parents.

Bent **Clemmensen,** *Bergen Museum, Norway*

Dynamical systems theory and Human macro history

The purpose of this paper is to show that Dynamical Systems Theory (DST) can be an essential tool in the development of a new qualitative understanding of human macro history. (DST) specifically deals with the long term qualitative behaviour of dynamical systems of which human history is a good example. Due to the very extensive record, that is the massive amount of data we have on the process of human history, we can expect to see progress in our general understanding of the dynamics of complex systems by applying (DST) to the study of history. The origin of this way of thinking goes back 50 years, and is to be found in a short article by Rene Thom: Topological models in Biology. Here he broadens the understanding of the concept of Morphogenesis. He writes: The problem of morphogenesis - broadly understood as the origin and evolution of biological structure - is the outstanding question in present day Biology . My extension of this idea to include change in social structure is what is at stake here. Thom describes in this article a revolutionary new way of thinking about dynamics - multiple causes, the need of a spatiotemporal understanding of real systems via visualization made possible by his topological models, and the necessary role of global qualitative thinking. The key is to think about the dynamics of natural systems as a spatiotemporal process. I hope that I, following Thom, can show that (DST) and Catastrophe Theory (C.T.) can help to solve this problem. When we apply (DST) to model history, our state space is necessarily very high dimensional, human history is a vast and complex process of behavioral and structural changes, but using the language of (C.T.) to zoom in on local processes can give us a much clearer picture. For the purpose of clarification I suggest we divide the process of human history into three temporal sequences.The first lasted several million years and culminated around 300.000 years ago in our own species homo sapiens. Following this we have a period lasting until about 10.000 years ago, where humans live in small groups of 50 to 200 members. Their response to evolutionary success , that is population growth, in this period is that of division, an increase in the number of people meant at some point splitting up into two separate independent groups. At the end of this era, we have the highest number of independent human societies ever, surely many thousands. Then around 10.000 years ago when the availability of empty land (space) was depleted an entirely new process started, where human groups began integrating into ever larger and fewer societies, a process we still see today. The assumption that this process will end in a unified global community seems obvious. I now come to defining what I find to be the necessary control parameters. I suggest these to be division of labour, technology, population growth and consciousness. It is important to notice that these four parameters are the same for the emergence of homo sapiens and for the present emergent global community. To get the process towards homo sapiens started there had to be a socially organized primate with a rudimentary division of labour and along came innovations in technology new levels of consciousness and evolutionary success. When the integrative process began 10.000 years ago we see new types of division of labour and new technologies specifically farming changing fundamentally how food is acquired. This also lead to innovations in consciousness including writing. What we can hope to achieve here is what Ralph Abraham calls a holarchic understanding of dynamics based on topological models (C.T. and DST). What we are striving for is in Ion C. Baianus words to visualize in our minds eye the complex new idea of spatiotemporal change. Space here refers to not just size but also density, distance and borders. A spacetime understanding of macro history is a holistic qualitative understanding, that will bring systems dynamic thinking back into focus.

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

Gender Abuse in Intimate Relationships from Structural Coupling Theory to Emergence of Couple System

The new way of conceiving social systems proposed by contemporary Sociology in the light of acquisitions of the New Dynamical System Theory or Science of Complexity provides an appropriate theoretical framework to reflect on gender-based violence issue in intimate relationships. How we understand a relationship in which the same victims have

opened the doors of their intimate life to the one who is their abusive partner? Why women choice a partner able to victimize them in such a tragic manner? Maybe the choice is too hasty, little weighted? Maybe it"s just a matter of personality .? If what is here put in the form of a question is often a conviction in the plan of common places, this interpretative hypothesis finds place in the field of Behavioural Psychology. Here, referring to Bowlby s Attachment Theory, Structural Coupling Theory assumes personality structure as the predictor of partner choice as well as risk of victimization, identifying in the structural coupling of avoidant (for victims) / ambivalent (for abusive partners) attachment styles the discriminating factor between dysfunctional couples and non-dysfunctional couples. In so doing, SCT circumscribes this risk just to one category of women (insecure/avoidant women coupling with ambivalent partners), implying a victimization risk that is not uniformly distributed. Therefore, should we believe that victims are, in a certain extent, predestined" victims? By applying theoretical coordinates of current sociological interpretations of intimacy and conceptual categories of New General System Theory (emergence, surprise, self-organization, operational closure), the paper reflects on one-factor and linear determinism implicitly underlying mate selection processes in Structural Coupling Theory and its implications for IPV (Intimate Partner Violence). It proposes that adaptive complex system and non-banal machine concepts are more effective to understand the mate selection process than linear deterministic approach, which appears too mechanistic for a process that exhibits an inextricable dimension of emergence, surprise, uncertainty, unpredictability, resulting from an interweaving of choice interactions and factors able to orient them. The modern language of Complexity allows us to understood couple system as emergent self-organization of an interaction system between agents being involved in a mate selection decision-making process and, therefore, partner s choice as a not determinable, not predictable choice. This means a change of perspective than structural coupling hypothesis, implying that any scenario, any structural coupling is possible. Research results on a sample of 100 victims of IPV do not corroborate the linear one-factor determinism underlying Structural Coupling Theory neither its implications. Rather they go in the direction of Complexity, supporting the idea of a victimization risk being uniformly distributed. If from a theoretical point of view this perspective may appear more democratic, less prejudicial than structural coupling hypothesis, from a practical point of view it is certainly more alarming. From this point of observation, there would be no personal resource able to exert a preventive function: personal security is not a reservoir of resources to which a woman can draw upon to protect herself from the risk of being victimized. Vulnerability appears absolute and general, and victimization risk imponderable.

Gregory **Derry**, *Loyola University Maryland, USA*
Ethan Mullen, *Loyola University Maryland*
Kenneth Marcelino, *Loyola University Maryland*

The Role of Dynamical Time Scales in Extracting Information from Event Occurrence Data

A valuable tool to characterize the dynamics of a chaotic system is time series analysis, which provides information about the dimensionality of the strange attractor governing this system, along with other chaotic measures. The data for such analysis typically consists of measurements taken at equally spaced time intervals, but an alternative method is to use data consisting of a sequence of unequal time intervals occurring between events generated by the system. In both cases, obtaining valid results requires the characteristic time scales for changes in the system to be comparable to the time intervals employed, but this is not always possible in real experiments. In the present work, we explore the effects of such time-scale mismatches in order to better understand how to interpret the results of investigations subject to constraints of this sort. Two model systems are used to conduct this exploration: a computational model of the endocrine system underlying the menstrual cycle, and empirical voltage/current data from the well-understood Chua circuit. In the former case, the relevant time intervals are the times separating the onset of successive menstruations. For the Chua circuit, time intervals were constructed using an integrate-and-fire protocol, which has also been employed to model the activity of neurons. In both cases, we have access to values for all of the relevant dynamical variables, so results using embedding techniques (i.e. state space reconstructions) can be compared with analyses that don t require that complication. The results of this study include: the relationship between correlation dimensions computed at differing time scales; conditions needed for improved validity of a time series analysis; and an assessment of the practical usefulness of our findings for systems in which time intervals available for empirical study differ greatly from the dynamical time scale for significant change in that system. In addition to the explicit connection with nonlinear dynamical studies of physiological systems already mentioned, the results presented here have methodological implications for studies of a variety of nonlinear phenomena in the life sciences, psychology, physical systems, and engineering, because the time-scale mismatch issues involved are analogous in all of these disciplines. Finally, as a specific example of the application of insights from this study to the interpretation of results from a real problem (i.e. not a model), we will briefly discuss the time series analysis of empirical menstruation data in which issues of this sort arise.

Please note: The abstracts are alphabetically ordered by the last name of the first author

Paula **Derry**, *Paula Derry Holistic Health Perspectives, USA*

Implications of a Nonlinear Dynamical Framework for the Conceptualization of Health: The Case of Menstruation/Menopause

The basic assumptions and conceptual frameworks underlying research and practice in health care have powerful influences on how health and disease are conceptualized and treated. Researchers and practitioners have examined how a perspective based in nonlinear dynamics alters common assumptions about disease, such as: disease is a deviation from a predictable order, strict differences between health and disease exist, and others. In this presentation, I explore how a nonlinear perspective, and chaos theory in particular, influence the conceptualization of health and disease in four areas, drawing on examples from the menstrual cycle, especially the transition to menopause. Research conducted by Greg Derry and myself provided evidence that the menstrual cycle is the output of a nonlinear dynamical system in a chaotic trajectory. This was true for our subjects, followed from age twenty until menopause, throughout life. The transition to menopause, when cycles become unpredictable, is most commonly thought of as indicating an unstable system breaking down, but we found that the system remained chaotic rather than disordered throughout life. Our results have implications for: 1) Conceptualizing the physiology of the normal menstrual cycle and of pathology; for example, irregular cycles or other deviations from average patterns define pathology vs. individual patterns are variable and pathology may be multidimensional; 2) Health education; for example, education focuses on symptoms vs. process or patterning; 3) Encouraging positive health, including well-being and coping skills; for example, providing positive images of physiological processes to encourage agency and hope; 4) Biological processes as indicators of a woman s place in the life cycle; for example, menopause defined as senescence and otherwise problematic vs. menopause is one aspect of a life stage with its own meaning. The implications of our menstruation/menopause research provide concrete examples of how a nonlinear perspective can influence one s stance towards health and disease, with a nonlinear perspective lending itself to a holistic, systems perspective.

Martin **Gardiner**, *Brown University and New England Conservatory of Music, USA*

Two Strategies for learning Skill

This paper will present new evidence and continue to develop theory to address effects of music training on broader mental skill learning which I have been discussing at these meetings. I now propose that we are born with two strategies for learning and developing skill. One is to prepare desired skillful activity in advance and to then execute Reproductively what is prepared whenever needed. The other is to prepare to execute skill Creationally, that is, assembling behavior Dynamically, when and as needed, using ability to do so prepared in advance. Ability to recite the Pledge of Allegiance memorized in advance involves application of Reproductive strategy, while many spoken utterances must be assembled for the first time as needed Creationally. In practice we can use and integrate both strategies as we develop our capabilities, more stereotyped actions executed reproductively, less predictable one executed Creationally. Our educational systems, especially prior to college, often focus training on, and thus encourages development of uses of Reproductive strategy producing mental capabilities. But advance in any ability increasingly demands Creational strategy as well. All of us develop many creational capabilities involving physical actions, but many of those who struggle with academic subjects could, I maintain, profit from better development of further development of creational strategy addressing area of skill such as math and verbal language. New evidence of broader impact of music training I will present supports the hypothesis that what is documented relates to advances in specific forms of musical skill that depend heavily on creational strategy, and that this in turn helps a learner to discover how to more easily develop important creational strategy needed for advances in verbal and mathematical skills.

Martin **Gardiner**, *Brown University and New England Conservatory of Music, USA*

Far Transfer between Skill Domains Can Illuminate Dynamics of Creational Construction

Continuing from my previous presentation at this conference, by creational strategy I refer to dynamic assembly of behavior at the time and as needed, comparing this to reproductive strategy that addresses behavioral needs by preparing behavioral capability in advance. Because it is more easily taught and learned, education often stresses reproductive

strategy as skill learning of any kind begins. But advance in every area of skill increasingly demands creational strategy. Creational strategy, I propose, influences not only how skilled behavior is executed, also how preparation for skilled behavior is learned. Creational construction is inherently dynamic, building behavior through details of implementation and from components prepared in advance specifically adapted to the needs the skill addresses. Ability to read for meaning, as an example, involves many different details depending on whether verbal language, or musical notation or math equations are being read. What can be identical or, more likely, similar, are strategies even if many details of implementation remain different. I do research on and document what some term far transfer , i.e. the impact of skill learning in one application domain to development of skill in another. Creational construction theory implies that such transfer could not involve transfer of brain operations from one application domain to another, but rather fruitful adaptation of details of creational strategy found useful in one domain to related strategic application in another. I will illustrate this with examples of transfer between music and math and between music and verbal language skills.

Orlando **Gomes**, *ISCAL Lisbon Polytechnic, Portugal*

From Conventional Equilibrium Models to Multi-Agent Virtual Worlds: A Prototype Economic Growth Example

In a 2013 essay, the economist W. Brian Arthur highlighted that science in general is experiencing an irreversible metamorphosis: the mechanicist equation-based equilibrium approach is being consistently and pervasively replaced by a different view about natural, social, and economic phenomena, a view that is fundamentally procedural, algorithmic, and complexity-based. Economics is, currently, one of the scientific fields where this change is most apparent. Economic models founded on the concept of representative rational agent, whose optimizing behavior is destined to conduct the economy to a pre-specified equilibrium outcome, are being challenged by a voluminous amount of literature where ideas and notions in the exact opposite pole dominate, i.e., the ideas and notions of agent heterogeneity, bounded rationality, network connectivity, and out-of-equilibrium dynamics. In this paper, we take one of the most emblematic models of the economic orthodoxy, the representative agent optimal growth problem, and discuss the adaptations it needs to go through to be reflexive of a virtual world of interacting agents. The rational agent that maximizes intertemporal utility is replaced by a profusion of heterogeneous households, who are endowed with distinct productivity and confidence levels, who are connected through complex networks, and who make consumption-savings decisions based on a boundedly rational rule (a heuristic). In the end of the day, the new theoretical framework preserves the fundamental concept of what an economic growth model should be, at the same time it offers a richer structure of analysis, allowing for a deeper debate on the dynamics of the aggregate economy.

Niels Neirynck, *Ghent University, Belgium*
Willy **Govaerts**, *Ghent University, Belgium*
Yuri A. Kuznetsov, *Utrecht University, Netherlands*
Hil G.E. Meijer, *Universit of Twente, Netherlands*

Advances in Numerical Bifurcation Software: MATCONT

We discuss a completely renovated GUI for the software package MatCont for bifurcation studies of continuous dynamical systems, i.e. systems of nonlinear differential equations whose solutions change qualitatively under the variation of parameters. It is built upon the corresponding command line package Cl_MatCont. Both are freely available, in fact undistinguishably, from www.sourceforge.net. From the applications point of view, MatCont is already the most often used software for bifurcation studies in research fields where phenomena are modelled by dynamical systems with parameters. Though first mainly used in (bio)chemistry, physics and engineering, MatCont is nowadays used in many life science applications. Among the list of published applications we mention bacteria-phage interaction in a thermostat, organic matter decomposition, use of transcriptomic data, population dynamics, bottom fishing, neural models, insulin secretion, innate immunity responses of sepsis and infectious diseases. The previous version of MatCont was at the end of its life span of maintainability and the new MatCont will give it a fresh start. Mathematically, the functionalities of MatCont with respect to bifurcation techniques are unrivalled. E.g., no other software allows to compute the normal forms of codimension two bifurcations of periodic orbits, or to start curves of codimension one bifurcations of periodic orbits from codimension two equilibrium points. From a computer science point of view the new MatCont is a completely new creation. The GUI is programmed to allow a maximal flexibility to reprogram the layout of windows, buttons and input fields on the screen. It contains automatic tests to check if a new MATLAB version produces the same results as the previous version. Error handling of plots is much improved so that malfunctioning of plots (for any reason) does not crash the computations. Unlike the previous versions, it has an external documentation and a detailed internal documentation which can also be consulted

from the MATLAB command line. The core mechanism of the new MatCont is an intermediate software layer between Cl_MatCont and the GUI as seen by the user. Important other parts, which can be used semi-autonomously, are the generator of the system m-files (SysGUI.m), the spreadsheet viewer and the GUI subsystems Data Browser and Diagram Organizer. The database of the new MatCont is reorganized and its Data Browser is one of the main new features in MatCont. Among the many other new features we mention a novel method to compute Poincarı sections by the use of the properties of Event functions in MATLAB and the reorganized Options tab with a Plot Properties window which allows to make detailed choices on the way in which computed curves are drawn in the plot windows.

Stephen **Guastello**, *Marquette University, USA*
Lucas Mirabito, *Marquette University*
Anthony Peressini, *Marquette University*

Autonomic Synchronization under Three Task Conditions and its Impact on Team Performance

Psychologists have had a long-standing interest in the connections between group social processes and team performance. The biopsychosocial perspective has piqued an interest in further connections between team processes, performance, and synchronized physiological arousal levels among team members. Studies of synchronization in work teams have been stalled, however, by the lack of a metric that captures the total synchronization within teams of three or more people. This study examined the conditions under which synchronized physiological arousal does in fact connect to team performance and related group process outcomes by utilizing the SE coefficient developed by Guastello and Peressini. Forty-three groups of 3 to 8 participants (total N = 197) participated in a survival simulation in which their airplane crashed in northern Canada. Synchronization coefficients were produced for three task segments: watching an orientation video together, an individual decision task, and a group decision task. Primary results showed that (a) synchronization was greater in larger groups across the three task segments. (b) A combination of the three synchronization coefficients higher during the team task and lower otherwise was correlated with higher workload ratings for performance demands, greater team dissatisfaction, and lower demands for time-sharing between the individual and the team. (c) Team performance was best when synchrony was lower during the individual task and stronger otherwise.

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Laura Marsicek, *Marquette University*
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The Prediction of Chaotic Events and the Prediction of a Rare Skill

People often live and work in chaotic systems, and thus need to predict and control what will happen next. A span of research (1993-2002) showed that people were able to predict chaotic number series to some extent and probably use some mental heuristics to so. The management of chaos is thought to be a rare skill, and the mental heuristics are not well understood. It could also be valuable to be able to identify this skill in the general workforce. In the present study, 147 untrained undergraduates predicted number series from chaotic attractors of varying levels of complexity: Logistic Map, Henon, Sprott, and Lorenz attractors. Results showed that participants ability varied greatly by type of attractor, whether the attractors time series were relatively persistent versus anti-persistent, and whether the attractors time series were predicted for one, two, three, or four steps into the future. Analysis of cognitive variables and 16PF personality traits showed that field independence was the most frequent correlate of performance along with some personality traits usually associated with the creative personality profile.

Shan **Guisinger**, *University of Montana, USA*

The evolution of specialized human instincts

Natural selection operating on the tremendous diversity created by complex systems operating near the edge of chaos has resulted in the rich diversity of forms and behaviors of living things. As Prigogene and others contend, the information dynamics of dissipative systems (such as those involved in human phylogeny and ontogeny) can create order and structure. The many ways that humans nature is fundamentally different from that of other apes points to humanity s specialized instincts to pair bond, raise children, hunt and fight in groups, explicitly teach children skills and knowledge, nurse, doctor and lead. The study of how species foraging and breeding strategies evolve to maximize fitness, integrating recent neuroscience research, nonlinear dynamical systems theory, evolutionary biology and behavioral ecology, helps us understand our ancestors specific psychological adaptations to life as nomadic, omnivorous, opportunistic hunter-gatherers. Astonishing diversity can result from small differences in initial conditions that lead to large differences

later on. The actions and interactions of the individual parts of an organism -- neuronal branching, enhanced blood flow to particular brain regions and circuits and decreased activation of others -- can lead to a person s different powerful ideas about what one is doing and can be conceptualized as chaotic attractors. Examples include, I am a good mother, winning athlete, or brother-in-arms, and these (in interaction with hormonal and other systems) organize personality and behavior. Large networks of individual neurons, following simple rules with no central control give rise to patterns such as the distinctively maternal and yet diverse and constantly changing behavior patterns of a new mother or father. Instincts are possible because of the tendency of emotions and cognitions (or their biological substrates) to self-organize into a coherent story. Innate predispositions for individuality and for relatedness combine in nonlinear ways during individual development.

Rachel **Heath**, *University of Newcastle, Australia*
Brendan Tisdell, *University of Newcastle*

Human Implicit Recognition of Chaos: An Empirical and Theoretical Investigation Using Cross-correlation Analysis and Multifractal Detrended Fluctuation Analysis

Previous research by Heath (2002) and others has shown that people are sensitive to the nonlinearity contained in a chaotic sequence even when they are unaware that the series is chaotic. This sensitivity to chaos is evident when people's predictions of a chaotic series are better than those obtained with phase-randomized surrogate control series that have the same linear properties as the chaotic series but no nonlinearity. In Experiment 1 people tracked the moving center of a circle displayed on a computer screen for 12 two-minute trials during which the stimulus sequence was equally likely to be chaotic, a surrogate control or Gaussian noise. The average tracking error was significantly less for the Hénon chaos condition than for the surrogate and Gaussian series, $F(2,6) = 55.41$, $p < .01$, indicating that people are sensitive to the nonlinearity within the chaotic series. Cross-correlation functions relating the stimulus and response locations provided an accurate prediction of responses within each trial. A nonlinear index derived from a system identification analysis of the two-dimensional stimulus-response sequences indicated that tracking performance for the chaotic and surrogate series was significantly different from that for the random series for which prediction was not possible. In Experiment 2, people tracked one of four chaotic series derived from Hénon, Ikeda, Logistic and Lorenz attractors. The average area under the linear cross-correlation functions relating stimulus and pointer locations increased monotonically with the amount of chaos contained in the series, as was quantified by an estimate of the maximum Lyapunov exponent, $F(3,28) = 22.9$, $p < 0.001$. This result showed that people are not only sensitive to the nonlinearity contained in a chaotic series but also to the rate at which nearby trajectories diverge over time. As these results showed that people are sensitive to environmental fluctuations that may occur over different time scales, a multiplicative cascade model driven by a Gaussian diffusion process with mean μ and variance σ^2 was fit to the multifractal spectra estimated using MFDFA. The fit of the Gaussian model to multifractal spectra computed for the data and surrogate series derived from the data was virtually perfect in most cases. It was shown that the ratio of variances for the response and noise series was larger for the Hénon series than for the Ikeda and Lorenz series, $F(3,27) = 6.73$. $p = 0.002$. This finding suggests that people's sensitivity to chaos in their environment may reflect the variability inherent in multiplicative processes rather than the average values. These novel findings suggest that people are sensitive to nonlinear features of their environment that operate over multiple time scales, as is the case for the weather, the mountains and trees, as well as birdsong and many other phenomena (Heath, R.A. (2002). Are people sensitive to chaos? *Nonlinear Dynamics, Psychology and Life Sciences*, 6, 37-54).

Rachel **Heath**, *University of Newcastle, Australia*

Automated Lifestyle Assessment and Relapse Monitoring

People who have been diagnosed with chronic conditions experience periods when they are not as well as they normally are. Examples include those with physical ailments such as chronic heart disease, asthma and diabetes who can suffer a temporary deterioration in their condition, and those with mental illnesses such as chronic anxiety, depression and bipolar disorder who may need a change in medication or hospitalization in serious, possibly life-threatening, situations. The medical challenge is to anticipate when the client is most in need of assistance, especially when there is no scheduled medical appointment and regular medical monitoring is not available. These days, advantage can be taken of lifestyle monitoring using smart devices such as a mobile phone, a Fitbit and an Apple Watch that provide detailed information about people s daily lives, their activity, heart-rate, social interactions, sleep quality, and much more. With appropriate monitoring software, these smart devices can use changes in lifestyle measures to indicate the early signs of relapse. If allowed, a message can be sent to the person s medical team so that urgent assistance can be obtained. Our Automated Lifestyle Assessment and Relapse Monitoring (ALARM) system uses activity measures obtained from an Actiwatch and

heart-rate measured by a Fitbit Charge HR and an Apple Watch. The pooled time series data are analyzed using a Gaussian diffusion network that produces a predicted multifractal spectrum and its associated Relative Entropy. This index compares entropy obtained from the data series with entropy computed from the average of 30 surrogate series, the latter having the same linear characteristics as the original data but with any nonlinearity removed. It is assumed that Relative Entropy indicates how well a person is dealing with environmental changes, some of which may be stressful. We assume that good health is indicated by a relatively stable and high value of Relative Entropy and a low value of Relative Entropy may provide an early sign of impending ill-health that may require medical intervention. When the multifractal model was applied to data from patients diagnosed with bipolar disorder, for a few cases the early signs of relapse were indicated by a significant decrease in Relative Entropy. In other cases, a relatively unchanging Relative Entropy indicated that the person s condition had stabilized, at least during the monitoring period. Even for someone who has not been diagnosed with any chronic medical condition, fluctuations in Relative Entropy provide an ongoing estimate of that person s normal ups and downs , as is indicated by some personal data. So, ALARM can be used by anyone who wishes to monitor continuing changes in their adjustment to environmental demands. ALARM is being developed for use on mobile devices and wearables that allow continuous monitoring of relevant lifestyle variables. It is hoped that such a system will reduce the large cost and personal burden that occurs when people need to be hospitalized following relapse.

Matthijs **Koopmans**, *Mercy College, USA*

From the Time Domain to the Frequency Domain and Back Again: Finding the Best of Both Worlds in Three Illustrative Datasets

From the Time Domain to the Frequency Domain and Back Again: Finding the Best of Both Worlds in Three Illustrative Datasets Matthijs Koopmans Mercy College (USA) Two complimentary but distinct approaches are available to analyze fractal patterns in time series data. One is fractional differencing, an extension of the conventional autoregressive integrated moving average models formulated by Box and Jenkins (1970), which relies on the estimation of a differencing parameter to describe the extent to which a time series displays persistence or anti-persistence, i.e., nonrandom patterns that persist throughout the series (e.g., Staditski, 2012). These patterns are said to indicate fractality (Mandelbrot & van Ness, 1968). This approach assumes that the statistical properties of the series are constant (stationarity), but allows one to distinguish seasonal and fractal patterns through stepwise competitive modeling. This approach represents the time domain. The second approach is spectral density analysis (SDA), which uses a mathematical operation called the Fourier transform to re-structure a time series into a relationship between cycles at varying lag sizes (relative frequencies) and the variance in the data explained by these cycles (i.e., their amplitude or power). This approach, which represents the frequency domain, relies on the generation of power spectra, which log-transform the power and relative frequency into a plot that can be readily interpreted as indicating the presence or absence of fractal patterns. SDA incorporates the stationary and non-stationary cases into a single analytical framework, but it does not detect seasonal regularities very clearly. Results from the two approaches will be compared using three illustrative data sets: Monthly unemployment figures in the United states from 1948 through 2017, a non-stationary series that is highly seasonal (U. S. Department of Labor, 2017), daily number of births to teens from January 1964 through March 1966 in the state of Texas, a series showing complex seasonal patterns (Hamilton et al., 1997) and left-right political orientation in the Netherlands from January 1978 through December 1996, a highly persistent but non-seasonal series (Eisinga, Frances, & Ooms, 1999). These three analyses illustrate the advantages and disadvantages to each approach and they also indicate what can be gained by using them in conjunction to cover both domains.

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Fractal characterization of stochastic series fluctuations of children with reading disorders

The generation of knowledge through learning in humans is carried out by the brain through nonlinear interrelations of several layers and types of neurons, from which collective behaviors emerge in the form of a combination of physiological and cognitive processes that allow interaction with the environment and maintain physical and cognitive stability. The connections in neurons are variable among people, so the structures for learning are too, which in turn makes identification and origin complex when these interrelationships are not functional and bring about

difficulties in learning. This disorder has been the subject of study among different branches of knowledge, whether it is referring to the physiological or cognitive component with the performance of studies that provide data that are treated with qualitative and quantitative linear tools to obtain the average behavior determined and the causality of it. However, living systems do not obey linear issues; the actions that emerge from them have complex characteristics, which explanation or understanding is far from being able to be represented from their components and their individual behavior, so their study and understanding requires the joint use of different scientific approaches and non-linear tools. This research focuses on the non-linear quantitative characterization of learning disorders, specifically, the acquisition of reading. For it is required in the first place, to establish the characteristics of the system, from physiological, psychological and systemic perspectives, the first refers to all the physical implications related to the cognitive processes that allow the detection of the disorder and the second to establish inclusion between different theoretical and methodological frameworks. It was determined through the metamethodology of Total Systems Intervention, the complex context of coercive difficulties in learning (reading) and in this way the postmodern systems thinking was selected, approach where the theory of Fractal Geometry is set to be used as a non-linear quantitative tool in the processing of brain wave quantification (EEG). Brain information is characterized by the dynamics of time series fluctuations of children with reading disorders in Estado de Mexico, by applying fractal geometry and roughness interface growth theory. From the EEG of children (experimental and control group) were built time series of standard deviation for each of the 19 channels (electrodes) distributed in cerebral cortex. The self-affinity of the time series (treated as interfaces in motion) is characterized by the scaling behavior of the structure functions by one hand , with as the local exponent, and the other hand , with as the fluctuation growth exponent. It was found that the behavior of the time series of children with reading problems (experimental group) and without them (control group) is similar to the Family-Vicsek scaling dynamic for a kinetic roughening of moving interface. Therefore it would possible to characterize and model the studied time series by using the tools from the theory of kinetic roughening such as the Langeving type where is the external force, the noise, and is the real form of the function.

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Linear vs. Nonlinear Regression Models in Psychology and Life Sciences: Why to Compare Non-comparable

At the moment several groups of mathematical methods are used for explaining and predicting the behavior of psychological and/or sociological systems. Frequently a dichotomy is made between complex (knowledge-based) and empirical (black-box) models. Unfortunately, the high accuracy of complex models comes at the expense of interpretability; e.g., even the contributions of individual features to the predictions of a complex model are often difficult to understand. In opposite, empirical models usually include statistical analysis procedures based on the general linear model or one of its multivariate generalizations (structural equation models (SEM), generalized linear models (GLM), etc.). Although the different types of linear models are most frequently used approaches in psychology and life sciences, there is a widespread consensus that linear models and the conceptual strategies behind them are inadequate for explaining and predicting psychological and many other types of events. However, when there are physical reasons for believing that the relationship between the response and the predictors follows a particular functional form not only knowledge-based model can be applied but nonlinear regression models as well. To our surprise the application of nonlinear regression models in psychology and life sciences are very rare. Decades of our experience in mathematics/psychology sciences reveal that nonlinear semi-empirical approach be may be regarded as a method that provides the explanation power of knowledge-based models without their insufficient interpretability. Semi-empirical is defined as a model in which calculations are based on a combination of observed associations between variables and theoretical considerations relating variables through fundamental principles (e.g., conservation of energy) (IPCC-2013). This approach is able to take into account the most essential features of complex social systems. Although there are a number of characteristics of complex systems, such as uncertainty, interactions among processes deployed at different scale, self-organization and emergence, the nonlinearity of their behavior poses most of the challenges for scientists. Previously we studied the performance of generalized multiplicative models (GMultMs) which are based on the method of response functions (MRF) and can be used to identify, explain and predict nonlinear synergistic effect of potential prognostic factors on the processes under study. Short presentation of several constructed GMultMs will be provided. Although, no one linear model is able to provide the

information needed for understanding the behavior of complex system as the GMultMs are able, the reviewers usually strictly request the comparison of the results of conventional linear models and GMultMs. Arguments with subsequent examples will be presented that such comparison has no any scientific sense. Also, the most common measure which discriminates a good from a bad fit of the models is the coefficient of determination R2 proposed in 1921 by S. Wright. Although it is known from the literature that at least eight different expressions for R2 exist that are not equivalent and in case of nonlinear regression it should be applied with great caution, many scientists and also reviewers insist on it being supplied in papers dealing with nonlinear regression. Several arguments with relevant examples will be provided when and how R2 can be applied to assess the goodness of fit of nonlinear regression models.

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Predicting sickness absenteeism in firefighter teams through cusp catastrophe modelling

Firefighting is a highly demanding occupation, with individuals and collectives being submitted to high levels of strain during performance episodes. Therefore, firefighter teams are regarded as complex adaptive systems. Building on the job demand-resources (JD-R) model and teams as complex adaptive systems (tCAS) theory, we analyse whether the initial conditions of team adaptability and task cohesion, as team resources, will influence work overload and sickness absenteeism dynamics over a period of seven months. Participants were 37 firefighter teams (n = 250 individuals) from a main European capital city. Hypotheses testing was done using the package cusp . In the cusp model, while team adaptability and task cohesion were regarded as symmetry factors, workload was regarded as an asymmetry factor. The results show that sickness absenteeism does change over time, with the cusp model, R2 = .29, AIC = 626.96, AICc = 627.41, BIC = 651.86, explaining more variance than the linear, R2 = .06, AIC = 616.17, AICc = 616.40, BIC = 633.95, and logist, R2 = .13, AIC = 598.31, AICc = 598.65, BIC = 619.65, models. Task cohesion was negatively related with sickness absenteeism, B = -.70, SE = .31 p = .023, 95% CI [-1.305; -0.097], suggesting that higher task cohesion is a team initial condition leading to less sickness absenteeism behaviours over time. Team adaptability and workload were unrelated with sickness absenteeism. This study contributes to the growing evidence that the incorporation of longitudinal and nonlinear techniques for data analysis is necessary to enrich what we know about action teams in extreme environments.

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Anticipatory care in potentially preventable hospitalizations. Making data sense of complex health journeys

Purpose: Potentially preventable hospitalizations (PPH) are minimized when adults (usually with multiple morbidities ± frailty) benefit from alternatives to emergency hospital use. A complex systems and anticipatory approach to PPH, the Patient Journey Record System (PaJR) is proposed. Application: PaJR is a web-based service supporting ≥weekly telephone calls by trained Care Guides (CG) to individuals at risk of PPH. The Victorian HealthLinks Chronic Care algorithm provides case finding from hospital big data. Prediction algorithms on call data helps optimize emergency hospital use through adaptive and anticipatory care. Monash Watch deployment incorporating PaJR is conducted by Monash Health in its Dandenong urban catchment area, Victoria, Australia. Theory: A Complex Adaptive Systems (CAS) framework underpins PaJR, and recognizes unique individual journeys, their historical and current influences, and difficult-to-predict tipping points. Rosen s modelling relationship and anticipation theory additionally informed the CAS framework. PaJR uses current and future health perceptions (interoception) through conversations to anticipate potential tipping points and intervene in PPH trajectories. Evaluation: Monash Watch is actively monitoring 272 of 376 intervention patients, with 195 controls over 22 months (ongoing). Trajectories of poor health (SRH) and anticipation of worse/uncertain health(AH), and CG concerns statistically shifted at a tipping point, 3 days before admission in the subset who experienced ≥1 acute admission. The -3 day point was generally consistent across age and gender. 3 randomly selected case studies demonstrate the processes of anticipatory and reactive care in relation to tipping points. PaJR-supported services achieved higher than pre-set targets consistent

reduction in acute bed days (20-25%) versus target 10% and high levels of patient satisfaction. Discussion: Anticipatory care in an emerging trajectory data analytic approach that uses human sense-making as its core metric demonstrates improvements in processes and outcomes. Multiple sources can provide big data to inform trajectory care, however simple tailored data collections may prove effective if they embrace human interoception and anticipation. Admission risk may be addressed with a simple data collections including SRH, AH and CG perceptions, where practical. Conclusion: Anticipatory care, as operationalized through PaJR approaches applied in Monash Watch demonstrates processes and outcomes that ameliorate PPH.

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Networks of Boards of Directors: A Gender Gap of Power laws

There is a large body of research on the underrepresentation of Women on Board (WoB). However, the literature has focused in analyzing the proportion of women, but this only presents part of the picture. Complex network analysis applied to this problem allows to study the influence and centrality of women (i.e. their economic power) in the social network of directors. In this empirical research, we extend the literature on the role women play in the network of directors in Europe, using analyzing the power laws for both men and women. To do so, we have used a database of 41,107 directors of 38 countries and 5 territories in Europe that hold 425,322 board positions from 2000 to 2015, to build up 16 separate networks for each year, in which 2 directors are linked if they have a seat in the same board of directors. Once we have these networks, we have computed four different centrality measures (degree, closeness, betweenness and eigencentrality) for each director. Comparing the values of these measures for male and female directors we observe that women not only are underrepresented (they are just 11.9% of the sample), but they have a lower centrality measures (at least, in terms of degree, closeness and eigencentrality). We also observe that the distribution of the network degree for both men and women follows a power law for all the years where we have reconstructed the network. In the case of men, the exponent of the power law is remarkably persistent (going from 2.6 in 2000 to 3.3 in 2014), and higher than in the case of women (that moved from 2.2 to 2.9 in the same period). The lower exponent for women implies that the power in the network of female directors tends to be more concentrated in a smaller fraction of women, than in the case of men. This lower value of the power law exponent could be a consequence of the existence of a small number of women that have attained a large number of directorships and that has been labeled as the Golden Skirts by newspapers like the Financial Times, that tend to fade away as times goes by and political and regulatory pressure by various European countries is increasing the degree of democratization for women in the European board member"s network. This implies, that affirmative action policies regarding the increasing of WoB in Europe is causing that the Golden Skirt phenomenon fades away as more women directors are getting influence on the European directors network.

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Neoclassical growth model with two-fixed delay

Delay has been considered as one of destabilizing factors in macroeconomic dynamics since the seminal work of Kalecki (1935). In this paper introducing two fixed delays into the traditional neoclassical growth model, we first rigorously determine the conditions for which the stability is lost and then numerically confirm the analytical results. We add one interesting feature of the delay dynamics. Stability loss and gain repeatedly occur as a delay parameter increases. This implies that the delay is not only a destabilizer but also a stabilizer.

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Chaos in Plankton Population Size Oscillations: The Ambivalent Effect of Temperature Variations

We present the results of the analysis of the dynamics of plankton populations, which inhabit the Naroch Lakes, Belarus. The Naroch Lakes system consists of three water bodies: Lake Naroch, Lake Myastro, and Lake Batorino. We demonstrate that the dynamics are chaotic. Chaoticity of fluctuations in population abundance can be either an immanent feature of the dynamics and/or be related to environmental influences. In order to evaluate the action of changes in the environment on plankton dynamics, we assessed numerically the extent to which chaotic fluctuations of bacterioplankton and phytoplankton abundances in the Naroch Lakes were synchronized with temperature oscillations. With the use of the analysis of phase relations between bacterioplankton and temperature time series we show that the chaotic bacterioplankton oscillations are synchronized with water temperature oscillations, while chaotic fluctuations of the phytoplankton abundance are not synchronized with the temperature oscillations in Lake Naroch and Lake Myastro in contrast to the phytoplankton fluctuations in Lake Batorino, the smallest of the Naroch Lakes, where phytoplankton fluctuations are phase-locked by the temperature oscillations. We conclude that temperature is the factor that has significant impact on predictability of the bacterioplankton fluctuations, while dynamics and predictability of phytoplankton dynamics can apparently be controlled not only by the temperature but also by trophic interactions and nutrient supply. Hence, temperature is apparently the factor, which does not directly impact the temperature-phytoplankton phase synchronizations in the Naroch Lakes, but is indicative of coupling/uncoupling of bacterioplankton and phytoplankton oscillations. This work was partially supported bt the Russian Foundation for Basic Research (grant # 17-04-00048).

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How an emotional dynamic occurs during prolonged stressful situations (among college students)

The explicit and implicit positive and negative affects of 151 people were measured daily for a month. During this month the subjects (bachelor students -85 persons) were in stressful situation caused by participation in intensive educational course and other 66 were newcomers and their stress was caused by adaptation reasons. All subjects are students of Branch Lomonosov Moscow State University in Tashkent (Uzbekistan). Dynamic characteristics for each subject were measure as Shannon entropy and lambda-parameter from logistic map helping to describe the level of each affect at time (n+1) as function of the same affect at time n. Also average and variance for each affect during 30 day as static characteristics were calculated. Also the subjects were tested by methods measuring traits personal potential determining optimal personal functioning (aspects of self-regulation, styles of personal interaction and different types of activity.) Static indicators (average and variance) of positive emotions are directly related to personal potential, and static indicators of negative emotions related with characteristics that impede the optimal functioning of a person. Signs of correlations of static indicators with personal characteristics are more consistent than signs of correlations of dynamic indicators. So static indicators are higher and more often correlate positively with the characteristics of personal potential and negatively with characteristics that aggravate the experience of stress for positive emotions and vice versa for negative emotions. Emotional activation in the dynamic aspect (the total level of single point attractors of positive and negative emotions in a person) correlates positively with the traits of personal potential. Here a common emotional background - the level of

simultaneous expression either positive or negative emotions is important and a sign of emotion is not. The relationship between personal characteristics and indicators of the emotional state manifests itself in different ways for explicit and implicit emotions. At the implicit level, connections with dynamic indicators (entropy, attractor) are more established. At an explicit level, connections with static indicators of emotional states (average, variance) are significant. It can be assumed that emotional states defined on an explicit level reflect stable personal qualities to a greater degree, and not the dynamics of emotional states.

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Dankert Vedeler, *Norwegian University of Science and Technology (NTNU), Trondheim, Norway; Arizona State University, Tempe, AZ, USA*

Psychiatry revisited: Understanding mental disorders as a consequence of chaos and maladaptive order maintenance

Self-organization is a process where local order emerges in a context of irreversible processes creating a distinction between an open system and its environment. In accordance with the imperative of the Second Law, ordered systems arise by the conjoint dissipation of energy and matter far from thermodynamic equilibrium at the expense of an increased entropy (or chaos - the here preferred term) in the environment. The concept of a dissipative structure has a powerful epistemological potential for psychiatric research and clinical practice because it is well adapted to a non-linear analysis of very complex phenomena, thus departing from some fundamental assumptions held in a linear, classical reductionist view on psychiatry. In the proposed model presented here, two main sources - primary and secondary - of psychiatric disorder are identified, the primary being conditions increasing chaos (either thermal chaos or far-from-equilibrium turbulent chaos) the secondary being maladaptive, self-organizing attempts to maintain order. This model also separates between primary and secondary psychiatric symptoms related respectively to the increase of chaos and the attempted maintenance of order. It involves an autocatalytic process, characteristic in self-organized processes: The primary symptoms, when pushed to the limit of the system s chaos tolerance, enforces a phase transition, which yields interim order, i.e., secondary symptoms, yet subsequently enforces the primary symptoms either by energy overflow or disruption of the dissipative process.

Bernardo **Moura**, *Psychiatry and Medical Psychology Department, Faculty of Medicine, University of Lisbon, Portugal*

A dynamic systems toolbox for psychiatrists

Background: Considering the mind as a dynamic system, one can describe its functioning through models specifically developed for those systems. Thus, the disordered mind - object of psychiatry - may as well be approached through a dynamic systems analysis. Despite the acknowledgement of psychiatric disorders as dynamic entities by classical psychiatry, this is not usually stated in terms used by dynamic systems/complexity science. Some groups of researchers have however been conceiving dynamic systems approaches to psychiatric topics and these have been exponentially increasing their impact over the last years. Aims: The aims of this work are: to review concepts taken from the dynamic systems science that have been applied to mental disorders; describe their meaning and discuss their possible utility and applications in psychiatry. Mode of inquiry: a non-systematic search of articles in journals of psychiatry/mental-health including theoretical and empirical studies adopting concepts from dynamic systems analysis (also including network science) applied to any psychiatric field or disorder. Outcomes: outcomes of this study were assembled into three groups of concepts: 1) attractors and the state-space, 2) complex dynamic networks and 3) state transition models. Each of these groups contains models and concepts that might be applied in different contexts in psychiatry. Conclusions: many models from dynamic systems science can be applied to psychiatry and seem useful at least on a theoretical level. They might contribute to a better understanding of problems related to: epistemology; onset of mental disorders/resilience; causes of relapse and its prevention, among others. They might as well contribute to a more personalized approach to patients. However, empirical tests of these models are still scarce or limited to small patient groups. Implications: dynamic systems analysis tools have the potential to become an important part of psychiatry and hence one of the immediate implications of this study is to strengthen the call for bigger clinical studies using those tools and the need to familiarize mental health practitioners with them.

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Alexander B. Medvinsky, *Institute of Theoretical and Experimental Biophysics*

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Chaotic Happiness: an Evidence of Nonlinear Changes of Psychological Well-Being from Longitudinal Observations

Psychologists made a lot of efforts to develop reliable scales to measure psychological well-being as well as to determine its structure and components. It has been assumed that the psychological well-being is a stable phenomenon, while feelings, mood and emotions vary over time, being in the same time closely connected and interrelated with the psychological well-being. The questionnaires usually measure the psychological well-being at a particular point of time, and, as a result, they unable to describe its temporal fluctuations. That is why one of the aims of this work is to reveal whether the psychological well-being is stationary or variable in time. Another aim of this work is to determine patterns of variability of the psychological well-being (if the variability takes place), and to find out the numerical indicators that characterize these patterns. Four participants (two males and two females, age from 25 to 48) rated their psychological well-being on 7 point Likert scale every two hours (eight times per day) over a period of month. This period was chosen due to the need to obtain time series of at least 200-250 recordings per participant. The time series with the length of 240 294 points demonstrated aperiodic changes in the well-being. Aperiodicity of the changes was verified by the Fourier spectra. Recurrence plots (built with the use of the VRA package) showed the aperiodic structures typical of the chaotic time series. The values of the horizon of predictability (TP) of these oscillations were assessed with the use of the recurrence plots; they equaled to averaged length of diagonal lines. The horizon of predictability, which was specific for every participant, is between 5 and 11 points. Notice that the chaotic time series were characterized by alternations of unchanged and oscillatory states. In order to reveal a relative contribution of the unchanged states in predictability of the well-being time series, we evaluated averaged length of vertical lines, which corresponds to the so-called trapping time (TT). TT shows how long the system remains in a specific state. Based on the TP and TT values we introduce a measure of vulnerability (V) of the systems under study to influences of any nature: V = (1 TT/TP) * 100%. In our case, vulnerability may be closely related to such psychological resources as resilience.

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Margalida Caimari-Ferragut. *U. of the Balearic Islands*

Maria Balle *University of the Balearic Islands*

Aina Fiol-Veny *University of the Balearic Islands*

Xavier Bornas *University of the Balearic Islands*

Heart rate variability and Nonverbal synchrony along positive and negative episodes of interactions between adolescents and their fathers and mothers

The Nonlinear Dynamical Systems theory considers parent-child interactions as complex dyadic systems evolving in time. Its quality has been largely shown to be implicated in promoting parent-child secure attachment, infant's social, emotional and cognitive development, and even in fostering emotion regulation skills in adolescence.Synchrony can be considered as the temporal coordination of micro-level relational behaviours into patterned configurations that become internalized and serve to shape infant development over time and repeated experience. Such synchrony has been widely used as an indicator of parent-child dyadic quality and it has been generally studied within mother-child interactions, since maternal figure has classically been considered as the primary attachment figure. However, as most mothers accessed the workface, especially in European countries, fathers became more involved in parenting. Consequently, research progressively focused on both mother-child and father-child interactions.

Physiological responses such as heart rate variability (HRV) have been linked to affective and behavioural patterns within dyadic interactions, suggesting a connection between individuals' physiological activity and reciprocal positive social engagement which may play a role in promoting secure social attachments.

In this study we used high-frequency of HRV as measure of HRV and the Motion Energy Analysing (MEA) software to explore if physiological activity influences the behavioural one and whether mothers-adolescents interactions were physiologically and behaviourally different from those involving fathers. MEA considers nonverbal synchrony as the temporal coordination of micro-level social behaviour between interlocutors during communicative situations and provides an objective value that represents how adolescent's movement synchronised with parents' and vice versa. The main hypothesis of this study was that behavioural synchrony would be similar regardless of the gender of the interacting adult (mother or father). In addition, we expected that higher individual HRV may promote greater values of nonverbal synchrony. Adolescent gender differences were examined for both cardiac and behavioural measures.

Sixty-four mother-adolescent dyads and sixty-four father-adolescent dyads (mean age of adolescents was 14.16; SD = 0.66) were videotaped during two (positive and negative content) episodes of ten minute's interaction, separately and counterbalanced. To collect IBI data from within each interactive task, each participant wore a Firstbeat Bodyguard 2©. The MEA software was used then to analyse the synchrony between interlocutor's movement, selecting the whole bodies (head, arms, and legs) as regions of interest. The resulting quantitative indices were then exported to SPPS for statistical analysis.

No differences were found between patterns of NVS in fathers-adolescent and mothers-adolescent interactions neither along positive or negative episodes. Nevertheless, a positive correlation was found between mothers and their daughters HF-HRV within both positive ($r = .570$, $p = .002$) and negative ($r = .412$, $p = .030$) interactions.

These results lend partial support to our main hypothesis (i.e. fathers and mothers share similar levels of nonverbal synchrony with their children) showing more similarities than differences in mother-adolescent and father-adolescent interaction patterns. Otherwise, daughters shared greater physiological linkage with their mothers which could indicate a safer attachment than shared with their fathers.

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Probing Complexity in Educational Settings: Achievement Goals Orientation, Class-Structure Goals and Creativity Pursuit

Following the new paradigm of Complexity and Nonlinear Dynamics in educational research three independent studies add to the current literature by presenting catastrophe theory models explaining learning, metacognitive skills and quest for creativity. The first study was aiming to investigate the interaction of students achievement goals orientations and the perceived-class-structure goals on students self-efficacy, achievement and classroom involvement. One of the main hypotheses was to test whether students achievement goals orientations and the corresponding class structure goals can act synergetically to enhance outcomes. Cusp catastrophe analysis showed that examining students efficacy as the state variable, the mastery goals orientation acted as asymmetry factor predicting linearly the dependent variable, while class-structure goals acted as bifurcation factor. The second study was a research investigated the socialization of university students. Achievement goal theory was also used to explore students perceptions and views about their future careers. One of the dimensions considered was the creativity quest in career development, which was associated with motivational constructs. Cusp catastrophe analysis revealed that the quest of creativity predicted by mastery goals orientations in the role of asymmetry factor, while both performance approach and performance avoidance goal orientations acted as bifurcation factors. The findings are in line with previous results reported within achievement goal theory demonstrated the detrimental and maladaptive role of performance orientation goals. The nonlinear models explained better the empirical data demonstrating ones more the ubiquitous nonlinearity in psychological constructs involves in educational research. Last, it is important to stress that nonlinear dynamics and complexity opens new avenues of inquiry, by offering new methodological approaches and ways of looking at encountered findings.

Sarah **Stanfield**, *California Institute of Integral Studies, USA*

Optimizing Irreducibility: Zwicky Games as Participatory Engineering for Research Design in Complex Systems Science

How can a Zwicky Game be utilized to generate innovative research design ideas among the mamy complex systems science and nonlinear dynamics and tools and methods? Method: meta-methodology, general morphological analysis. The vast universe of tools and methods used for analyzing complexity in nonlinear dynamical systems can seem overwhelming to transdisciplinary researchers, and therefore these concepts remain inaccessible to many. Engaging multiple disciplinary frameworks increases complexity on an exponential scale while, at the same time, seeking to make the material understandable to the reader. Research design is an inherently fuzzy and acausal decision process which can tend towards reductionist models that attempt to mitigate complexity, obscuring the emergent properties of complex systems. Gamified General Morphological Analysis (G-GMA), also called a Zwicky Game is proposed as a systematic approach to research design that builds upon the work of late astrophysicist Fritz Zwicky and researcher Tom Ritchie who developed General Morphological Analysis (GMA), or the Zwicky Box method, to solve wicked problems from diverse disciplines. G-GMA is a gamified version of this problem-solving framework which is comprehensive of the possibility space while preserving the emergent, irreducible properties of complex systems in order to reveal elements and features descriptive of their unique topology and dynamics.

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Escape from fraughtness: Human game play gives insight into how self-organizing systems surmount a pervasive coordination challenge

We define fraughtness in a group coordination effort as a situation where unilateral change by any participant cannot improve a suboptimal situation, but coordinated change can do so (related to Nash equilibria in Game Theory but, here, players are not privy to the overall structure of the game and thus can t fully rationally analyze). We argue that fraughtness is a pervasive challenge for self-organizing systems and then study a particular path by which they sometimes resolve it. First, we show that a number of interesting self-organizing models struggle with fraughtness (the Voter Model, the Naming Game, Zero Temperature Glauber Dynamics of the Ising Model). Then, we point out ways that these situations resemble challenging real-world cases (e.g. political party entrenchment, endemic national conflict, plateaus in group problem solving). Third, we describe empirical results with human participants in a game called the ``Slider Game that is prone to enter fraught states. Each participant manipulates a slider that can that can be moved continuously between endpoints to the left and right. The goal is for all the players to get on the same side. Under various topologies, the players, who cannot directly observe their cohorts sliders, are told how much they agree with their neighbors regarding the choice of extreme position. Fraughtness arises frequently in a toplogy resembling small-world configurations (we ve so far tested groups of 7). The groups that fall into fraughtness get stuck in it for a while, but often escape it by a process of increasingly higher amplitude expression of what might be called intention to shift in locally interconnected neighborhoods. We present a formal model that gives the lie to the assumption that a phase-change in the computational behavior of individuals underlies the escape from fraughtness, pinning the effect instead on the evolution of information-flow in the system. We conclude by offering insight into how useful self-organizing processes may be discovered.

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Psychology and the infinite domains of nonlinearity

Simplifying a very complex matter, for the sake of clarity, and using a helpful metaphor, it can be said that, in many respects, the era of linear phenomena was for Science (in general) and for Physics (in particular) the Age of Discovery, or the Age of Exploration. It was the period, at least in European history, of fervent discovery of new or previously unknown (metaphorical) lands; from the nature of atomic structure to the experiments or theories that made possible the creation of electromagnetism and the new technologies that came about. Science, however, has meanwhile reached the point where broadly speaking there are no longer legendary lands in the southern hemisphere, such as the ultimate fantasy continent that Captain James Cook erased from the map, after an extraordinary three-year voyage across the Pacific Ocean. With very few exceptions, there are no more large landmasses to reveal, in the realm of science; there are solely (so to speak) small islands or islets. An infinitude of them, to all intents and purposes, in the midst of the ocean of our collective ignorance. That Leibnizean ocean, continuous everywhere and without a break or division, which symbolizes scientific inquiry. What Science has, speaking in generic terms, ahead of it, are the apparently infinite domains of nonlinearity. And psychology is no exception to that rule; or rather that current scenario. Quite the contrary. Breland and Breland famously ascerted, back in 1961, that there seems to be a continuing realization by psychologists that perhaps the white rat cannot reveal everything there is to know about behavior. Now is (perhaps) the time for the realization by psychologists that perhaps the study of linear phenomena if there is such a thing as a linear causality in the whole of psychology cannot reveal everything there is to know about behavior; or anything else, for that matter. Even if such a study is conducted with the utmost statistical rigour. Psychology, or rather dominant psychology, allowed the growth of a major research industry (more often than not based on voodoo correlations), in which the overwhelming majority of published findings are statistically significant, in spite of being statistically underpowered; in which high-profile studies frequently report extremely (or implausibly) high correlations, despite the dramatical increase of false-positive rates; and so on. To paraphrase the great (if largely unacknowledged) historian of psychology, Kurt Danziger, the products of this travesty of scientific method can now be seen as having contributed nothing of either practical or theoretical value. Yet, most psychologists wanted from the very beginning to emulate the harder sciences. Why did psychology not follow the new physics, in the beginning of the 20th century? Perhaps because the quantum theory, as pointed out by Gerd Gigerenzer, seemed to violate the ideal of determinism in the sense of a microscopic chaos that results in macroscopic order. Perhaps now is the time for all good psychologists to come to the aid of the discipline. And to help identify the most promising paths forward.

Hildaura **Zulantay**, *University of Barcelona, Spain*

Nonlinear Dynamics in Artistic Schools. Time Series and Class Attendance

The present case study gives an account of the partial results of a doctoral thesis whose objective is to analyze from the Complexity, from the Non-linearity, the school management, with the purpose of facilitating new perspectives in Education for the design of strategies towards the achievement of student learning. About the method. Although this study develops several investigations applying network analysis and multilevel analysis, this communication informs about partial results of the study of time series, specifically the variable Class Attendance. For this purpose, an artistic school database was used in one school year (2017), considering the school calendar and rest periods between classes (t = 259 days), the sample considered are the students (n = 461). For the treatment of data and analysis Excel spreadsheet, Visual Recurrence Analysis Software, SPSS and CDA Software were used. After preparing the database to generate the partial time series (annual attendance per student, per course, per cycle and per school), we proceeded to calculate the reliability of the data and calculate the Hurst Exponent. In a complementary way, to enrich the analysis was calculated bivariate correlations with other related variables, such as Attendance/Day, Attendance/Time, Attendance/Semester, Attendance/Course, among others (total 10). The results were the following: Reliability of time series: Alpha 0.97 Exponent of Hurst Temporal Series Attendance 2017 Artistic School: 0.123. Within the Bivariate Correlations on Attendance, nine correlations were obtained equal to zero, 1 positive and high significant correlation indicating linearity, and focusing on the study, 4 low and negative correlations, significant, indicating caoticity. It could be concluded that the variable Annual Student Attendance in Artistic School, in this case study, responds to a non-linear, chaotic dynamic in which order and disorder flow. Given this conclusion, from school management and its actors, it is possible to visualize the dynamics of periods, cycles, in order to analyze, discuss, propose and design strategies to improve student attendance, beyond a synthetic result of frequencies and/or percentages.

60-minute Workshop

Marie-Laure **Blanc**, *Synchronie, France*

How to make your complex ideas better understood and shared thanks to a dynamic "from design to delivery" path

While we consider non-linearity and complexities as features of today s world, how often do we end up designing and delivering presentations in a linear fashion? One of the reasons is that while we are aware of linearity s pitfalls, linearity has the power to reassure us when faced with the challenge of designing and delivering a talk especially to international audiences. Reasons for this strange attraction to linearity are multi-faceted: - the warrior terminology sometimes used (target audience, impact, etc) that no one can really relate to as we do not work, research and teach to conquer, impress or shine simply to share. - the belief that presentation skills are a minor technical-aesthetic issue that is nothing compared to substance and content. - too much preparation leads to artificiality and inauthenticity. This 60-minute interactive workshop is therefore designed for delegates who want to go past linearity in designing and delivering their presentation thanks to a more dynamic approach for their own benefit and the benefit of their audience. The general outcome of the workshop is: Your complex ideas are better understood and shared. The five specific outcomes are: - Finding the aim of your presentation. Aim comes from the Latin aestimare , meaning to determine the value of . Once you clearly picture the value you can share with other people, you have a starting point that will set a direction that goes beyond achieving the objective of delivering a talk on a given subject. - Designing a dynamic scenario with discontinuities that fosters attention in your audience and makes your speaker s life easier. "Is the mic " on ? and How much time do I have left ? are not options anymore. - Going past the dualities: Verbal versus Non-verbal, Content versus Style or Words versus Action, thanks to works by Mikael Twyman and inspired by Mathematician and developer of catastrophe theory Renı Thom, who used to say that action is a solidified word . - Understanding and being OK with your own discontinuities (stress, finishing in time) AND your audience discontinuities. - Designing visuals that embody your ideas. Each of these 5 specific outcomes is related to a coloured marble in the Newton Pendulum. Sometimes only regarded as a typical desktop toy, the Pendulum provides a dynamic physical and memorable analogy of the designing and delivering process. Each participant will receive a 5-dimension roadmap that they will be able to start using as we go through the workshop and continue using presentation after presentation.

Posters

Jessica **Boyatt**, *Infant Parent Training Institute, Boston, USA*

Psychological Development as a Complex Adaptive System: Three Dyadic Vignettes- Good Enough, Rigid, Chaotic

Complex Adaptive Systems theory is a useful way to describe and investigate psychological development. However, it is difficult to know what this actually means on the ground in a dyadic relational moment. This work clarifies how a specific relational moment can move psychological development towards flexibile complexity or unyielding rigidity or chaotic dysregulation. Three real life vignettes of observed dyadic relational moments are described in a framework of complex adaptive systems and analyzed for the ways in which they move psychological development along a path towards increasing complexity and coherence or ways in which they disrupt psychological development. Disruption can occur by rigidifying the system to the point of shut down or creating so much dysregulation that the system shatters. Emergent phenomena of the three relational moment vignettes are examined in the context of the psychological development for both participants (adult and child) as well as the complex adaptive system of their relationship. There is a detailed discussion of how these emergent phenomena fold back into the complex dynamic systems of each participant as well as the relational system itself to better understand the importance of early relationship in the development of a coherent, flexibly sense of self with agency. In the good enough vignette there is evidence that psychological development is spiraling towards flexibility and coherence. In the rigid vignette, we see the system slowly shutting down with a truncation of emergent phenomena and a dampening of psychological engagement. In the dysregulated vignette, we see a noncontigent, overstimulated psychological engagement that overwhelms and shatters the system so that no emergent growth promoting psychological phenomena can occur.

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Humberto Rocha,
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Paulo Renato Lourenço, *Faculty of Psychology and Education Sciences*
Teresa Rebelo, *Faculty of Psychology and Education Sciences, University of Coimbra, Portugal*

A nonlinear perspective on the relationship between team cohesion and team learning

The purpose of the present study was to contribute towards clarifying the relationship between team cohesion (task and social) and team learning by adopting a nonlinear approach. A quantitative study with a cross-sectional design was conducted. The sample was composed of 82 teams from 57 Portuguese companies. The relationships between variables were analyzed through Radial Basis Functions (RBF). Results showed that the Thin Plate RBF obtained the best Cross Validation Error leading to the best predictive model. The Thin Plate RBF response surface revealed that an increase in either task cohesion or social cohesion leads to an increase in team learning up to a certain threshold. The optimal pair of the cohesion values (3.4 social cohesion, 4.8 task cohesion) evidenced that higher values of task cohesion are more important than higher values of social cohesion for optimal team learning. Therefore, the task dimension emerged as the critical component of team cohesion in what team learning is concerned. Our study highlights the importance of using methods beyond the widespread linear approach, in order to model nonlinear behavior as the one produced by dynamic systems such as teams.

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Kei Moritsugu, *Yokohama City University*
Yoshifumi Fukunishi, *AIST*

A nonlinear ordinary differential equation with a fully statistical description for a physical system and an environment system

Molecular dynamics (MD) simulation is a standard tool for soft-matter, chemical, and biological physics to investigate the characteristics of physical system (PS) in terms of microscopic descriptions, including the atomic degrees of freedom and the interactions between them. The fundamental classical equation of motion (EOM) in MD is the Newtonian equation, which creates the micro-canonical distribution of the PS, P(q,p). By using the Nosı-Hoover (NH) EOM, it is also possible to create the canonical distribution, which enables us to compare the

simulation results and the experiments under a constant temperature. The NH equation is a nonlinear ordinary differential equation (ODE), described by the Newtonian equation with a dynamical friction coefficient whose time development is defined so as to keep the temperature of the PS to be constant. However, a framework to conduct more flexible, diverse MD simulations is required from many aspects, including non-equilibrium molecular simulations, free energy estimations, and drug discoveries. At the same time, this framework should be rigorous and simple to conduct reliable and tractable simulations. For this, we have developed a smooth ODE, whose flow has an absolutely continuous invariant measure R(w)dw, which is proportional to r(q,p,z)f(z)dqdpdz, where r(q,p,z) denotes an arbitrary target distribution of the PS that is associated with a certain "environment" (vector) variable z, f(z) denotes an arbitrary distribution of the "environment" system (ES), and dw is the Lebesgue measure. The corresponding vector field is generally constructed by the double density dynamics, which we have developed in our earlier studies. When we set z to be the inverse temperature in our formalism, we can have the "coupled NH" equation, which defines a coupling of two dynamical systems: one is a NH EOM described by the PS with "dynamical" heat bath; and the other is the NH EOM for the temperature system (TS), one of the simplest ESs. This coupling enables the total system (that is composed from the PS and TS) to be chaotic and ergodic, even if the PS is not solely chaotic but regular. Thus, the coupled NH equation can be used to effectively sample the phase space for the PS, wherein the existence of the invariant measure ensures a use of reweighting formulae that transform one equilibrium distribution to another. The numerical examples we will show include the results on model systems and explicitly solvated protein molecule systems. We demonstrate that the numerical results are well described by the theoretical estimations based on ergodic theory. We would also like to discuss how the coupling of such two systems should be in order to sample the phase space effectively and stably.

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How is virtuality influencing team-learning behaviors? Testing cusp structures

Nowadays, almost all work teams use communication technologies to collaborate, share knowledge and perform their tasks. Therefore, virtuality is part of their daily life. Research on how virtuality influences team functioning is expanding and this study aims to contribute to this research body by adopting a nonlinear dynamical system approach. Thus, a cusp catastrophe model for explaining learning behaviors in teams with different degrees of virtuality was tested in this study. In this model, team cultural orientation (support, innovation, rules or goal orientation) is the asymmetry variable and the degree of virtuality is the bifurcation. The sample is made up of 67 project teams, and data were collected at the beginning, half-time, and end of the project. Data analysis was carried out using maximum likelihood estimation of the parameters performed in R cusp package (Grasman, van der Maas, & Wagenmakers, 2009). We analyzed the three data collection moments (T0, T1, and T2) separately to test the presence of cusp structures in these distinctive team development times. Results suggest the presence of a cusp model only at T0 (beginning of the workgroup life) and only when teams are support and innovation oriented. Moreover, at T0, when teams are rules and goal oriented, virtuality is negatively correlated with team learning. At T1 and T2 (halftime and end of the workgroup) virtuality is not significantly correlated with team learning. Overall, these findings show that the degree of virtuality assumes a bifurcation role at the beginning of the workgroup, which suggests that beyond a certain threshold of virtuality, teams might oscillate between two attractors, the modes of high and low team learning behaviors. However, team virtuality seems to lose influence on learning behaviors over time. This study is a clue for further research focused on the processes that teams develop over time in order to minimize the bifurcation or the negative effect that virtuality seems to initially have on team learning behaviors.
