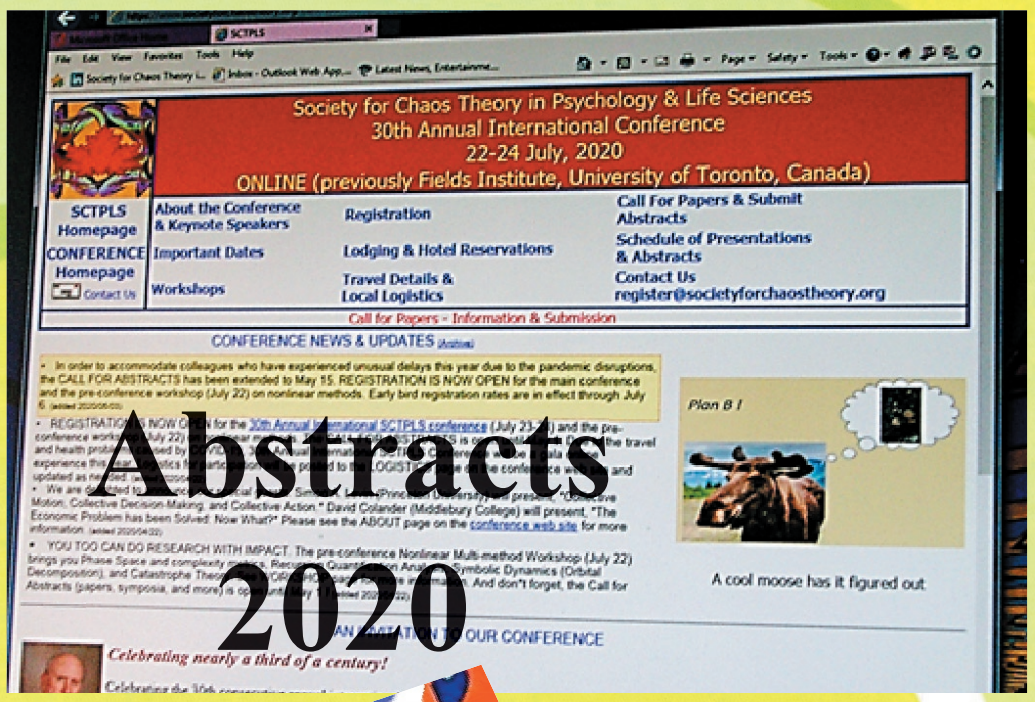
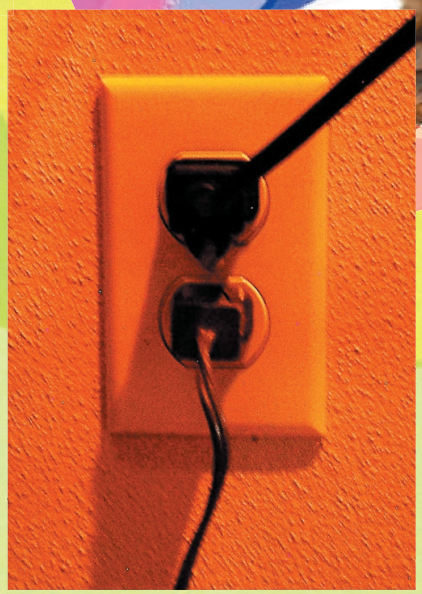
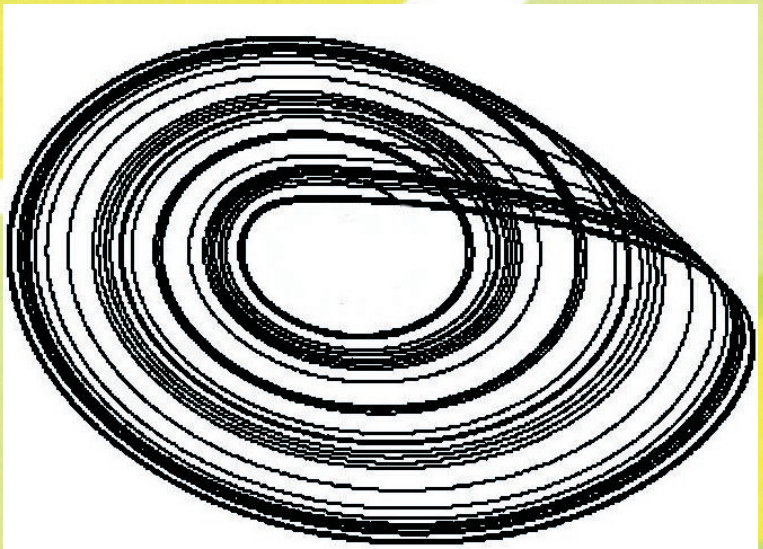
Society for Chaos Theory in Psychology & Life Sciences



Abstracts 2020





Society for Chaos Theory
in Psychology & Life Sciences

30th SCTPLS Annual International Conference
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Alphabetical List of Authors & Abstracts

Simon A. Levin, Princeton University, USA, *Keynote Speaker*

Collective Motion, Collective Decision-Making, and Collective Action

There exists a rich history of research on the mathematical modeling of animal populations. The classical literature, however, is inadequate to explain observed spatial patterning, or foraging and anti-predator behavior, because animals actively aggregate. This lecture will begin from models of animal aggregation, the role of leadership in collective motion and the evolution of collective behavior, and move from there to implications for decision-making in human societies. Ecological and economic systems are alike in that individual agents compete for limited resources, evolve their behaviors in response to interactions with others, and form exploitative as well as cooperative interactions as a result. In these complex-adaptive systems, macroscopic properties like the flow patterns of resources like nutrients and capital emerge from large numbers of microscopic interactions, and feedback to affect individual behaviors. I will explore common features of these systems, especially as they involve the evolution of cooperation in dealing with public goods, common pool resources and collective movement across systems; Examples and lessons will range from bacteria and slime molds to groups to insurance arrangements in human societies and international agreements on environmental issues.

Simon A. Levin *received his BA from Johns Hopkins and Ph.D. from the University of Maryland, both in mathematics. He is the James S. McDonnell Distinguished University Professor in Ecology and Evolutionary Biology in the Department of Ecology and Evolutionary Biology at Princeton University, and the Director of the Center for Biocomplexity, Theoretical Biology and Evolution. His research examines ecosystem structure and function, dynamics of disease, and the coupling of ecological and socioeconomic systems. He is a fellow of the American Academy of Arts and Sciences; his numerous awards include the Heineken Prize for Environmental Sciences, the Ecological Society of America's MacArthur and Eminent Ecologist awards, as well as the National Medal of Science.*

Simon A. Levin

Yuji Aruka, Chuo University, Tokio, Japan

The Evolution of the Exchange Process

There exists an ambiguous attitude in economic theory toward referring to the details of exchange mechanisms as a social system. To date, in classical theories, the main research target has been the exchange mechanism for commodities in general. Instead of studying the exchange of the broader social or community system, recently, much work has focused on auction mechanisms for particular goods in the context of experimental design. However, the advent of the community currency and crypto-currency suggests that we should study the feasibility and sustainability of the broader system. In this article we will focus on systems of exchange with auctioneers and without auctioneers. We then examine the properties of bilateral exchange between randomly selected traders without auctioneers and explore the resulting properties of iterations of such transactions. Finally, we mention special issues of cryptocurrency in the face of the Byzantine General Problem and discuss a well-coordinated distributed system involving digital tools such as blockchain.

Najia Bao, The Fu Foundation School of Engineering and Applied Science, Columbia University; B & B Institute of Human Brain Potential
Nangui Bao, B & B Institute of Human Brain Potential
Nasha Bao, Jiangnan University, China

A Half Century Follow-Up Study ----- Using "Long-Term Memory Ability" as a Test Benchmark

Psychologists have always believed that: (1) a person's long-term memory ability is born; (2) a person's memory ability will inevitably decline with age. This article proposes a subversive conclusion here: the long-term memory ability of a person is not only not born, but also has nothing to do with age, the key is how to use the brain reasonably! The author of this article conducted a 56-year follow-up study on several representative figures in a three-generation family using "long-term memory ability" as a test benchmark. 1st generation: Henry s father is a university professor and his mother is a middle school teacher. They are strict with their children; the second generation: four men and one woman (including Henry); the third generation: six women and one man. The elder brother and younger brother of the second generation have excellent memory. The two of them, from elementary school to middle school to university, always ranked first in the grade. The other 3 people have mediocre intelligence. Especially Henry, not only his memory ability is far inferior to that of his elder brother and younger brother, but he is also lazy in reading. He is often criticized by his mother. The strange thing is that when Henry was in the eighth grade, his brain suddenly opened up and his test scores were among the best. Later, he entered a famous high school. According to his self-report, he figured out a set of memory methods that could easily keep knowledge in mind. Henry (engineer) is 80 years old this year. In the eight years from 2013 to 2020, he participated in dozens of brain experiments as subjects. At present, his memory ability still surpasses many college students studying in school. However, the elder brothers (professors) and younger brothers (engineers) with outstanding memory at that time, like the old people in the world, have far less memory ability than their own youth. Even when tutoring their children s homework (middle school students), they feel powerless. Nancy, a girl in the third generation, dropped out of high school due to extreme school weariness. Later, under the guidance of Henry, she mastered the "long-term memory method." She was admitted to a famous university. She has successively obtained three master s degrees: Master of Arts, Master of Educational Psychology, and Master of Engineering. She is a registered engineer in the United States. The half-century follow-up investigation and study focused on Henry and Nancy. We explore the winners in this field with a difficult level of STEM (i.e. engineering, scientific thinking) cognitive field. In terms of research methods, this research spans many fields such as engineering mechanics, biomedical engineering, neuroscience, psychology, education, literature, philosophy (aesthetics) and so on. Through biomedical experimental methods, the nonlinear dynamic analysis of EEG and the macro analysis of cognitive psychology are combined. This article will show the topographic map of EEG entropy in the right brain when Henry and Nancy quickly memorize the difficulties in a certain knowledge field. What is more attractive is the large humorous conversation between the testee and the tester. The mechanism can be analyzed from the perspective of psychology. The researchers compared the objective dynamic data with the subject s psychological self-report.

Najia Bao, The Fu Foundation School of Engineering and Applied Science, Columbia University; B & B Institute of Human Brain Potential
Nangui Bao, B & B Institute of Human Brain Potential
Nasha Bao, Jiangnan University, China

Lower the Threshold of Long-Term Memory and Improve Metacognitive Ability

In recent years, there are several famous universities that encourage liberal arts students to interdisciplinary and switch to science and engineering, because there is

a shortage of STEM university graduates in the United States, especially engineering majors. Despite the high enthusiasm of teachers and students, the results were not satisfactory. Here, we must emphasize a few words: Outstanding liberal arts students may not be competent to transfer to engineering. Although they are good at memorizing liberal arts textbooks, they may not easily cross the long-term memory threshold of science and engineering. The threshold for long-term memory of "science and engineering" knowledge is composed of two levels: one is the breadth and dispersion of knowledge; the other is the degree of abstraction of knowledge. The breadth and dispersion of knowledge refer to: the content of the course is numerous, and the organic combination is not enough, which is not conducive to the learner forming a long-term memory of network structure. The degree of abstraction of knowledge refers to: this kind of knowledge is far away from episodic memory. A large number of abstract concepts, theorems and formulas make it difficult to form concrete and vivid episodic memories. In the process of transforming short-term memory into long-term memory, the energy consumption of brain activity is very large, because the threshold of long-term memory must be crossed. Episodic memory is one of the elements that lowers the threshold of long-term memory: the most significant difference between episodic memory and semantic memory is the speed of learning. The learning speed of episodic memory is fast, and the learning speed of semantic memory is slow. Moreover, the previous extraction of situational memory information is helpful for the later extraction of the same information, on the contrary, the extraction of semantic memory hardly affects the next time. In a word, the learning efficiency of episodic memory is high. Therefore, we view it as a key factor in lowering the threshold of long-term memory. This collection of fictions "The Mathematical Flowers Blooming in the Short Story World" contains 50 fictions. The unique feature of this collection of short stories lies in the Trinity, that is, the novel combines literature, STEM knowledge and character education through storytelling to become an organism. This style is very suitable for high school students and college students to read. The various STEM knowledge, learning methods, and memory strategies in the book are unforgettable, because with the novel s scene description, plot development, and the protagonist s joys and sorrows, it plays a role of "situational memory". Humor teaching is the second element of lowering the threshold of long-term memory: The reason why humor teaching methods can improve students memory ability is because these humorous materials (including humorous comics and humorous stories) used in STEM teaching have profound meanings. This kind of humor stimulates the learner's right brain nerve with a specific image with a profound meaning, so that the learner's right brain also participates in cognitive activities. "Training method and teaching sample library for solving problems with space imagination" consists of two parts: training and testing. If situational memory and humor teaching are conducive to the formation of long-term memory, spatial imagination problem-solving training is a measure for the solidification and resolidification of long-term memory. Based on a large number of test experiments and related engineering mechanics analysis, we have concluded that: STEM cognitive activity is a rapid and dynamic representation of psychological schema. For highly difficult problems, objectively, working memory still has a time limitation, that is to say, the thinker must complete the problem immediately in a short time, because when the thinking is delayed, temporary information is easily lost, and the problem is solved. Unable to proceed. At this time, its potential metacognitive ability will be activated naturally. In order to eliminate obstacles, it is necessary to either immediately modify the original idea or immediately come up with a new idea. In short, through the "space imagination problem solving" activity, the cognitive schema of the cognitive person can be refreshed instantly to overcome the limitation of the working memory duration, and at the same time, the metacognitive ability can be given Opportunities are greatly developed. "The application of humorous teaching sample library in STEM teaching", "the mathematical flowers blooming in the short story world", and "the training method and teaching sample library for solving problems with space imagination", the contents of these three books are all our original creation of. It is our practice summary and theoretical sublimation for decades.

Cortney Armitano-Lago, **Brian Pietrosimone, Alyssa Evans-Pickett**, **Hope Davis-Wilson, Jason Franz**, **Troy Blackburn**, **Adam Kiefer**, University of North Carolina at Chapel Hill, NC

Feedback Cueing Changes in Lower Limb Loading During Gait Alters Underlying Stride Interval Dynamics and Intralimb Coordination Dynamics in Individuals Following Anterior Cruciate Ligament Reconstruction

The visual cueing of lower extremity loading optimizes gait biomechanics and may slow post-traumatic osteoarthritis progression following anterior cruciate ligament reconstruction (ACLR). However, it is unclear how this feedback influences the underlying dynamics that promote movement stability and adaptability. We examined the influence of this feedback on an individual's gait dynamics at different scales: (1) the intralimb coordination of the sagittal plane knee-hip angles via measures of both relative phase and cross-

recurrence quantification, and (2) the temporal persistence of stride-to-stride intervals as indexed via detrended fluctuation analysis (DFA). Twelve ACLR participants (age: 20±4 years; 8.8±1.0 months post-surgery; 4F) performed three loading conditions on separate days: no feedback, high load, and low load with real-time feedback based on a force-measuring treadmill cuing a 5% body weight change in peak vertical ground reaction force. One-way repeated-measures ANOVA were used to compare outcomes among conditions. There was a main effect of loading for mean and standard deviation of relative phase ($F_{2,26}=6.9$, $p<.05$ and $F_{2,26}=9.5$, $p<.05$, respectively), with low load feedback driving reduced intralimb coordination stability. A significant effect of loading on %CDET ($F_{2,26}=2.7$, $p<.05$) was also observed indicating that high load led to a more rigid coordination pattern ($p<.05$). A main effect of DFA α ($F_{2,26}=7.98$, $p<.01$) indicated more persistent stride dynamics for both high and low load conditions. These results indicate that altering lower extremity load changes both the intralimb and stride interval gait dynamics of ACLR patients and may have implications for the design and implementation of gait training interventions.

David Chan, **Hollee McGinnis**, **Michael Broda**, **Claire Luce**, **Camie Tomlinson**, **Joy Ma**, **Jeremy Winslow,** Virginia Commonwealth University, Richmond, VA

The Protective Effect of Having a Prime Supporter Within a Social Network of College Students on Mental Health and Education

Interviews from 38 undergraduate students were conducted to collect mental health and educational data, as well as egocentric network data. The structure of the network data was then analyzed with respect to mental health and education variables, including the effects of having individuals who support the individual in multiple ways, i.e. a prime supporter. A number of correlations were found and are presented. Additionally the network structure was compared between different groups of students including STEM versus non-STEM, cisgender male versus cisgender female, by self-identified race/ethnic group, and with respect to adverse childhood experiences (ACEs). The comparison between groups are also presented.

Megan Chiovaro, **Alexandra Paxton**, University of Connecticut, Storrs, CT
Leah C. Windsor, University of Memphis, TN

Recurrent Quantification Analysis of Real-time and Online Social Cohesion During the Arab Spring

Social mobilization can be found in the form of real-world events and online cohesion. Virtual platforms more accessible than ever are increasingly used to spread information for collective action, but to date, there have been few definitive answers as to whether online social mobilization reflects real-world mobilization. In this study, we provide empirical evidence of this link by analyzing real-world and online cohesion in Syria during the Arab Spring. From a dynamical systems perspective, these two avenues of social action were theorized to be coupled systems, with strongest coupling between violent events and social cohesion. To test this hypothesis, we analyzed the relationship between peaceful, aggressive, and total count of real-world events (obtained through Integrated Crisis Early Warning System data) and social cohesion on Twitter in Syria. Using cross-recurrence quantification analysis and windowed cross-recurrence quantification analysis, we explore the relationships between real and virtual mobilization and reflect on how these analyses may inform political science research broadly. Preliminary analyses find that peaceful, aggressive, and total events show statistically significant levels of determinism (DET) with social cohesion, but only aggressive events show significant mean length (meanL) and complexity (ENTR) of shared trajectories with social cohesion. This suggests that salient, negative events are more strongly coupled with social cohesion on Twitter, but the time spent in shared states is more variable.

Allan Combs, Stanley Krippner, Steven Mitchell, California Institute of Integral Studies

Tottering on the Edge of Chaos

"Self-organized criticality," a central concept the sciences of complexity, refers to unstable accretions of small events that can accumulate and trigger system-wide "catastrophic" bifurcations. Examples include piling dry sand until an avalanche is triggered; and the activation of nerve cells by multiple dendritic stimuli. But the concept can also describe the condition of a single human life teetering on the "edge of chaos." This is a situation that is at once precarious and potentially transformative. As Stanley Krippner has pointed out in an unpublished essay, small or even unnoticed influences on a human life can escalate through

"sensitivity to initial conditions" (the butterfly effect) to the creation of "catastrophic" transitions. Examples include rapid changes of mind and behavior, for instance experienced as sudden insights, shifts in states of consciousness such as falling asleep at the wheel; and even dramatic behavioral transitions such as choosing suicide. At a different extreme are the reports of "lightening enlightenment" sometimes permanently transforming an individual's whole ground of experience. Certain such instances are paradoxically triggered by traumatic experiences in battle and otherwise. This presentation highlights examples of a such bifurcations in human thought, behavior, and experience. Illustrative cases are described, and discussion is encouraged.

Allan Combs, Institute of Integral Studies, San Francisco, CA

Fractals All The Way Down

Fractals all the Way Down Presentation and Discussion by Allan Combs (California Institute of Integral Studies) Fractal patterns are found throughout the cosmos at virtually every spatial and temporal scale. Even human conversation displays fractal-like temporal features. For instance, an analysis of Plato s Republic exhibits a fractal pattering of interactions between Plato himself and his interlocutors. Such patterns are also evidenced in the spatial distributions of words in typical texts, and in the modulation of ordinary speech sounds. Moving to the neurological level, considerable research now supports the fact that the brain is an immensely rich activity network poised on the edge of chaos. As cortical networks move away from this point of optimal balance consciousness fades and disappears into minimally conscious and vegetative states. On the other hand, certain entheogens seem to heighten the degree of chaotic activity, associated with higher fractal dimensionality. In such research we find that heightened or lucid waking consciousness is associated with greater neural complexity and higher fractal dimensionality. Like the golden ration and Fibonacci sequence, both mathematically related to the fractal, fractal mathematics offers another key insight into understanding the basic organization of nature. Keywords: Fractal patterns, fractal dimensionality, cortical network, edge of chaos, consciousness. Contact: ACombs@CIIS.EDU

Chad Danyluck, University of Colorado, Boulder
Katherine Tamminen, University of Toronto , Canada
Ruochen Chen, University of Toronto, Canada

Physiological Synchrony During a Pre-Practice Routine is Associated with Poor Performance in a Team of Male Volleyball Athletes

Physiological synchrony - mutual changes in physiological arousal between people - has been related to performance coordination in various social contexts. Despite the importance of performance coordination in team sports, researchers have paid little attention to the association between physiological synchrony and performance in athletic contexts. This study examined physiological synchrony among a team of 16 male university volleyball athletes over two months. On nine occasions, athletes participated in a pre-practice group visualization routine while wearing heart rate monitors to continuously measure heart rate variability (HRV). Athletes and the team coach completed post-practice measures of individual and team performance. SyncCalc statistical software (Guastello & Peressini, 2015) measured group-level synchronization of the nonlinear dynamics of the HRV data over time. Synchronization estimates were then regressed on athlete and team performance ratings. HRV synchronization and performance ratings were negatively related, suggesting that physiological synchrony may be detrimental to athletic performance in some athletic contexts. Implications of the timing of synchronization (i.e., prior to team performance) and the physiological system in which synchrony occurs will be discussed.

Kevin Dooley, Arizona State University, Tempe, AZ
James Hazy, Adelphi University, Garden City, NY
Benyamin Lichtenstein, University of Massachusetts, Boston, MA
Dionysios Demetis, University of Hull, Egland
Tomas Backström, Mälardalen University, Eskilstuna, Sweden

A CAS Model of Systemic Corruption

Theories and studies of corruption typically focus on individual ethics and agency problems in organizations. In this presentation, we use concepts from complexity science to propose a process theory that describes how corruption risk emerges from conditions of uncertainty. We theorize that corruption involves dynamics that emerge when agents in a system take actions that exploit disequilibrium conditions of uncertainty and ethical ambiguity. Systemic corruption emerges when agent interactions are amplified locally in ways that create a hidden value sink which we define as a

structure that drains resources from the system for the exclusive use of certain agents. For those participating in corruption, the presence of a value sink reduces local uncertainties about access to resources. This dynamic can attract others to join the value sink, allowing it to persist and grow, eventually challenging broader norms. In its final phase, the application of stabilizing feedback can maintain and strengthen the dynamic stability of the value sink and eventually embed it into the broader dynamics of the system, thus institutionalizing it.

Orlando Gomes, ISCAL - Lisbon Accounting and Business School, Portugal

Behavioral Savings

Well documented empirical evidence points to the existence of strong heterogeneity regarding households savings behavior over the life cycle: individuals endowed with identical inherited wealth, and with similar prospective income earnings and life expectancy, often select antithetical strategies when formulating their consumption-savings intertemporal plans. Underlying this evidence resides the fact that psychology matters, i.e., that economic agents are frequently influenced by their intrinsic beliefs (commanded by genetics and education) and by social and cultural motivations, thus deviating from strict rationality and strict optimal behavior. In this paper, a model of behavioral savings is proposed. In the model, three psychological profiles potentially coexist: individuals can be aligned with the rationality benchmark or, alternatively, they may depart from it by holding optimistic or pessimistic beliefs about future earnings. Each generation of households assumes one of the profiles (rational - optimistic - pessimistic), and new generations form their beliefs by making a constrained assessment of the utility levels attained by the existing generations (namely, they will mimic the behavior of generations which they perceive as being role models). The analysis characterizes the life-cycle implications of assuming each one of the belief profiles and proposes an explanation for aggregate fluctuations on savings and consumption based on the cyclical renewal of beliefs across the mentioned states.

Stephen J. Guastello,**Brittany Witty**, **Camerhon Johnson**, **Anthony F. Peressini**, Marquette University, Milwaukee, WI

Autonomic Synchronization, Leadership Emergence, Drivers and Empaths

Synchronization of autonomic arousal levels within dyads and larger teams has been associated with several types of social-behavioral outcome. One previous study reported greater physiological influence (activation levels in one area of the parietal lobe associated with verbal activity) of leaders on followers than of followers on leaders of dyads; influence was measured pairwise within triadic problem solving groups. The present study explored synchronized autonomic arousal with leadership outcomes in two experiments with group sizes of 3 to 8 members. Drivers, who had the greatest physiological impact on other team members were consistently less like the leader of the group. Empaths, who were the most receptive to autonomic signals from others, were only inconsistently associated with leadership roles, although they did show sensitivity to team dynamics in their workload ratings. The tentative conclusion, subject to future research, is that successful leadership requires a balance between the driver and empath orientations.

Stephen J. Guastello, **Anthony F. Peressini**, Marquette University, Milwaukee, WI

A Comparison of Four Dyadic Synchronization Models

Synchronization is a special case of self-organization in which one can observe close mimicry in behavior of the system components. Synchrony in body movements, autonomic arousal, and EEG activity among human individuals has attracted considerable attention. This paper is specifically concerned with autonomic synchrony and finding the best model for the dyadic relationships that could be extrapolated to synchrony levels for groups and teams of three or more people. The four models that are compared in this study have different theoretical origins and pose different statistical challenges: the two-variable linear regression function, a three-parameter nonlinear regression function, the logistic map function stated in polynomial form, and the logistic map function stated as an exponential regression structure. The data for this study were electrodermal responses collected from a team of four people engaged in an emergency response simulation, producing 12 dyadic time series. Results shows strong levels of fit between models and data for all four models, although there were significant differences among them. Further research directions point toward finding conditions that favor one model over another and exploring other possible nonlinear structures.

Harold Hastings,**Young-Taft Tai**, Bard College at Simon's Rock and Levy Institute, Sheffield, MA

Empirical Scaling and Dynamical Regimes for GDP: Challenges and Opportunities

We explore the distribution of gross domestic product (GDP) and per capita GDP among different countries in order to elucidate differences in the dynamics of their economies. An initial analysis of GDP data and per capita GDP data from 1980 and 2016 (and many years in between) typically finds three scaling regions signatures of likely differences in dynamics. The GDP of the largest ~25 economies (nations, EU) follows a power law GDP ~ 1/rank followed by a second scaling region in which GDP falls off exponentially with rank and finally a third scaling region in which the GDP falls off exponentially with the square of rank. This broad pattern holds despite significant changes in technology (enormous growth in computing power, intelligent automation, the Internet), the size of the world economy, emergence of new economic powers such as China, and world trade (almost free communication, containerized shipping yielding sharp declines in shipping costs, trade partnerships, growth of the EU, multinationals displacing the traditional economic role of nation-states. Thus, empirically, these patterns may be universal in which case one approach to growth of less developed economies (in the second and third scaling regions of per capita GDP) may be to identify and target causative differences between these economies and those in the first (power law) scaling region. For example, Montroll and Shlesinger (1982) suggest a basic lognormal distribution as a consequence of multiplying many independent random variables, with a power law high-end tail because the very wealthy generally achieve their superwealth through amplification processes that are not available to most. On the other hand, Reed and Hughes (2002) show how power law behavior can arise if stochastic processes with exponential growth in expectation are killed (or observed) randomly.

Harold Hastings, **Tai Young-Taft**,**Chris Coggins**, Bard College at Simon's Rock, Sheffield, MA

The Coronavirus Pandemic and the Multi-Network City of the Future

The effects of the coronavirus pandemic have been tragic on global (250,000 + deaths worldwide to May 4, 2020, local and individual levels. Cities which have developed as engines of economic, social and cultural growth have also become substrates for the spread of Covid-19. It has become evident to many writers that return to normal means return to a new normal, especially for cities which have seen large per capita case and mortality rates. The goal of this interactive symposium is to begin to : (1) Apply our knowledge of non-linear dynamics to understand how the impacts of coronavirus depend upon community size and structure, and our simple graph of coronavirus death rates as a function of population density in Massachusetts counties among other factors. (2) Explore the multitude of interacting networks in which we live. (3) Further understand threshold behavior in these networks (locally, R_effective, globally, percolation thresholds) and its implications, and (4) apply our understanding of psychology and the life sciences (and social sand other sciences) to explore multinetwork structures which might preserve the advantages of cities as engines of economic, social and cultural growth, while proving resistant to the spread of future pandemics. Some background: Geoffrey West and colleagues have shown that many intensive (per capita) quantities describing urban life display superlinear growth, increasing by ~ 15% for each doubling of population. Alternatively, every 30-fold increase in population approximately sees an approximate doubling per capita socio-economic quantities such as wages, GDP, number of patents produced and number of educational and research institutions There is, however, a dark side: negative metrics including crime, traffic congestion and incidence of certain diseases all increase at the same rate. Thus the good, the bad and the ugly come as an integrated, predictable, package. The basic SIR (susceptible, immune, removed) model for infectious disease spread displays a local (in space) phase transition from exponential decay to exponential growth (with saturation at a high epidemic level) as the effective local growth rate R(t,x), a function of the intrinsic growth rate R0, social distancing factors, and in particular, local population density, is increased above 1, whether in care facilities, industrial settings, urban centers, or any other location. These two observations point to the key challenge addressed by this symposium: how can we achieve the benefits of urban density without causing exponential growth in novel infections? The COVID-19 pandemic has driven significant changes in our behavior and interactions; for a small example, we are meeting on line rather than in Toronto this year. Will these changes lead to a new multi-network structure in the network of cities of the future? Harold Hastings will introduce scaling rules and more general mathematical issues which inform the analysis of the multi-network city of the future. Tai Young-Taft will describe the historical role of cities and city-states. Chris Coggins will explore models for cities of the future aimed at combining the good of current cities and the benefits of low population density in the current pandemic. There will be ample time for discussion, which we hope to stimulate.

Tyler Hatch, **Grace Neiswander**, **Jenny Magnes**, **Miranda Husley-Vincent**, **Cheris Congo**, **Kathleen Raley-Susman**, **Eric Szwed**,Vassar College, Poughkeepsie, NY
Harold Hastings, **Anshul Singhvi** Bard College at Simon's Rock, Sheffield, MA

Nonlinear Time Series Analysis *of C. elegans* Motion

The motion of two different phenotypes of C. elegans, roller type (OH7547) and wild type (N2), is studied using the dynamic diffraction methods developed in the Vassar Applied Optics Lab. By placing the worms in a cuvette, dynamic diffraction converts the locomotion in 3D into a time series obtained from optical fluctuations in the dynamic diffraction pattern. We calculate the largest Lyapunov exponent (LLE) of this time-series. We use this calculation to characterize the locomotory predictability of the microscopic species. The computational methods used to perform these techniques as well as the experimental setup will be presented. The resulting LLEs and embedding dimensions will be compared. We found largely deterministic and low-noise dynamics for both species with a mean LLE of .918 +/- .02 Hz for the roller type and 1.29 +/- .02 Hz for the wildtype. The underlying cause of the differences in LLE between different C. elegans is still unknown. Further studies examining the effects on the LLE by various characteristics of the worms, most notably age, must be performed to understand variations in dynamical invariants

Bob Hodge, Western Sydney University, Australia

Some Implications of Anderson's Ontological Hierarchy: the Case of Semiotics

This paper explores some implications of Phillip Anderson s seminal 1972 paper on complexity, specifically his application of the fundamental principle of complexity science, that the whole is very different from the sum of its parts, to a hypothesis about different domains of sciences. From this starting point the paper develops the proposition that the human sciences consist of an assemblage of phenomena obeying most of the fundamental laws of successive lower levels as implied in Anderson s ontological hierarchy, as new wholes that are very different from the sum of their parts, each reconfigured in its successive new contexts, and further reconfigured in the various sub-systems of the humanities and social sciences. The exemplary discipline it will examine in the context of this theory will be semiotics, but the analysis could apply equally to other disciplines in this assemblage, such as linguistics, psychology, sociology, philosophy and literary/media studies. To put it more simply, all psychological, sociological and semiotic schools are branches of complexity science, related to reality through rules some of which are unique and irreducible to fundamental laws.

Aleksander Jakimowicz, Institute of Economics, Polish Academy of Sciences, Warsaw, Poland

Hyperchaos in financial markets

Financial markets are among the most complex systems that occur in the real world. The nature of this complexity has not yet been fully understood. The aim of the article is to show that hyperchaos found in multidimensional nonlinear dynamical systems can contribute to explaining the complexity of modern capital and currency markets. The behavior of systems with many degrees of freedom is significantly different compared to systems with less degrees of freedom. In hyperchaotic systems dynamics is expanded in two or more directions simultaneously, which results in a more complex attractor than in the case of a dynamical system with only one positive Lyapunov exponent. The possibility of economic interpretation of two such systems is being investigated: a 9D model for a Rayleigh-Bénard convection in a square cell and the generalized Rössler system. In both models, equlibria and stability, various hyperchaotic attractors, bifurcation phenomena, and Lyapunov exponents spectrum are studied numerically. Control options for high-dimensional chaos are also being considered.

Matthijs Koopmans, Mercy College, Dobbs Ferry, NY.

The Distinction Between Seasonal and Fractal Patterns in Long-Range Time Series: I. Concepts of Fractal Estimation

Mandelbrot has argued that the estimation of fractal patterns in time series analysis data reveals adaptive behavior in the system of interest, implying unpredictability. Fractality shows up in time series as self-similar patterns in the variability of data points, as well as scale invariance in those patterns. When it comes to fractal estimation in time series data, two major problems need further attention. First, there are many different methods to estimate fractal patterns, and we need to evaluate the extent to which they yield consistent results. Second, fractal estimates tend to be heavily correlated with non-fractal ones, and therefore, we need to know how capable these methods are distinguishing these two sources of variability. The first of these two concerns has been addressed previously by Delignieres and by Stadnitski; the second one is the focus of this presentation. This presentation consists of

two parts. In the first part, abstracted here, I will outline how fractal patterns are estimated by the following methods: detrended fluctuation analysis (DFA), re-scaled range analysis (R/S), Higuchi s fractality dimension, smoothed spectral regression, Geweke & Porter Hudak s (GPH) estimator, the spectral periodogram (Sperio) estimate, Whittle s estimate and the fractional differencing parameter. A brief overview is provided of each method, distinguishing between those that rely on the time domain and those that work with Fourier-transformed series (i.e., the frequency domain). A separate presentation evaluates the results of a simulation study estimating the response of these techniques to fractal, seasonal and other short-range dependencies.

II. Modeling Responses to Seasonal and Fractal Simulations

Many methods have been proposed in the literature to estimate fractal patterns in time series data, but little is known about how well these methods are able to distinguish fractal patterns from other types of variability in the series. Of particular substantive interest is the extent to which these techniques can distinguish fractal from seasonal patterns. The two patterns are qualitatively different in the sense that fractal patterns show scale invariance, whereas seasonal patterns do not. Will the various estimation techniques notice the difference? This presentation examines the responses of detrended fluctuation analysis (DFA), re-scaled range analysis (R/S), Higuchi s fractality dimension, smoothed spectral regression, Geweke & Porter Hudak s (GPH) estimator, the spectral periodogram (Sperio) estimate, Whittle s estimate and the fractional differencing parameter. Using the Autoregressive Fractionally Integrated Moving Average (ARFIMA) routine in R, ten data scenarios were generated, including various combinations of one-lag dependencies, seasonal dependencies (at 7 or 12 lags) and fractal dependencies (H = .20, .65, .75 and .85), with 100 realizations of each scenario. The results indicate that while the fractal estimates in all models were responsive to variations in fractal input values, their fractality estimates were also affected when seasonal dependencies were introduced while H was held at .50, a non-fractal input value. Fractional differencing was the exception, allowing one to handle seasonal parameters as modeling covariates during estimation. Unfortunately, the other models were unable to distinguish the two scenarios, and preliminary diagnostics are required to adjust for seasonality prior to the estimation of fractal patterns.

Jenny Magnes, **Tyler Hatch**, **Grace Neiswander**, Vassar College, Poughkeepsie, NY
Anshul Singhvi, Bard College at Simon's Rock, Sheffield MA and Columbia University, New York NY
Susannah Zhang, Vassar College, and University of Georgia
Harold Hastings, Bard College at Simon's Rock, Sheffield MA

Dynamics Markers of *C. Elegans* Motion in Three Dimensions

This symposium will be a guided tour of our recent results on the application of non-linear dynamics to C. elegans locomotion. Here are the key points: C. elegans is a commonly studied model organism based on ease of maintenance and simple neurological structure. In contrast to traditional microscopic techniques, which require constraining motion to a 2D microscope slide, dynamic diffraction allows the observation of locomotion in 3D as a time series of the intensity at a single point in the diffraction pattern. The electric field at any point in the diffraction pattern is the result of a superposition of the electric fields emanating from all points on the worm. Therefore, key features of the motion can be recovered by analyzing the intensity time series. One can now apply modern nonlinear techniques, e.g., embedding and Recurrence Quantification Analysis (RQA), providing valuable insight for comparing data sets. Finally we implemented a minimal biomimetic simulation of the central pattern generator of C. elegans with FitzHugh-Nagumo neurons, which exhibits undulatory oscillations similar to those of the real C. elegans. Jenny Magnes will present the overall program, the techniques of dynamic diffraction in her Vassar Applied Optics Lab, spectral analysis and Takens embedding of the resulting diffraction signal. In particular, we found largely deterministic, low-noise dynamics with mean largest Lyapunov exponent (LLE) for this species 1.27 +/- 0.03 Hz. Susannah Zhang will discuss Recurrence Plots (RP) for visualizing experimental data, and in particular, RQA of diffraction intensity time-series. The recurrence rate increases linearly with recurrence threshold (ε) for small ε before saturating at larger ε. The transition yields an informative RQA parameter, which further distinguishes types of motion. Harold Hastings will discuss mathematical underpinnings, in particular a simple direct application of the Rosenstein et al. algorithm to computing the LLE from recurrence plot data, considered as an approximate distance matrix, compare the graph-based reconstruction of an attractor from its RP . Anshul Singhvi will discuss the use of simple models of neurons and neuronal pathways to generate the undulatory motion of C. elegans, and the construction of simulated (using FitzHugh-Nagumo model neurons) and electronic using Keener's implementation of the Nagumo circuit biomimetic models to replicate unconstrained C.

elegans undulation; a biomimetic version of the Izquierdo and Beer robotic worm. The recent and more complex model more closely follows C. elegans neural wiring. Overall the symposium will combine tutorial elements with our current research into non-linear analysis of the motion of C. elegans.

Akio Matsumoto, Chuo University, Tokyo. Japan
Ferenc Szidarovszky, Corvinus University, Pecs, Hungary.

Stability Switching in Cournot Duopoly Game with Three Delays

A three-delay duopoly is considered where the firms have identical implementation delays with different information delays. The equilibrium is locally asymptotically stable without delays however this stability is lost with increasing values of the delays. The stability properties of the equilibrium depend on the common implementation delay of the firms and on the sum of the two information delays. The stability switching curves are first analytically characterized and illustrated, and then the direction of the stability switching is determined at each point of the curves. The possibility of multiple pure imaginary eigenvalues is also discussed when the directions of the stability switches cannot be determined. Simulation examples illustrate the theoretical results.

Pedro Marques-Quinteiro, William James Center for Research, ISPA-Insituto Universitario, Lisboa, Portugal
Pedro Ramos-Villagrasa, Departamento de Psicología y Sociología, Universidad de Zaragoza, Spain
Jose Navarro, Department of Social Psychology and Quantitative Psychology, University of Barcelona, Spain
Ana Passos, Business Research Unit, ISCTE-Instituto Universitario de Lisboa, Portugal
Luis Curral, CICPSI, Faculty of Psychology, University of Lisbon, Portugal

The Rough Journey to Success: Examining the Nonlinear Dynamics of Processes and Performance in Teams

We build on the Nonlinear Dynamic Systems (NDS) perspective to test the hypothesis that team performance change across a complete performance cycle is nonlinear and that such change results from team processes change over time. Participants were 214 ad-hoc teams enrolled in one management competition. The hypotheses were tested using nonlinear regressions and catastrophe modeling. The results of the nonlinear regression support the hypothesis that change in team performance over time follows a cusp catastrophe distribution, Rsquare Cusp = 1.00, F (5, 1065) = 14539400.00, p < .001; and that team processes do function as asymmetry (transition and action processes) and bifurcation (interpersonal processes) factors. Finally, the results also suggest that the cusp catastrophe model (Rsquare = .68) explains team performance better than the linear (Rsquare = .05) and logistic models (Rsauqre = .07). This study reiterates the importance of incorporating the NDS perspective within the teamwork literature to leverage our knowledge about the way teams perform over time.

Martin D Pham, The Hospital for Sick Children, Toronto, Canada
Randy A Harris, **Suzanne Tyas**, The University of Waterloo, Ontario, Canada

Towards Nonlinear Dynamical Neural Models of Linguistic Indicators in Cognitive Impairment with Implications for an Evental Psychiatry

We utilize the Neural Engineering Framework (NEF) and Semantic Pointer Architecture (SPA) in order to model language impairments. The NEF is a method for constructing neural simulations based on three principles: (1) neural representations are defined by nonlinear encoding and weighted linear decoding, (2) transformations of neural representations are defined by alternative weighted decodings, (3) neural dynamics are characterized by viewing neural representations as control theoretic state variables. The SPA extends NEF by assigning partial semantic concepts to neural representations that can be composed into complex representational structures to model cognition. Presented is a spiking neural network using SPA to investigate the effect of neural deficits in the thalamus on the retrieval of an ordered sequence of unique symbols (the English alphabet). The model includes four subnetworks: associative memory, working memory, basal ganglia and thalamus. Neural deficits are modelled by attenuating the signal of the neural representation travelling through the thalamus. The model remains mostly successful in the ordered retrieval of the alphabet but stutters : working memory forgets the current letter and steps back several letters before continuing correctly. Finally, future directions towards the deployment of such models for personalized health informatic tools are discussed through the philosophical

lens of Alain Badiou and Vincenzo Di Nicola's Evental psychiatry.

David Pincus, Chapman University, Orange, CA

Fat Tails, Burstiness, and Stochasticity in the Malleability of Physical Activity

Health behavior research has successfully identified thresholds to be used as targets for increasing physical activity (PA). For example, 150 minutes of moderate-to-vigorous PA each week for most adults is protective of all-cause mortality. Yet, key questions about the process and patterns of variance for changing PA remain a mystery, such as which behavioral patterns might be more malleable, and which might be associated with resistance to intervention? Wearable technologies that can track daily activity levels provide the opportunity to better address these questions. A year-long intervention (N=512) aimed at increasing insufficiently active adults daily levels of PA via goal setting and financial reinforcement provided secondary data to examine whether dynamical patterns associated with self-organization moderate long-term success in meeting intervention goals. The appropriateness of Inverse Power Law (IPL, or fat tailed) frequency distributions at summarizing individual s i.) the daily production of moderate-to-vigorous PA (MVPA) and ii.) the time elapsed between meeting daily goals (goal inter-response times [IRTs]) was calculated. Distributions of goal IRTs was also used to calculate burstiness in meeting goals, i.e. degree to which target behaviors are clustered in time. IPLs accurately summarized goal IRTs, but not daily bouts of MVPA. For people producing higher levels of PA earlier in the study, more burstiness in reaching goals over time was predictive of long-term resistance to the intervention. By contrast, people with more randomness, or stochasticity, were more malleable to intervention. These results provide initial evidence that burstiness may be a potential marker for self-organizing resistance to change, and that higher stochasticity may be a desirable precondition to reduced resistance and increased behavioral malleability.

David Pincus, Chapman University, Orange, CA

Romantic Resilience: Fractal Conflict Dynamics, Network Flexibility, and Relationship

Previous research has demonstrated that interpersonal dynamics are fractal, and that conflict is a key control parameter that drives fractal complexity (e.g., Pincus, 2015). The present study aimed to extend this line of research to examine the putative fractal structure of conflict dynamics over time, and the role that this fractal structure may play in the resilience of romantic relationships. An experience sampling methodology was used to assess conflict, relationship satisfaction, and commitment levels three times daily for 30 days (n = 90) for 52 undergraduates self-identifying as being in a monogamous romantic relationship. Hypotheses: (1) ratings of conflict will conform to an inverse power-law (IPL; i.e., fractal) distribution; (2) the fit to IPL s (R2) will be (a) positively associated with mean relationship satisfaction and (b) will be negatively associated with network reactivity (i.e., synchronous temporal bivariate correlations) among conflict, satisfaction and commitment; (3) IPL fit will moderate the correlation between conflict and satisfaction. Results will be discussed with respect to the theoretical role that IPL structure plays within romantic conflict and the development of intimacy, as well as implications for relationship assessment and couple s counseling.

Vivian Rambihar, Medical University of Toronto, Canada

Chaos Complexity and Complex Systems: to Prevent, Contain and Manage Covid-19

Chaos, complexity and complex systems should apply to a complex 21st century complex problem like COVID-19, with complexity considered the science for the 21st century by Stephen Hawking and the science for a complex world by the Santa Fe Institute. Viruses are considered complex adaptive systems, and COVID-19 a global pandemic that emerged from the complex dynamic nonlinear interactions of the novel corona virus, disrupting global health, society and the economy in unprecedented, unexpected, unpredictable ways. An

online search for chaos, complexity, complex systems, COVID-19 found many references, ranging from academic journal publications, Letters to the Editor and newspaper articles to blogs and websites, and from scientific analysis to leadership and decision making, including: *Websites* like Santa Fe Institute and New England Complex Systems Institute and others provide analysis. *Reports*, *Policy* and practical advice. *Journals*: The Lancet EClinical Medicine: A Systems Approach to COVID-19, Canadian Journal of Medicine Chaos. Complexity and complex systems to contain and manage COVID-19: A Complex Systems System's Theorist explains how we can stop coronavirus; the Atlantic newspaper - Covid-19 experience as a failure of usual science, requiring a complex systems approach; Forbes: How the COVID-19 pandemic is creating complex adaptive challenges affecting public health and economics, and a blog: How Complexity Theory can Help Decision-Making in Chaotic times , describing COVID-19 as chaotic, beyond complex, requiring a different leadership and decision making with rapid action, then sense to change from chaos to complex using a Cynefin complex systems model.

Vivian Rambihar, Medical University of Toronto, Canada
Sherryn Rambihar, Mackenzie Health and Medical University of Toronto, Canada
Vanessa Rambihar, Women s College, U of Toronto, Canada

Chaos Complexity Covid-19: 30 Years Teaching Health Professionals Chaos and Complexity

Chaos and Complexity, considered the science for the 21st century by Stephen Hawking and the science for a complex world by the Santa Fe Institute, should apply to medicine, health, education and global challenges like COVID-19. It describes complex dynamic social, economic, biologic, and other interactions leading on to health and disease, and between health professionals, patients and society. These exhibit nonlinearitymykimok, sensitive dependence, feedback, adaptation, uncertainty, self-lol organization and emergence, and used as a tool for change, as adaptive, dynamic, co-evolving and co-learning. A 30 year experience teaching, using, and advocating for thinking complexity, through education/scholarship and leadership included: Lectures, Editorials, book-writing, global networking and advocacy Health promotion/Preventing premature heart disease Complexity to rethink/transform medical education for the 21st century, with McMaster med ed as complexity Complexity theory of medicine and health, books CHAOS from Cos to Cosmos, Chaos/complexity Based Medicine. Proposal for Thinking Complexity for Educating Health Professionals for the 21st century (after Lancet 2010 Report) Letters to the Ed on using chaos, complexity and systems approach to prevent, contain and manage COVID-19. Health professionals were taught chaos and complexity over a 30 year period 1990-2020, to understand and manage the complex dynamic 21 st century interactions of medicine, health and disease, starting form preventing heart disease to applications to Covid-19.

Teresa Rebelo, **Paulo Renato Lourenco, Isabel Dimas** , University of Coimbra, Portugal

Does Virtuality Influence Team Learning? An Analysis With Cusp Models

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 is now receiving a tremendous boost with the COVID-19 pandemic. This study aims to contribute to this research body by adopting a nonlinear dynamical system approach. Thus, cusp catastrophe models for explaining learning behaviors in teams with different degrees of virtuality was tested in this study. Team cultural orientation (support, innovation, rules or goal orientation) was considered the asymmetry variable and the degree of virtuality 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 and using the dynamic difference equation modeling approach. With the first approach, we analyzed the three data collection moments (T0, T1, and T2) separately to test the presence of cusp structures in these distinctive team development moments. Results suggest the presence of a cusp model only at T0 (beginning of the workgroup life) when teams are support and innovation oriented. Using the second approach, that allows to include team learning changes over time, cusp structures were not identified. Overall, these findings show that the degree of virtuality assumes a bifurcation role at the beginning of the workgroup. It suggests that when members begin to work together, beyond a certain threshold of virtuality, teams might oscillate between two attractors, the modes of high and low team learning behaviors. The results also suggest that team virtuality loses influence on learning behaviors over time. This study is a clue for further research focusing the processes that teams develop over time in order to minimize the bifurcation

effect that virtuality seems to initially have on team learning.

Bernard Ricca, St. John Fisher College, Rochester NY

On the Meanings of "Phase" in Collaborative Group Research

Phase transitions in small groups have been studied for more than fifty years, and there is broad agreement that groups operate in qualitatively distinct phases. More recently, entropy-based approaches have been used to identify transitions between these distinct phases; maxima in the windowed entropy of time series data are taken as markers of potential phase transitions. Despite advances in this line of research, and even though there is an "I know it when I see it" ability to identify different phases, the notion of "phase" remains ambiguous. This ambiguity obscures the dynamics of the differences between distinct phases, and prevents data from being fully mined for information. This study presents a comparison of different systems (e.g., the Lorenz butterfly, Langton's ant, and collaborative group discourse) that identifies areas where the entropy approach fails to capture important system dynamics. These comparisons highlight three deficiencies in entropy approaches: First, a transition may result in a change in dynamics or only a change in measurements; this is important empirically and theoretically. Secondly, common entropy methods say little about the period of transitions between phases, instead relegating these transitional regions to a position of relative unimportance. Third, entropy approaches can be overly sensitive to changes in data, such as a change in the length of the data series. The consequences of these deficiencies have implications for the qualitative coding of data, the analysis of such "quantitized" data, and for the theorizing that is connected to such data and analyses.

Bernard Ricca, St. John Fisher College, Rochester NY

An Introduction to Topological Data Analysis

This workshop will introduce participants to the use of topological data analysis. Nonlinear data suffer from a number of properties that greatly limit the use of traditional data analysis techniques. Three problems in particular are both endemic to nonlinear data and not addressed by common techniques. First, the need to understand the "shape" of data (such as is accomplished with various embedding and state space techniques) can provide information about system dynamics even when these are a priori not known. Second, despite the fact that data may be sampled by an unknown process (e.g., neither normally nor uniformly sampled, and often not sampled by any analytic process), the researcher would like to make claims about the population from which the sample was drawn. Third, there are many situations where the difference between noise and signal cannot be determined in any theoretical manner, and so only arbitrary boundaries between those two can be used. The last two decades, however, have seen principles of topology applied to statistics, resulting in topological data analysis (TDA); TDA is ideally suited to address many problems of data shape, population and samples, and noise vs. signal. In this workshop, three topological concepts will be introduced, explained, and used in the analysis of data: Betti numbers, level sets, and "coverings". Betti numbers describe a topological set by counting how many objects are in the set, and how many "holes" of different dimensions are in the set. Level sets are one way of characterizing the minima and maxima of sets, such as a graph or a time series of data. Coverings of a data set can roughly be understood as attaching a disk or ball of a given radius to each point of the data set. Of particular importance in TDA is the concept of persistent homology, which is the study of how these topological features (here, Betti numbers and level sets), when applied to the "covering" of a data set, persist over many different scales (i.e., radii) of that covering. The persistent homology approach allows the data set to define the important scales rather than having those scales imposed by the analyst. The application of persistent homology to data results in "bar codes" and/or "persistence diagrams"; each of these objects can be used to identify the shapes that underlie data or distinguish between noise and signal. This workshop will introduce the participants to the elements of persistent homology and how to apply that to the shape of data, the analysis of single time series data, and how to work with data from multiple time series. Using both simulated and real data, this workshop will apply both the ideas of level sets and Betti numbers to better understand complex data. Although all participants will benefit from the presentation of persistent homology methods, this workshop will include examples of data analysis using the R statistical environment; hence, the fullest benefit will accrue to those who have some familiarity with the R statistical environment and have access to R during the workshop.

Barkley Rosser, James Madison University, Harrisonburg, Virginia

Complexity and Knowledge

This paper examines ways that complexity complicate solving the epistemological problem of knowledge. One such problem arises in connection with nonlinear dynamics, particularly with the butterfly effect of chaos theory and related issues associated with fractal basin boundaries. Computational complexity arising from logical problems of infinite self-regress entangled with interactions of heterogeneous agents. These problems connect with the idea of bounded rationality due to Herbert Simon, a founder of hierarchical and computational complexity theory. Finally we consider the question of non-ergodicity arising from complexity and the roles of ontological and epistemological uncertainty in dynamical systems.

Janice Ryan, Attunement Solutions, LLC, Chattanooga, TN

Applications of Prisoner's Dilemma Modeling in Search of a More Socially Just Dominant Strategy: Overcoming Anxiety Associated with Group Oppression: Lessons from a Single Case Study

The solipsistic gulf that is naturally created when minds operate differently is hard to overcome and, applications of Nash Equilibrium Statistics provides an appropriate illustration. Nash developed the statistical analysis process called Prisoner s Dilemma to compare cooperative and competitive strategies based on Darwinian Logic. Complex Adaptive System Self-Organization is suggested in this case study to be a more socially just dominant strategy for overcoming the hyperstable patterns that typically emerge during survival of the fittest contests such as those that can be modeled using evolutionary game theory. Real human data was collected from a single case study that demonstrates how anxiety associated with the divisive force of inclusion-exclusion dynamics can be overcome by embedding a set of, Human Systems Dynamics Simple Rules that support a feeling of unity between key game players representing diverse sociocultural groups characterized by minds that operate quite differently. New theories grounded in complexity science, have developed out of this single case study regarding the unconscious force of memories we share with other social animals and how that reactive force must be overcome through emotional self-regulation to successfully navigate the power of inclusion-exclusion dynamics represented in population-based Prisoner s Dilemma contests that typically create individual and collective patterns of anxiety and through that force, continue to support hyperstable patterns of sociocultural group oppression throughout the world.

Mark Shelhamer, Johns Hopkins University, Baltimore, Maryland

A Complex-Systems Approach to Human and Mission Resilience for a Mission to Mars

Human spaceflight is inherently complex. A successful mission involves the proper interaction of the system-of-systems of individual physiology and psychology, crew teamwork, vehicle and habitat design and function, ground-control communications, mission rules and goals, and many other factors. NASA has a very strong plan to assess and mitigate many of the individual physiological, psychological, and medical risks. However, this plan does not explicitly address interactions between disciplines. In addition to the risks that are already addressed through various mitigation strategies, there will be problems that have not yet been identified, some of which will be a consequence of the complex web of interactions among the many subsystems that make up such an undertaking. Here I propose a systematic mechanism to capture and analyze the multi-disciplinary aspects that makes up a human space flight. This approach is based on complex-systems theory and complex networks. Properly implemented, it can not only help maintain performance but also provide astronaut crews with needed autonomy and the tools to detect latent problems. The main factors that contribute to health and performance can be structured as an interconnected network. A key concept behind the network formulation is that there are emergent properties from complex interconnected systems properties that are not predictable based on the characteristics of the individual subsystems. Analysis of emergence properties and unintended consequences of interactions can help to improve the resilience of spaceflight crews and missions.

Maria Solano, McGill University, Montreal, Canada
Yuxin Qian, UCLA
David Kreindler, University of Toronto, Canada

Dynamic Time Warping to Analyze the Similarity of Mood Symptom Time Series Data

Background: Dynamic Time Warping (DTW) is a method developed in the field of speech recognition in the 1990 s for calculating the distance between pairs of time series based on the degree of shift in the time domain to achieve a best fit between the two series. In this paper, we present an approach showing how DTW can be combined with Exploratory Factor Analysis (EFA) to assess how multiple symptoms of mood disorders vary over time in relationship to each other and highlight how we addressed some challenges associated with this approach. Methods: We collected 11 symptom severity ratings plus a control item twice-daily over 18 months from (n = 18) individuals with rapidly cycling bipolar disorder and (n = 18) healthy controls, then used DTW to calculate similarity ratings between the 66 pairs of severity ratings within each subject. EFA was then used to identify clusters of symptoms that vary similarly over time across subjects. Results: Using DTW pairwise distance as a measure of similarity, we were able to identify two of 12 items that clustered on one factor and seven of 12 that clustered on a second factor; the remaining three (including the control item) did not cluster with any of the others. Conclusion: This work highlights how using EFA for dimension reduction of pairwise DTW analysis may provide a practical method for assessing data redundancy in concurrent time series, including nonlinear ones.

Sungchoon (Aviva) Sinclair, University of Utah, Salt Lake City UT

A Common Pattern Across Different Disciplines in Theoretical Physics,Chemistry, Biology, and Plastic Art: Using an Archetype of Universal Nonverbal Plastic Patterns by Kang Woo-Bang from a Qualitative Perspective

Dynamical Systems Theory (DST) allows us to view a body of knowledge from theoretical physics, chemistry, and biology as a shared complex and dynamic phenomenon, as seen in the Belousov-Zhabotinsky (BZ) reaction. Yet less is known about what the BZ reaction has to do with seemingly unrelated fields such as plastic arts, including all visual art. To qualitatively examine whether there is a common pattern across the aforementioned different disciplines and to see if there is a universal pattern, we must ask if there is a linkage between the shape of the BZ reaction and plastic arts. Kang Woo-Bang, who developed a new method for studying plastic arts that is applicable to diverse cultures, argues that there is a common artistic pattern which he has called yeonggi-hwasaeng (Transcendental Birth from the Cosmic Energy) and which is surprisingly similar to the BZ reaction. This poster aims to qualitatively and pictorially show the common patterns between the emergent form of the BZ reaction across diverse disciplines and yeonggi-hwasaeng, and explore their potential psychological meanings.

Dimitrios Stamovlasis, **Georgia Stavropoulou**, **Eleni Karastergiou**, Aristotle University of Thessaloniki, Greece

Achievement Goal Orientations and Classroom Goal Structures: Dynamic Interaction Effects on Students Academic Behaviors

Complex systems, such as school and class environments embrace a plethora of factors that influence students" attitudes, motivation, goal orientations and learning outcomes. The interesting research area of achievement goal theory has been examined within the Complexity and Nonlinear Dynamical Systems framework and the relevant psychological constructs, such as, mastery, performance-approach and performance-avoidance orientations have been proved linear and nonlinear predictors, which, through self-regulation mechanisms, affect motivation and performance. These individual differences are developed within family and school environments, from which the latter have distinctive influence. The class goal structures operationalized by the perceived by students teacher goals in the classroom have been proposed as continuously interacting with the students motivational resources, enhancing or restraining them and the anticipated outcomes. Investigating these hypotheses, we present empirical evidences from two studies. The first study carried out with low secondary school students (N=297), explores the cognitive and metacognitive strategies in writing, as a function of a number of factor, among which are the perceived teacher goals in the classroom (mastery, performance-approach, performance-avoidance), achievement goals orientation (mastery, performance-approach, performance-avoidance), self-efficacy and

interest. The second study was a longitudinal research during an academic year, carried out with high school students (N=61) attending an ancient Greek class. The measurements included the aforementioned variables along with students participation and performance recorded every week as time series. Catastrophe theory was the methodological framework used to analyze the empirical data aiming to detect dynamic effects, hysteresis and bifurcations. A series of cusp catastrophe models showed that the perceived teacher goals in the classroom acted as bifurcation factors in a number of circumstances. This signifies that the role of the class goal structures, not captured by linear analysis, is more crucial and influential, because they can induce discontinuities and transitions in the anticipated behavior. The results are discussed in light of the current theories.

William Sulis, McMaster University, Hamilton, Ontario, Canada

The Continuum from Temperament to Mental Illness: Clinical and Dynamical Perspectives

Although major depression and bipolar disorder are described in episodic terms (i.e. as intermittent states) they are commonly dealt with clinically as if they were traits. That is, there is little, if any, attention paid to examining the transitions from normal to pathological function and back again and to identify those critical states when such transitions become possible. This makes it difficult to identify those who are at risk of or transitioning into these illness states so that interventions can begin early, and to determine when treatment is actually working so as to avoid premature discontinuation or unnecessary prolongation of treatment. Most definitions of depressed or manic states describe the end state, when the process is already well established. Needed are biomarkers which can identify people in critical or transitional states. Insight into possible biomarkers comes from the conjecture that temperament in healthy individuals and mental illness lie along a continuum of neurobehavioural regulation. This continuum is described from the perspective of complex adaptive dynamical systems, the formal study of which has led to the development of a host of markers. These include geometrical markers (periodicity, intermittency, recurrence, chaos) and analytical markers such as fluctuation spectroscopy, scaling, entropy, recurrence time. The continuum can be understood as consisting of second or higher order dynamical phases in a multi-scale landscape of superposed dynamical systems. Clinically accessible biomarkers, in particular heart rate variability and activity markers are suggested to distinguish these dynamical phases and to signal the presence of transitional states.

Michael Susko, Baltimore, MD

Ten Pulses of Evolution & the Logarithmic Nature of Evolutionary Time

This work uses a novel way to map ten major pulses of evolution between 4 billion years and 7.5 million years ago, from the start of life to the emergence of early humans. Rather than use the traditional, linear scale in which events bunch up toward the end, this work uses a logarithmic scale that expands our resolution as we come to the present. Thus, events can be spaced out evenly and seen more clearly, as well as revealing the logarithmic pacing of evolutionary events. The use of the concept of logarithm should not deter us, as being too complex to use or understand. In this case, it means that we will simple halve units to mark the pulses or nodes of change as we go from the deep past to more recent times. Thus, if we begin with the start of life at around four billion years ago, we next to go to two billion years ago with the eukaryotic cell which make up our body, to one billion, to 500 million, all the way to 7.5 million and the start of humanity. Thus begins a journey, in which the patterning of time reveals the pulses of consciousness that seem to have no end.

Ken Ware, NeuroPhysics Therapy Institute, Gold Coast, QLD, Australia

Initial Conditions that Give Rise to Pathological and Non-Pathological Chaotic 'Brain/Body Dynamics' Commonly Referred to as Tremors: A Testable Hypothesis

Gravity is the vertical constant that shaped our environment and had/has a 100% influence on the design and functionality of all living systems. All animals have evolved a sensory motor apparatus to enable them to navigate through their environment in an optimal manner to enhance their survival and the survival of their species. The entire central nervous system evolved around that one constant in nature. For the human being optimal psychophysical performance emerges from good posture. Anything less than good posture equates to a measurable drop off in psychophysical performance and compromises our relationship with and our perception of our environment. The beautiful thing about having a reliable constant to measure performance of the system against is reliability of the accuracy of data. It is expected that any particular

instrument of measurement of the signal to noise ratio taken at times when a person is exhibiting optimum posture, that if they were to stray away from optimum posture that there would be measurable increases in noise that the systems evolved stabilizing features would need to criticize and compensate for. This infers sudden hyperstimulation of basal ganglia, cerebellum, thalamus etc. No problem short term, but what about long term; years and years of poor posture? Can we say that all people with poor posture will develop a pathological tremor? No, we cannot. What we can say from all our studies with and observations of the numerous patients who we have treated who presented with a pathological tremor, is that each patient had maintained very long-term significant posture neglect. In the case of Parkinsons Disease for example; if the system is forced to continually compensate for posture neglect – is mass long term overstimulation to an overworked substantia nigra the root cause of the disease; where neurons die off from overstimulation, eventually passing the threshold where more than 70% of neurons have died - at which time tremor and other pathologies emerge within dopamine dependent functions? This presentation will include compelling comparative data relative to a systems performance at the vertical constant and during periods of 'sways away' from the vertical constant.