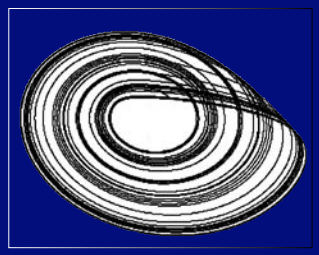
Society for Chaos Theory in Psychology & Life Sciences



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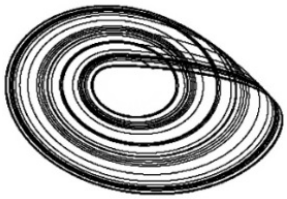
Abstracts to the 28th Annual International Conference, Raleigh, NC 2018



Society for Chaos Theory in Psychology & Life Sciences

28th SCTPLS Annual International Conference
Raleigh, North Carolina
August 2-4, 2018

KEYNOTE SPEAKERS

Jamie C. Gorman
Georgia Institute of Technology

Dynamics in Human-Human and Human-Technology Systems: Models, Metrics, and Unifying Principles

Abstract

As conditions change and perturbations are encountered, purposeful systems, including human-human teams and engineered human-technology systems, must continually reorganize themselves to achieve their goal. Does the dynamical systems approach provide any unifying principles for understanding how this process works? I will present studies of (1) interpersonal coordination, (2) team cognition, and (3) sociotechnical system performance that begin to suggest that the answer is yes. In the context of those studies, models and metrics for analyzing interaction will be described, including neural synchronization, perceptual-motor coordination, team communication, and human-technology coordination. Emphasis will be placed on the need for methods to analyze and visualize those dynamics in real time. In conclusion, I will argue that the dynamical systems approach does present a unifying framework for understanding purposeful behavior across human-human and human-technology systems while avoiding some of the complications of reductive strategies for understanding how behavior is coordinated across system layers.

Bio

Jamie Gorman earned a BA in Psychology from the University of Texas-San Antonio in 2000, a PhD in Psychology from New Mexico State University in 2006, and was a post-doctoral research associate at Arizona State University from 2007-2010. He is currently an associate professor in Engineering Psychology at Georgia Tech. Dr. Gorman's research on human performance in complex social and technological settings, including sports, medicine, and aviation, focuses on understanding and modeling human behavior using systems-level concepts. His research incorporates a variety of methodologies, including communication analysis, perceptual-motor coordination, and neurophysiology. Dr. Gorman is a member of the Human Factors and Ergonomics Society (HFES) and serves on the editorial board of Human Factors. In 2011, he and his coauthors received the Jerome H. Ely award from HFES for the best paper published in the 2010 volume of Human Factors.

Bill Warren
Department of Cognitive, Linguistic and Psychological Sciences at Brown University

Behavioral Dynamics and Human Agency

Abstract

A paradox lurks in the heart of CTPLS: An increasingly wide range of psychological phenomena is successfully brought under the umbrella of self-organizing nonlinear dynamics. Yet intentional systems with agency, such as humans and animals, differ in important respects from physical systems such as ferromagnets and sandpiles. I will suggest that intentional behavior is not only self-organized, but also adaptive: agents harness dynamics and information in the service of goal-directed behavior. Consider three examples. First, infants bouncing in a 'jolly jumper' learn to drive the system at its resonant frequency, harnessing both physics and information. Second, adults bouncing a ball on a racket adopt a 'mixed control' mode that uses information to actively modulate the passive dynamics. Third, collective behavior in flocks, schools, and crowds emerges from local interactions, but varies with particular visual control laws. Stable, adaptive behavior thus emerges from the

dynamics of the agent-environment interaction, under physical, informational, and intentional constraints.

Bio

Bill Warren is Chancellor's Professor of Cognitive, Linguistic, and Psychological Sciences at Brown University. He earned his undergraduate degree at Hampshire College (1976), his Ph.D. in Experimental Psychology from the University of Connecticut (1982), and did post-doctoral work at the University of Edinburgh. He is the recipient of a Fulbright Research Fellowship, an NIH Research Career Development Award, and Brown's Elizabeth Leduc Teaching Award for Excellence in the Life Sciences. Dr. Warren's research focuses on the visual control of human action – in particular, locomotion, navigation, and rhythmic perceptual-motor behavior. He takes an ecological approach to these problems, which seeks to explain how the organization in behavior emerges "for free" from the interaction between an organism and its environment, and is adaptively regulated by sensory information, within a dynamical systems framework. His current research investigates the visual control of locomotion and crowd behavior, combining experiments in virtual reality, dynamical modeling, and agent-based simulation.

Conference Abstracts

Din Chen, University of North Carolina Chapel Hill
Xinguang Chen, University of Florida

Cusp catastrophe Modeling and Binary Variables

The purpose of this study is to advance cusp catastrophe methods for modeling binary outcome variables commonly used in life sciences, psychology and behavioral studies. Building upon our previous research on the regression cusp (RegCusp) model as a linear regression-based method for modeling continuous outcome variables, we developed a method termed the binary cusp (BinaryCusp) catastrophe model, based on the principles of logistic regression for binary variables. The outcome variable y (yes/no) was expressed as a latent binary variable Y through a logistic regression model, providing a mathematical connection between an observed variable and the deterministic cusp catastrophe at its equilibrium. By connecting the two, Y in the logistic regression model would be one of the true roots of the deterministic cusp catastrophe model based on the Maxwell and Delay conventions. We tested this through a 5-step Monte-Carlo simulation with two predictors and three parameters for asymmetry. Results from 5000 Monte-Carlo process simulations indicated that the BinaryCusp method can obtain unbiased estimates for all the model parameters, but with the estimated empirical coverage probability varying from 0.0149 to 0.0252, substantially below the required 0.95. This indicated the Fisher information matrix method for variance estimation was inefficient. Thus, a bootstrapping approach was incorporated. With B=300, results from the bootstrapping analysis indicated great improvement in the variance estimate with the appropriate estimated coverage probability varying from 0.978 to 0.981 using the bootstrapping variance, and from 0.992 to 1.000 using the bootstrapping confidence interval. (We are still running this time intensive process with larger B to improve the estimate.) BinaryCusp appears to be a valid method based on theoretical investigation and simulation studies. We can obtain unbiased parameter estimates based on the theory of maximum likelihood estimation and valid variance estimates using bootstrapping. Our next step is applying this method in analyzing empirical data and to further the methodology and software development.

Xinguang Chen, University of Florida
Din Chen, University of North Carolina Chapel Hill
Yan Wang, University of Florida

Regression Cusp Catastrophe Modeling: A New Approach toward an Old Issue on Binge Drinking Behavior among U.S. Adolescents

Whether or not moderate levels of alcohol intake are beneficial, there is no doubt that binge drinking is harmful. It has been shown that alcohol use behavior may better be modeled as a nonlinear and discrete rather than a linear and continuous process. However, some methods for cusp catastrophe modeling are good for longitudinal data, while others, suitable for cross-sectional data, are often inadequate to determine important cusp characteristics. We capitalized on the newly established regression cusp (CuspReg) catastrophe modeling method to investigate characteristics of binge drinking. Data were derived from the 2015 Monitor The Future Study (MTF), based on a national representative sample. Participants (n=1105) were 12th graders who reported having ever used alcohol in their lives, of whom 549 (52.0%) reported alcohol use for coping. The outcome variable y was measured as the frequency of binge drinking in the past 2 weeks

(1=none, 5=six+ times). The asymmetry variable a, Perceived Alcohol Harm, was assessed using a 3-item scale. The bifurcation variable b, Drinking in three social settings, was assessed as frequencies of alcohol use during the last year (1) with one or two other persons, (2) at a party, and (3) at the beach. CuspReg indicated that perceived harm ($a1=0.2537$, $p<0.01$) and drinking in social settings ($b1=0.5631$, $p<0.01$) both significantly predicted binge drinking. Similar results were observed for subsamples of males and females, and for participants who were drinking for coping or not. The CuspReg model provides a new approach for analyzing cross-sectional data. Binge drinking follows a cusp catastrophe process better characterized by nonlinear and discrete dynamics. Findings suggest the critical role of social settings in promoting phase change toward binge drinking among U.S. high school seniors, which is beyond the commonly accepted notion of a negative linear relationship between alcohol-harm perception and binge drinking.

Ann Clancy, Clancy Consultants, Inc.
Jennifer Freeman, Transformation Coach, MT

Igniting Change in a Time of Turbulence: Coaching for Greater Internal Coherence & Context

We currently live in a time of turbulence for many individuals who feel susceptible to the influence of their external political, social and cultural contexts. The presenters are experienced transformational and appreciative coaches who focus on creating conditions and using priming strategies with their clients to help position them for deeper levels of internal change. They will present a dynamic model of self-organization based on qualitative and phenomenological research which shows the interrelationship of three core processes that contribute to a person's readiness for a substantial shift: the power of belief attractors, embodied inner knowing and the role of associative memory. Raising awareness of the lived experience of the present moment, accessing emotions, and focusing on the spiral movement of the change process all contribute to an expanded context for the client. Individuals can learn to trust in the discomfort of the process of self-organization as a way to create the friction necessary for moving to a new state. In times of external chaos, organizing to a higher frequency internally can provide a sense of stability and a greater level of coherence for clients. The presenters will demonstrate somatic movements that can bring coherence to the energy fields surrounding groups and individuals. This, in turn, leads to nuanced levels of discernment about their situations that is holistic in nature and supports higher vibrations of coherence.

Anthony Correro, **Stephen Guastello**, **David Marra**, **& Anthony Peressini**, Marquette University

Physiological Synchronization, Subjective Workload, and Team Performance in a Competitive Emergency Response Task

Human dyads and larger teams tend to acquire synchronized movements and autonomic arousal levels while working together or simply socializing. The synchronization of arousal patterns is theoretically of interest for group dynamics because the synchronization may add predictive value to the dynamics of group cohesion and team performance. This study examined the four-way relationship among experimental conditions: team size, task difficulty, and time pressure (between-subjects) and sessions (within-subjects). Previously, we have shown these conditions affect subjective ratings of workload that come from individual and group-level sources, synchronization of arousal, and team performance. In an experiment involving an emergency response (ER) simulation, 360 undergraduates, who were wearing electrodermal sensors, were organized into 44 teams of various sizes, 65 opponents, and 43 observers. Workload was experimentally varied by team size (3, 4, 7, or 8 members), number of opponents (1 or 2), and time pressure; the latter was introduced sooner or later across two experimental sessions. Results showed that the experimental conditions affected synchronization levels, either at the beginning of a session or in the middle; synchronization and experimental conditions were not directly related to team performance. Subjective group workload ratings of the coordination demand of the task predicted synchronization at the beginning of a session, while team satisfaction was associated with greater synchrony at the end of a session. The competitive nature of the ER task, as compared to strictly cooperative tasks, could be responsible for the complexity of these empirical relationships.

Paula De Franco, Saybrook University

Nonlinear Dynamics and Analytical Psychology Unification of Mind as Machine

This presentation introduces a radical departure from current cognitive psychological models and proposes an information processing approach to human behavior development or mind as machine. The new cognitive behavior model is theoretically grounded in the research of Thelen & Smith (1994) on nonlinear dynamic systems and integrates the terms attractors, control parameter and bifurcation. Briefly, Thelen and Smith identified human behavior as complex patterns or sub-systems

emerging from a few simple rules, and stressed the interdependency and interaction between these patterns, emerging behavior, and these rules. The new model's dynamic, round and interconnected framework addresses the concepts of emergent order and complexity by demonstrating how patterns of behavior arise from the interaction between the three elements of the model, which together operate as an information processing unit. A basic introduction to nonlinear dynamical systems and Jung's two-step model of the psyche are provided as the theoretical and empirical backdrop grounding the model's dynamic framework. Terminology relative to dynamic system theory and the new model is introduced, as well as the assumptions and the rules that bind and structure the model. Then, the three components that operationalize the new model are defined and accommodated within the model's framework, consisting of three interconnected circles, which together function as a unit or mind as machine. Human behavior as an information processing unit is then introduced as a simple mathematical model which represents the dynamics of the system as an ordinary differential equation.

Jonathan K. Doyon, **Joseph D. Clark**,
Tyler Surber, **Alen Hajnal**,
University of Southern Mississippi

Multifractality of head movements predicts the perception of object reachability in virtual reality. In four experiments we investigated the effects of multiscale interactions revealed through the multifractality of head movements on the perception of object reachability in virtual reality (using an Oculus Rift). Participants gave reachability judgments for objects placed on a table at distances of 60-140% of arm-length. The tabletop surface texture was also manipulated such that object reachability was judged across high and low luminance conditions, and with texture discontinuities present or absent. Head movements were quantified by differencing video recordings of the visual feed shown to the participant in the head-mounted display. Head movement data were then processed using a multifractal detrended fluctuation analysis, which directly estimates the multifractal spectrum width (MFW). Average magnitude of head movement and MFW for each participant were then used to model perceptual judgments and response times in several hierarchical mixed effects regression models. In all experiments both the mean and the multifractality of head movements exerted differential effects on participant judgments in the context of surface texture discontinuities and varying surface luminance. These results suggest that not just the magnitude of exploration, but also the complexity of exploration, both interact with environmental variables to inform the visual system when making judgments for everyday actions, such as reaching for a cup of coffee. The role of the multiscale interactions that give rise to multifractal structure in exploratory patterns and how they help to modulate judgments of reachability in virtual reality will be discussed.

Terri Dunbar & Jamie Gorman, Georgia Institute of Technology

To Sync or Not to Sync: Modulating Neural Synchronization in Teams

As people interact with each other, they simultaneously coordinate across motor, perceptual, and neural processes. At times coordination results in synchronization across, and within, these different psychological processes. This study investigated the effects of interaction partner (participant or experimenter) and type of task (decision-making or action-based) on team neural synchronization and communication. Communication was measured as both flow and content. Neural synchronization was measured as Stevens and colleague's neurodynamic entropy across different frequencies and sensor sites of the EEG. The results of the neural synchronization analysis indicate that neural synchronization is more likely to occur when team members are interacting with experimenters rather than with the other participant, in the decision-making task rather than the action-based task, and in the alpha frequencies (cognitive) rather than beta frequencies (motor) of EEG response. This pattern of results may be due to increased task engagement (i.e., more communication) when performing the task with the experimenter compared to the other participant, leading to more neural synchronization.

Jefferson Frisbee, University of Western Ontario
Joshua Butcher, Augusta University
Adam Goodwill, Indiana University
Phoebe Stapleton, Rutgers University
Steven Brooks, NIH
Stephanie Frisbee, University of Western Ontario

Cardiovascular Disease Risk Severity Progressively Constrains Perfusion Adaptability in Microvascular Networks

To determine the impact of progressive elevations in peripheral vascular disease (PVD) risk on microvascular function, we utilized eight rat models spanning from healthy to high PVD risk and using a multi-scale approach to interrogate microvascular function and outcomes. Healthy rats were Sprague-Dawley rats (SDR) and lean Zucker rats (LZR); Mild Risk were SDR on high salt diet (HSD) and SDR on high fructose diet (HFD); Moderate Risk rats were those with reduced renal mass hypertension (RRM), spontaneously hypertensive rats (SHR); High Risk were obese Zucker rats (OZR) and Dahl salt sensitive rats (DSS). Vascular reactivity and

biochemical analyses demonstrated that even mild elevations in PVD risk severely attenuated nitric oxide bioavailability and caused progressive shifts in arachidonic acid metabolism, increasing thromboxane A2 levels. With the introduction of hypertension, arteriolar myogenic activation and adrenergic constriction were increased. However, while functional hyperemia and fatigue resistance of in situ skeletal muscle were not impacted with mild or moderate PVD risk, measurement of blood oxygen handling suggested an increasingly heterogeneous perfusion within resting and contracting skeletal muscle. Analysis of in situ networks demonstrated an increasingly stable and heterogeneous distribution of perfusion at arteriolar bifurcations with elevated PVD risk; this is a phenomenon that was manifested first in the distal microcirculation and evolved proximally with increasing risk. This increased perfusion distribution heterogeneity and loss of flexibility throughout the microvascular network, the result of the combined effects on NO bioavailability, arachidonic acid metabolism, myogenic activation, and adrenergic constriction, may represent the most accurate predictor of the skeletal muscle's microvasculopathy and poor health outcomes associated with chronic elevations in PVD risk.

Joanna Garner & **Daniel Russell**, Old Dominion University

Orbital Decomposition Reveals the Differential Impact of Global Task Strategy during Self-Regulated Learning

This empirical study marks an initial attempt to conceptualize self-regulated learning as a complex dynamical system. We propose that the process of learning from text emerges through the interaction of hierarchically organized elements of a cognitive-metacognitive system, and that it manifests behaviorally as temporally contingent sequences of visual attention. To investigate this, we analyzed the visual attention sequences of 24 college students' 10 minute studying episodes using the symbolic dynamic technique of orbital decomposition. We created symbol sequence plots reflecting gaze location across materials and calculated a number of topological indices, including Shannon entropy and Lyapunov dimensionality. We found that the dynamical structure of gaze sequences demonstrates characteristics of complexity and self-organization, but that global task strategy (reading with or without note-taking) greatly influenced gaze dynamics. An inverse power law relationship was observed between the number of reoccurrences of gaze patterns and the number of observed unique patterns. Greater flexibility and adaptability in the sequence of studying the material were observed in the note-takers, and attentional points of origin for gaze sequences varied depending on whether participants engaged in note-taking or not. We conclude that the more complex visual sequences exhibited by note-takers were not simply due to greater stochastic noise, but rather arose from a richer attractor landscape. Further research is needed to triangulate this approach with variations in initial conditions, such as prior knowledge and metacognitive self-regulation, as well as outcome measures including changes in comprehension. Findings are considered in light of existing research in text-based self-regulated learning.

Stephen J. Guastello, Marquette University
Lucas Mirabito, Marquette University

Determining Optimal Lag Length and Down-Sampling Rates for Neurocognitive Data

A critical step in in a time series analysis, nonlinear or otherwise, is to determine the appropriate lag length between observations. Generalizable procedures for determining optimal lag length are not readily available, particularly if the eventual goal is to compare linear versus nonlinear models in large quantities of data or span across experimental conditions. Physiological data with dense sampling up to 200 obs/sec present further challenges. The present study examined the interacting roles of down-sampling rate, natural lag rates, task types, real-time lapse, and lag units on the accuracy of linear and nonlinear (exponential structures) autocor-relational models. Participants in the study were 197 undergraduates organized into groups of 3-7 people working through a survival problem when their hypothetical airplane crashed in northern Canada. The task generated three task conditions: watching a video that explained the problem situation, an individual mental task, and a group problem-solving task. Results showed that the optimal lag structures came from down-sampling rates of 2 or 3 obs/sec, and 1 lag unit. These sampling rates are consistent with the time horizons known for a number of elementary neurocognitive processes. Results varied across the subtasks such that greater stability occurred when participants watched the video, followed by the group task, followed by the individual task. Nonlinear models were more accurate than ARMA generally, although there were specific experimental conditions in which the reverse was true. Future researchers should investigate optimal lag from a natural rate perspective rather than rely on automatic computations such as r/e or minimum mutual entropy.

Stephen J. Guastello, **Lucas Mirabito**, **& Anthony F. Peressini**, Marquette University

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

Psychologists have had a long-standing interest in the connections between group processes and team performance. The biopsychosocial perspective has piqued an interest in the connection between team processes and performance, and coordinated and synchronized physiological arousal levels among team members. Studies of synchronization in work teams have been stalled by the lack of a metric that captures the total synchronization within teams of three or more people. This study examined how synchronized physiological arousal does in fact connect to team performance and related group process outcomes by utilizing our new synchronization coefficient (SE). Forty-three groups of 3 to 8 undergraduates (total N = 197) participated in a survival simulation in which their airplane crashed in northern Canada. SE coefficients were produced for three task segments: watching an orientation video together, an individual decision task, and a group decision task. Results showed that synchronization was greater in larger groups across the three task segments. A combination of lower SE during the individual task and higher SE otherwise was correlated with team performance and higher workload ratings for performance demands, greater team dissatisfaction, and lower demands for time-sharing between the individual and the team. SE thus indicated collective foci of attention and was responsive to ongoing group dynamics. The configuration of high and low SE supportive of team performance reflected a complex version of the optimum variability principle: Synchronization should be strong for some parts of the task and low for others.

Joshua Haworth, Whittier College
Christopher Malaya, Parker University
Cody Powell, Parker University
Dean Smith, Miami University
Katherine Pohlman, Parker University

Sensorimotor Control is Affected by Chiropractic Extremity Manipulation

Control of posture is complex and responsive to surface and context dynamics. Chiropractic manipulations are touted to be supportive of good posture and increase general mobility. Yet, there are few studies exploring the impact of chiropractic manipulations on sensorimotor control in a dynamic surface condition. For instance, does manipulation to a task-relevant site improve function at that site? To fill this gap in the literature, 18 healthy young adults completed 2 sessions in a randomized cross-over design study. Upper or lower body manipulations were delivered on separate days, with postural sway assessed before and after each manipulation using Shimmer IMU sensors to capture linear (accelerometer) and rotational (gyroscope) aspects of stance on ground or rocker board for 30 seconds. Sample entropy was calculated on the middle 20 seconds, and the pre-post- difference was calculated as the simple subtraction to represent the change in temporal orderliness of sway control. Large difference scores indicate a loss of orderliness, whereas small (or negative) values indicate a gain in orderliness. Results indicate no change in sway on the ground or when on the rocker board in the AP direction. However, on the rocker board ML condition, manipulation elicited a pre-post-difference ($p=0.002$), which differed according to site of manipulation ($p=0.025$): upper extremity manipulation was associated with an increase of 0.082 bits, lower extremity manipulation with a reduction by 0.061 bits. These results expand on previous findings that postural sway is context and task dependent by showing that it is also selectively affected by targeted sensorimotor inputs (e.g. chiropractic manipulation).

Lisa Johnson Davis, San Diego State University

The Chaotic Nature of Human Learning

Classical mechanics has informed an understanding of human learning as a process that can be reduced to a series of interventions and outcomes or knowable attributes of a particular learner given specific variables. This framework supports multi-disciplinary notions that man is a machine that can be behaviorally modified, and that human learning is simply a linear progressive process toward achievement of understanding, usually of specific content that is determined to have a given institutional value. Modeling concepts of human learning on a Newtonian chassis, however, provides an inadequate and rigid foundation that does not adequately encompass the ecological variability of the individual learner or those complex processes of emergent learning constructed from the metaphoric recontextualization of personal experience. Human learning is much more multi-faceted and unpredictable. Learners are complex human adaptive systems that self-organize, are primed toward growth, and demonstrate ongoing emergent properties as they persistently become more than just the sum of their parts. Applying a chaotic framework to the study of human learning is a novel, robust approach that provides for a flexible, expansive future-oriented model which more closely aligns with the complexity of other growth-oriented biological and chemical systems. A new conceptual framework that re-orients human learning from the mechanistic to a complex living systems focus is

presented. Implications for a new liminal learning approach, which describes how humans recontextualize environmental feedback by entering liminal spaces primed by chaos and complexity, provides a dynamic framework for describing human learning.

David Katerndahl, **Sandra Burge**, **Robert Ferrer**, **Johanna Becho**, **Robert Wood**, University of Texas Health Science Center, San Antonio

Is Perceived Need-For-Action Among Women in Violent Relationships Nonlinear and, If So, Why?

Background: Women's action-taking for their violent relationships is qualitatively a nonlinear process. Aims & Framework: To determine whether women's perceived need-for-help, legal action or leaving the violent relationship is quantitatively nonlinear and the source of that nonlinearity. Methods & Sample: 143 women from 6 primary care clinics who experienced violence. Baseline surveys assessed factors which may affect perceived need-for-action, while readiness-for-action was assessed at baseline and end-of-study. Multiple time series using daily assessments of violence and need-for-action were collected via telephone Interactive Voice Response for 8 weeks. Measures of nonlinearity of violence and perceived needs-for-help, legal action or leaving the relationship, as well as partner-perpetrated violence were computed with repeated measures analysis-of-variance assessing differences across measures of nonlinearity of violence, while vector autoregression sought the presence of multiple, interdependent predictors and circular causality; cusp catastrophe modeling sought to explain readiness-to-act. Results: The degree of nonlinearity for need-for-legal action alone was less than that of other needs. Of the four possible explanations for nonlinearity of need-for-action, need-for-help is best explained by its multiple, interdependent predictors and circular causality, while need-for-legal-assistance is best understood via cusp catastrophe modeling; nonlinearity of need-to-leave is best explained by its dependence upon the underlying nonlinear violence variable itself. Conclusions & Implications: Need-for-action was nonlinear, so we should expect that actions will seem sudden and unexpected, and that our interventions may produce unpredictable results. If we choose to intervene, then the nature of the intervention should match the potential source(s) of this nonlinearity.

Heidi Kloos, Ali Minai & Dieter Vanderelst, University of Cincinnati

The A-not-B Error Revisited: Modeling the Dynamics of Children's Attention and Memory

Recent advances in network theory and the thermodynamics of life indicate that children's memory and attention are best captured by a dynamic network of impressions, where impressions interact with each other once formed. Experiences of an event give rise to a series of impressions that synchronize with each other on the basis of outside order. The resulting network of interrelated impressions has two important features: Impressions remain sensitive to outside fluctuations, and impressions can sustain themselves by virtue of interacting with each other. Thus, a mental network is both embedded and self-sustaining, mimicking emergent adaptive networks more broadly. In the current presentation we will spell out the details of this model of attention and memory. As a test case we will focus specifically on the A-not-B error, a pattern of behavior in which toddlers search for a toy incorrectly not at the location where they see the toy disappear, but at a location where the toy was hidden and found before. This perseveration error, where children fail to apply the attention and memory skills that they are capable of, has puzzled the cognitive-development community for decades. We argue that the perseveration error reflects a temporary decrease in network sensitivity. This decrease in sensitivity is the result of the system living at a sweet spot between (1) relevant outside order available to the toddler, and (2) irrelevant outside variability perturbing the system. This sweet spot changes with development and task constraints, in line with the A-not-B findings.

Matthijs Koopmans, Mercy College

Short Workshop: The Analysis of Time Series with Complex Fractal Patterns Using R

One promising new method of analyzing complex patterns in sequentially ordered data (time series) is fractional differencing, also known as autoregressive fractionally integrated moving average (ARFIMA). This approach estimates long-range irregular processes, such as pink or 1/fα noise, which are often seen as an indication of self-similarity or fractality and therefore suggestive of complex adaptive systems behavior. This one-hour workshop will demonstrate how such

processes can be estimated in the R computing environment. The workshop consists of five parts: 1. A brief conceptual overview of the fractional differencing approach; 2. Introduction to the arima and fracdiff packages in R, used to conduct the analysis; 3. A step by step run through the diagnostic and analytical process, the programming statements (provided as handouts), plus interpretation of the output; 4. Interpretation of the differencing parameter d and the Hurst exponent H, indicators of long-range irregularity; 5. Generation of power spectra in R and their use to support a fractal interpretation of the data. Two illustrative datasets are used for this demonstration: 1. Quarterly recordings of the flow of the river Nile from 622 to 1248 AD, a classic dataset; 2. Daily attendance rates in one New York City high school from 2010 to 2014. Analyses such as these represent an attempt to address nonlinear dynamical processes systematically by extending conventional statistical approaches to include parameters pointing to complex processes. The advantages of this approach will be evaluated.

I-Chieh Lee, University of Georgia and North Carolina State University
Matheus Maia Pacheco, New York University
Karl Newell, University of Georgia

Qualitatively altering the attractor dynamics or quantitatively scaling postural sway? Functions of vision in supra-postural control

Studies that have manipulated visual information in postural control usually assume a general pattern of postural organization whereby changes in posture are caused by scaling changes in the sensory input. On the other hand, from the ecological psychology point of view, changing the task goal changes qualitatively the postural organization (i.e., the goal of quiet standing is different than the goal of standing while maintaining a relation of sensory inputs in a dual task), so that the organization of postural control should be considered as task specific, not general. Here we examine the function of vision on the attractor dynamics of posture in a supra-postural task, the influence of viewing a target as a function of distance. Sixteen participants were instructed to stand still while maintaining eye fixation on a target point located at 25, 50, 135, 220, 305 cm, and also in one no vision condition. The center of pressure (COP) was recorded and analyzed in the anterior-posterior (AP) plane. The standard deviation (SD) measured the COP dispersion and the correlation dimension (CD) quantified the dimensionality of the attractor dynamic. SD increased with the eye-target distance ($F[5,75]=3.650$, $p=.005$). CD showed a significantly lower value at the 25 cm condition ($F[5,75]=4.311$, $p=.002$). This study provides evidence of independent qualitative and quantitative changes in postural control when viewing distance was manipulated. The dynamics of postural sway reveal the specific nature of postural organization as a qualitative adaptation to the visual task requirements.

Akio Matsumoto, Chuo University

Delay Cournot Duopoly Models Revisited

In considering economic dynamics, it has been known that time delays are inherent in economic phenomena and could be crucial sources for oscillatory behavior. The main aim of this study is to shed light on what effects these delays can generate. To this end, different models of Cournot duopoly with different delays are built in a continuous time framework, and their local and global dynamics are analytically and numerically examined. Three major findings were obtained. First, the stability switching conditions are analytically constructed. Second, it was numerically demonstrated that different lengths of the delays are sources for the birth of simple and complicated dynamics. Third, the delay in collecting information on the competitors' output alone does not affect stability.

Laurie McCabe, Virginia Beach VA

Leadership Legacy of the Apostle Paul - A Biblical Exegetical Analysis

It is a ubiquitous belief that leadership is influence; and one of the most influential leaders through recorded history is Paul, the Apostle of Jesus Christ. The legacy of influence attributable to Paul could be described with various modern leadership theories; however, no one theory of leadership describes the entirety of his life and the impact of his teachings, nor the contribution of the postmodern theory of chaos and complexity. This paper provides an overview of Paul's impact as a leader through the lens of chaos and complexity theory with an exegetic analysis of the text that is Paul's letter to the Romans and Galatians. The analysis relies primarily on frequencies of text, and this is a simple method that can be easily applied to each of Paul's letters. Frequency analysis of the Romans (and Galatians) texts renders evidence that denotes key behavioral attractors describing the character and nature of God, the character and nature of mankind;, and regarding how God and mankind were intended to exist relationally for the sake of attaining salvation and a life of purpose fulfilled.

Michael K. O'Hearn, Center for Stress Related Disorders, University of Cincinnati College of Medicine

Transforming Entropy to Empathy: A Complexity-Based Approach to Cooperation and Resilience in Human Relationships

Fitness demands implicit in current sustainability challenges are unprecedented in cultural evolution. In the context of an overview of SOS developmental processes, it is theorized that key components and processes of cultural evolution are dysregulated by unprecedented sustainability fitness demands. An illustration is this paper's introduction of catalytic overload. The design of self-organization (SO) and self-organized criticality (SOC) are based on field theories of self-organizing systems (SOS) in evolutionary biology; catalytic (component) and autocatalytic (process) systems are structurally integrated in the design of SO. However, SO and SOC were latent at the turn of the twentieth century given the era's mechanistic worldview. Inadvertently, a catalytic-only paradigm emerged and shaped organizational design and management styles in social institutions. The first and only U.S. mental health system (MHS) organizational design is catalytic-only. Shannon's entropy manifests as structurally integrated cognitive dissonance in social interactions and social organization. Effective responses to sustainability fitness demands require greater clarity of perception. An intervention to regulate entropy-complexity dissipation and metabolism in marriage and committed relationships is proposed. With Odum's paradigm as a clinical framework, Gottman's behavioral correlates of relationship satisfaction and dissatisfaction are considered as products and by-products of partner interactions. Targeted behavioral algorithms quantify contribution and defection frequencies, a range of interaction metrics, and ultimately the relationship trust:entropy ratio. If attunement, cooperation, conflict management, and resilience are enhanced when couples regulate entropy-complexity metabolism, it stands to reason that a similar approach may have similar effects in and among broader networks in social systems.

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The Dependence of Postural Dynamics on Constraints of Vision, Postural Orientation, and the Temporal Structure of Environmental Stimuli

Activities of daily living require the maintenance of upright posture within a variety of environmental constraints. Having a healthy postural control system affords the ability to perform these tasks with little difficulty and allows switching between tasks with ease. Postural control is regulated by combining sensory information to determine where the body is in relation to the gravitational vertical and making corrections with the goal of maintaining the center of mass within the base of support. The purpose of this research was to understand how vision, direction of translation, and the temporal correlation of the support surface stimuli affected the short-term persistence and long-term anti-persistence characteristics of postural dynamics. Ten healthy young adults performed a standing task with either eyes open or closed, oriented anteriorly or medio-laterally, while the support surface underwent structured translations based on different levels of temporal correlation: white noise (no correlation), pink noise (moderate correlation), and red noise and sinusoidal movements (strong correlations). Center of pressure velocity was analyzed using fractal analysis to determine the dynamics of postural control. Short-term persistence was shown to be stronger with eyes closed, in the mediolateral direction, and when the structure of translation contained stronger temporal correlation. Long-term anti-persistence was stronger with eyes closed, in the mediolateral direction, and for all structures of movement except red noise. This study provides deeper insight into the flexibility existing in human movement responses to structured environmental stimuli through the fractal analysis of movement variability.

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From fractal to behavioral dynamics: Application of nonlinear analyses to probe the control of locomotion

Nonlinear analyses provide rich information about how humans navigate environments. From human-level gait patterns to global human-environment interactions, they have helped identify normal and pathological locomotor behavior patterns, setting the stage for applications. The first talk (Rhea) highlights research exploring potential utility of fractal gait training. Fractal patterns, hallmarks of healthy adaptable system, degrade with aging, injury, or pathology, linked to fall-risk and other poor outcomes. Re-developing gait characteristics may be a mechanism for adaptive gait re-emerging. Studies by Rhea and colleagues develop a fractal training paradigm. This includes overview of stimuli to alter gait patterns, retention of patterns after one training, effect of multiple sessions, 7-day program transferability, and clinical

applications. It concludes with theoretical rationale and implementation, including smartphone apps in data collection and training. The second talk (Kiefer) advances beyond individual dynamics and focuses on *metastability* in the context of human-environment locomotor navigation. Metastable dynamics, from systems remaining poised on the edge of criticality, are likely key for positively adapted behavior and successful performance. Metastability is examined as the mechanism for athletes' creative task solutions under environmental uncertainty. Data come from a virtual reality navigation task where real-time state machine algorithms drive Non-Player Character behaviors; athletes were instructed to run to a goal quickly, avoiding virtual obstacles and NPCs. Behavioral dynamics are examined relative to environmental uncertainty and performance across environments. It concludes with discussion of potential metastable dynamics driving successful athletic performance, with implications for training and performance enhancement.

J. Barkley Rosser, Jr., James Madison University

The Minsky Moment as the Revenge of Entropy

Considering macroeconomies as systems subject to stochastic forms of entropic equilibria, we shall consider how deviations driven by positive feedback as in a speculative bubble can drive such an economy into an anti-entropic state that can suddenly collapse back into an entropic state, with such a collapse taking the form of a Minsky moment. This can manifest itself as shifts in the boundary between the portion of the income distribution that is best modeled as Boltzmann-Gibbs and that best modeled as a Paretian power law.

Janice Ryan, Attunement Solutions, Inc.

Modeling Attunement as an Evolutionary Shift into a Broader and More Socially Just State of Shared Consciousness

Creatives are now recognized as people who have exceptional sensitivities that give us intuitive insights commonly not perceived by less creative members of the total population. A model of attunement is presented as an evolutionary shift into the broader and more socially just state of shared consciousness now available to the world when math/technology and artistic/spiritual creatives see, understand, and influence the world as a unified whole. In his book, Nonzero: The Logic of Human Destiny, Robert Wright proposed game theory for understanding human history as an outcome of the logic of biological integration and of social integration, as both follow the principles of non-zero-sum logic. I propose that Wright's description foretold a greater understanding of oscillatory multistable systems, and that Carl Jung's theories explain the noise-driven instinctive reactions to rapid and chaotic evolutionary drive activated within the collective unconscious during these times of rapid change. Attunement is proposed as the process utilized by groups of people who have been released from the emotional triggers that had previously fragmented less evolved groups into multi-scaled drama triangles. These groups, referred to as mystics or flakes throughout the course of human history, have repeatedly returned attention to the ideals expressed by universal archetypes, and have experienced shared synchronicities that led them to world-changing social justice movements. All conference attendees are invited to share this vision of what chaos theorists and complexity science practitioners will accomplish by coming together to make this world a better place in which to live.

Aidan Tol & Joshua Haworth, Whittier College

Prosthetic Shoulder Advancement through Consideration of Mathematical Chaos

The human arm swings rhythmically during gait, driven by the anterior and posterior deltoids during forward and rearward swing, respectively (Ballesteros, 1965; Collins, 2009, Meyns, 2013). Extensive work shows chaotic organization of leg swing during gait, but to our knowledge no work has explored this in arm-swing dynamics. Thus, we sought to do this via assessment of a computer model, a mechanical model, and a human study. In each case, evidence of chaos was determined by comparing the Lyapunov exponent (LyE; Wolf, 1995) of the experimental data series to a set of surrogate data series (Theiler, 1992; Miller, 2006). First, we implemented a MATLAB model of a double pendulum, known to exhibit chaotic dynamics. We then engineered a simple metal arm to approximate the design of the human arm. We then tracked the dominant arm swing of 14 participants (shoulder, elbow, and wrist) while walking on a treadmill at 1.1m/s in flat or inclined conditions (4.8% slope; ADA, 1999). OptiTrack cameras (8 Prime-17W) and MotiveBody software were used to track 3D position, although analysis was conducted only on the sagittal plane motion of the wrist marker (in line with the analysis of the computer and mechanical models). All assessments indicated the presence of chaotic motion. Interestingly, the LyE values were consistent between the flat and sloped surface. We suggest that chaos makes a system more robust to environmental variation and is thus a beneficial aspect of the dynamics of natural arm movement. We hope our findings may be used to improve shoulder prosthetics.

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Cusp Catastrophe Modeling of Suicidal Tendency among People Living with HIV

The number of people living with HIV (PLWH) is increasing rapidly. It is challenge to protect PLWH from the risk of committing suicide because of the high prevalence of HIV-related stigma, as well as social capital reduction after HIV infection. Linear models can explain only a small proportion of the variance in investigating the impact of HIV-related stigma and social capital on suicidal behaviors. We tested a nonlinear cusp catastrophe model to better understand the dynamics of suicidal tendencies with implications for prevention. Participants (n=523) were PLWH selected in Wuhan, China using a risk venue-based approach. Data collection used a self-report questionnaire. Modeling analysis was conducted using the multivariate stochastic cusp catastrophe modeling method. The modeled results were compared with those from linear and logistic regression. The cusp model fit the data better than the other models. Social capital was significantly associated with suicidal tendency after controlling for residence status, education level, monthly income and employment. The association was bifurcated by HIV-related stigma. Findings indicate that suicidal tendency among Chinese PLWH may follow a nonlinear cusp catastrophe process containing both a continuous and a discrete process. When HIV stigma is limited, the relationship between social capital reductions and risk of suicidal tendency is continuous and gradual. When HIV stigma is high, small changes in social capital may trigger the process for a PLWH to complete suicide. Findings support the importance of social capital enhancement and stigma reduction for suicide prevention and control in order to improve the quality of life for PLWH. Additional studies with longitudinal data are indicated to verify the findings we observed in this study.

Keith Warren, Ohio State University College of Social Work
Benjamin Campbell, & **Skyler Cranmer**, Ohio State University Department of Political Science
Nathan Doogan, Ohio State University College of Public Health

I Get by with a Little Help from My Friends: Triadic Closure Predicts Reincarceration Following Termination from a Therapeutic Community

Background and Significance: The mutual aid based nature of therapeutic communities (TCs) suggests that social network structure during treatment should predict post-treatment success. Denser social networks build trust and social support (Kadushin, 2012), and triadic closure is the primary influence on network density. We therefore predict that TC residents whose networks include a higher percentage of closed triads will be less likely to be reincarcerated following termination. Methods: Data consist of written affirmations exchanged between 1312 men residing at a 90 bed TC in a large Midwestern state over a period of eight years. Records of the affirmations were kept for purposes of clinical tracking. The data were analyzed using a Cox regression version of the Temporal Network Autocorrelation Model (TNAM) (Liefeld & Cranmer, 2016). The analysis controlled for the logarithm of age, the logarithm of days in treatment, race and total affirmations received. Results: An increase in triadic closure correlates with a reduced hazard of reincarceration (b = -2.38; se = 0.74). At the lowest level of triadic closure in the dataset, the likelihood of remaining free after one year is 42%, while at the highest level the likelihood is 93%. Log days in program predicts hazard of reincarceration (b = -0.89, se = .24) as does log age (b = -2.59, se = .20). Race does not predict hazard of reincarceration. Conclusion and Implications: Triadic closure predicts the hazard of reincarceration. This implies that TC clinicians could improve outcomes by intervening to foster dense social networks among residents.

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Ohio State University College of Social Work

Learning over Time: Senior Therapeutic Community Residents Have Higher Hub Values in a Social Network of Affirmations

Therapeutic communities (TCs) are residential treatment programs for substance abuse that are based on the ability of peer interactions to reinforce prosocial norms. For instance, TC residents are expected to affirm peers who demonstrate prosocial behavior. The hubs and authorities algorithm is an alternative to Google Page Rank for ranking the authority and importance of web pages (Kleinberg, 1999). The algorithm divides the pages into hubs, which point at other pages, and authorities, those pages to which the hubs point. Hubs are scored by their consistency with other hubs; a good one points to the same pages as other hubs. This algorithm can be used to analyze the TC process of affirming prosocial behavior; residents who are hubs have had their judgment confirmed. If residents understanding of TC principles increases with time in the program, then more senior residents should have higher hub scores. In this study fifty residents of a women s correctional TC tracked the verbal affirmations which they exchanged over the course of one day. This resulted in a directed social network with fifty nodes and affirmations between each node. Analysis of this network indicates that more senior residents have higher hub scores when controlling for age, education and the total number of affirmations sent to peers (p = .042). TC residents gain consistency in their judgments of

prosocial behavior over the length of their stay in the program, and by extension learn and are able to act on principles of prosocial behavior.

Bruce West, Mathematical and Information Science, Army Research Office

On Paradox and Criticality

How does cognitive dissonance through paradox play a role in innovation, heroic acts and creative behavior? More fundamentally, how does criticality resulting from complexity generate paradox? The empirical basis for paradox is the observational fact that people hold contradictory beliefs, even though such beliefs are logically incompatible and cannot both be true simultaneously. We have recently shown that one resolution of such paradox rests on a two-level network model of cognition; one subnetwork models emotion-based decisions, the other subnetwork models rationality-based decisions, and the interaction of the two subnetworks adapts the internal dynamics of decision making to simultaneously cope with both sides of a paradox. This is the self-organized temporal criticality (SOTC) model. The talk will, as an exemplar, explore selfishness, altruism and their logical incompatibility represented by the Altruism Paradox. This paradox was identified by Darwin, who pointed out that it was fundamentally incompatible with Natural Selection. We shall also show how the tragedy of the commons is related to this paradox. The logical contradiction will be resolved by direct calculation, using the SOTC model, which is an instantiation of Kahneman's Think Fast, Think Slow. The SOTC model is quite general and easily extended to other forms of paradox, for example, to facilitate innovation and creative behavior.

Toru Yazawa, Tokyo Metropolitan University

Scaling Exponents Computed by EKG-mDFA Method Serve as a Useful Bioindex: A Heartbeat Analysis for Speedy Health Detection

In crayfish (H Schapker et al. 2002; ZP Shuranova et al. 2006) and lobster (T Yazawa, 2015), and in humans too, cardiovascular responses reflect momentarily varying inner emotional tension. This challenges us to measure the internal world or internal drives. Methods: We collected 2000 beat long sets of heartbeat data in the form of R-R interval time series data from electrocardiograms (EKG). Fluctuation/variation of the heartbeat was characterized by modified detrended fluctuation analysis (mDFA), which computes a scaling exponent (SI) from the time series. Results: The value of SI varies with heart conditions. An SI of 1.0 is a value for a basal healthy level (Kobayashi & Musha 1982; Peng, Goldberger; T Yazawa 2015). In the present study, a healthy SI appeared: during (1) happily sitting at a waiting lounge in the airport, (2) safely driving a car on a country road without speeding. High SIs (1.2-1.5) are associated with unpredictable death (T Yazawa 2015). We found that excess stress increased SI, for instance during ergometer exercise (n=75), squatting exercise (n=50), and energetically walking (n=5). SI decreased to 0.8-0.5 while sleeping deeply (0.56), writing an abstract for a congress (~0.7), enjoying very tasty dishes (0.61), and watching Eddie Murphy's touching movie, Mr. Church (0.75). Conclusions: SI values dynamically vary with heart conditions, such as healthy basal or stressful conditions and so on. The heart is a window into the internal world.

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Chaotic Systems and Six Sigma Methodology

Six Sigma methodology is widely used in quality control processes to provide absence of defects. However, in these cases stochastic systems are considered. At the same time, many systems have chaotic characteristics. Therefore, customization of this technology to chaotic systems is of interest. It is supposed that in chaotic systems the parameters for probability densities are stochastic variables too. In this way, there is a possibility for estimating the probability of defects or negative consequences in chaotic systems as well. Thus, scope of Six Sigma Methodology is significantly enlarged. The possibility for analyzing defects occurring in complex systems then arises. This is important in many fields of industry and science.

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Olga Kumukova, High-Mountain Geophysical Institute, Russia

Chaotic Character of Meteorological Data and Avalanche Risk Forecasts

Meteorological data are very important in avalanche risk forecasts. Therefore, their proper description can improve such work. This is especially interesting in middle term analysis. Here, extrapolation is used, and although such techniques add raw error, they nonetheless permit us to find boundaries of snow slip danger and prepare suitable recommendations. The method of structural minimization of risk is applied to reconstruct dependencies. Chebyshev polynomials are used because their application gives the possibility of minimizing maximum error. First, parameters of the densities of probabilities are computed at a fixed time; then the probabilities of various levels of avalanche danger are calculated.