Society for Chaos Theory In Psychology & Life Sciences

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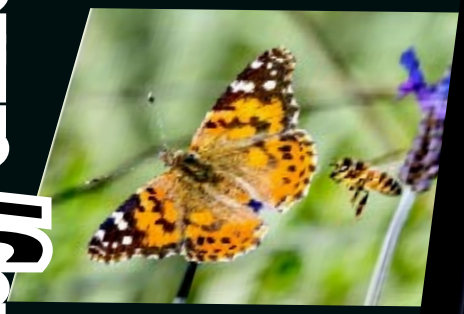

Abstracts *to the* 29th Annual International Conference

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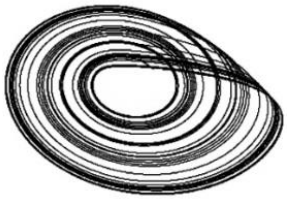

Society for Chaos Theory in Psychology & Life Sciences

ABSTRACTS

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Chapman University, Orange, CA, August 1-3, 2019

In alphabetical order by Author or Presenter

Gaetano Aiello, University of Palermo, Italy

A Logistic Approach to Drug Consumption in Timed Chemotherapy

A major cause of relapses of a tumor under chemotherapy is the presence of a parasitic phenotype of cancer cells that steals part of the drug for its own growth. This work suggests a strategy in dosing the drug which might help keeping this phenotype under control. By assuming the stealing is reciprocal, the response of each population should be accordingly with a Lodka-Volterra model, in the sense that each population would oscillate under therapy. However, the volume of the tumor - which is the sum of the two populations - will not oscillate, as the dynamics evolves around a "singular" fixed point - a point that is never reached. Oscillations in the volume of the tumor can be achieved for systems of a higher nonlinearity. The logistic equation provides the desired degree (cubic) of complexity. Accordingly, the drug consumption rate is directly proportional to the rates of growth/decay of each population. The plasmatic concentration of the drug decreases linearly with the sizes of each population. Then, a dose equal to the current plasmatic concentration is continuously delivered. As a response, the volume of the tumor oscillates, and so does the plasmatic concentration. The dose delivered changes with time, which keeps the volume of the tumor oscillating within (hopefully) safe limits almost indefinitely, which should prolonging patient's survival to a great extent. A few theoretical examples of the dynamics of a tumor will be shown.

Vincent Berardi, Chapman University
David Pincus, Chapman University

Fractal Self-Structure and Psychological Resilience

Mainstream social psychology investigations of self-complexity and psychopathology have produced contradictory results, potentially due to a lack of theoretical and methodological grounding in complexity theory. The current study proposes that the self has an interconnected fractal structure, and that this structure may be reflected within inverse-power law (IPL) distributions of response times to self-related questions. MMPI-2 item response sets (N = 300) were selected from a larger pool of 1,881 forensic administrations. Self-complexity was operationalized as the inverse of the shape parameter (β) of the frequency distribution of reaction-times to MMPI-2 items (n = 567) for each participant. It was predicted that: (a) these distributions would generally have strong fits with IPL distributions; and (b) that β would tend to be correlated with pathology among the MMPI-2 scale scores. The results confirmed that the response-time distributions tended to fit IPLs (mean r^2= 0.9416; range: 0.64 to 0.99). Furthermore, 18 of 45 correlations between β and MMPI-2 scale scores associated with pathology were statistically significant, suggesting that rigidity in fractal self-structure is associated with broadband psychopathology. A follow up principal components analysis of the 45 individual scale scores across the participants confirmed this conclusion, producing three latent components, each of which was significantly correlated with β, and had a broad variety of scales with factor loadings > |0.5|. These results may provide a first step toward a practical complexity-science approach to measuring the structural resilience of the self and viewing the self as a complex self-organizing system.

Vincent Berardi, Chapman University
David Pincus, Chapman University
Evan Walker, Chapman University

Resiliency and Resistance to Physical Activity Interventions

Over the past decades, there has been little change in adults meeting moderate-to-vigorous physical activity (MVPA) guidelines. Numerous individual-level MVPA interventions have been performed with varying, but typically modest, success. Recent technological advances now make it possible to continually assess physical activity for extended periods of time, which enables novel features within MVPA interventions to be examined. One such feature is the robustness of daily activity patterns, in terms of their resistance to change. In the current study, we hypothesized that a.) the robustness of daily activity patterns can be estimated by how well the distribution of daily MVPA minutes approximates an inverse power law distribution and b.) that individuals with more robust patterns will be more resistant to intervention procedures and will have poorer intervention outcomes. These hypotheses were explored through an intensive MVPA-promotion trial, where 512 inactive adults wore an accelerometer for one year and received financial rewards for meeting daily MVPA goals. The distribution of daily bout minutes over each participant s first 30 days in the intervention was calculated and an inverse power law was fit to the data. The association between the fit index and intervention performance, as measured by total number of goals met, was explored. After controlling for the intercept of the fitted function, which is a proxy for the frequency of low-activity days, the fit index was negatively correlated with total goals met. The consequences of this finding along with the description of various subgroups detected in the sample will be discussed.

Xinguang "Jim" Chen, University of Florida
Kai Wang, Harvard University
Ding-Geng "Din" Chen, University of North Carolina at Chapel Hill

Cusp Catastrophe Modeling of Testosterone in Bifurcating the Age-Related Changes in an Established Prostate Cancer Biomarker PSA

Advancing cancer research needs to adapt nonlinear dynamic systems (NDS) approach in addition to the linear dynamic systems (LDS). Dynamic changes in prostate-specific antigen (PSA), a biomarker of prostate cancer showed NDS character but this character has not been examined in literature. In this study, we examine PSA guided by a NDS paradigm. Participants were urology patients diagnosed with either prostate cancer (n=27) or benign prostate disorder (n=352) from a tertiary hospital in northcentral Florida. Data were derived from the 2001-15 electronic medical records (EMR). PSA levels (ng/ml) were analyzed with cusp catastrophe mode in which participants age at the PSA level was used as the asymmetry variable, and testosterone levels (ng/dL) as the bifurcation variable. Modeling analyses were executed in the open source R software. LDS-based linear correlation and regression analyses were also conducted as a comparison purpose. The mean age of the participants was 66.1 (SD=9.8) years old; the PSA range was 0.05-13.8 with mean = 1.7 (SD=1.2) ng/ml; and the total-testosterone range was 27.00-1297.00 with mean = 318.0(SD=191.6) ng/dL. Results from Chen-Chen cusp regression indicate better data-model fit for cusp (R2 = 0.47) than for linear regression (R2 =0.027). Serum PSA was significantly associated with age (a1=0.2691, p<.001) and bifurcated by blood testosterone (b1=1.0265, p<.00) with the estimated cusp point = (age=63, testosterone=630 ng/ml). The estimated cusp point was close to the epidemiology data that the risk of prostate cancer started to accelerate at about ages 60 to 65 years; and testosterone level of 630 ng/ml, closer to the up-limit 800 ng/dL of normal range (280-800) by the American Association of Clinical Endocrinologists (AACE). In conclusion, this is the first study that examined the dynamics of PSA in men and demonstrated that serum PSA level follow the NDS. In addition confirm the relationship between age, testosterone and PSA, findings of this analysis provide a reasonable explanation of the large PSA-range in healthy men and the small difference in mean PSA between healthy men and men with prostate cancer (1.2 vs. 2.6). There is a need to re-evaluate the role of PSA for prostate cancer screening guided by NDS paradigm.

Joel DiGirolamo, International Coach Federation (ICF)
Stephen Guastello, Marquette University

The Nonlinear Dynamics of Coaching: A Theory

Executive, life, and other types of coaches facilitate learning and change in clients. Very little theory has been developed in the coaching field, and the little theory that has been published relies heavily on the field of therapy. Perhaps more importantly, existing theory gives short shrift to the nonlinearities clients experience during coaching. This theory is based upon the research in the field of coaching that describes what happens in coaching sessions and most specifically on a set of critical incidents that took place in highly effective coaching sessions that were supplied by experienced coaches. All of these incidents followed a consistent pattern: the client had some receptivity to change, the coach listened attentively, the coach utilized a mechanism to evoke a new awareness in the client, and a positive outcome occurred. These incidents all occurred suddenly with dramatic shifts in the client. A lens through which to observe these conversations is that of nonlinear models. We know that clients can also come to new awareness and learning slowly over time. Cusp models can be useful tools to explain and visualize

both the gradual and sudden change. Let us consider that clients come to new awareness and shift by exerting some level of effort. In cases where clients have little resistance to change they may learn slowly and steadily. However, in cases of high resistance to change, if the client continues to expend effort, a sudden shift may occur as can be illustrated in a cusp model.

Kevin Dooley, Arizona State
Surya Pathak, U of Washington
Thomas Kull, Arizona State U
Zhaohui Wu, Oregon State U
Jon Johnson, U of Arkansas
Elliot Rabinovich, Arizona State U

Process network complexity and GHG emissions

Reducing greenhouse gas (GHG) emissions is key to reducing the impacts of climate change and global warming. The majority of GHG emissions are associated with the production of material and goods within the consumer economy. A process network is a self organized collection of industrial processes that make up the life cycle of a product s supply chain. In this study, we propose that these networks evolve to greater complexity and in doing so, become more efficient and reduce GHG emissions. We operationalize complexity in two ways: modularity of the network, and commonality between nodes in the network. We use Simon s "architecture of complexity" theory, and theory concerning division of labor and specialization to create our hypotheses. We test our hypotheses using a sample of 4,191 process networks extracted from a life cycle inventory database. Empirical results confirm that as process network complexity increases, greenhouse gas emissions decrease. Implications to product design and supply chains are discussed.

Stephen J. Guastello, Marquette University
William Futch, Marquette University
Laura Marsicek, Marquette University
Lucas Mirabito, Marquette University
Dominique Green, Marquette University
Brittany Witty, Marquette University

Forecasting of Chaotic Events, Heuristic Used, and the Prediction of a Rare Cognitive Ability

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

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

Cognitive Workload and Fatigue in a Chaotic Forecasting Task

Many real-world tasks require people to forecast chaotic events in order to take adaptive action. This study extended previous work on cognitive workload and fatigue, which separated the two phenomena through use of two cusp catastrophe models, by considering performance dynamics in a forecasting task. Participants were 147 undergraduates who were shown graphs of brief chaotic number series for which they needed to forecast the next four values. Performance data were complemented by variables known to represent cognitive elasticity versus rigidity, compensatory abilities for fatigue, and NASA TLX ratings of subjective workload. R-square for the workload cusp was .56, which compared favorably to the next best linear alternative model (.12); it contained five bifurcation variables and three measures of workload (asymmetry). R-square for the fatigue cusp was .54, which also compared favorably to the next best linear alternative (.07); it contained one bifurcation variable and two compensatory abilities. The role of field independence as an elasticity variable in the workload model and as a compensatory ability in fatigue was particularly noteworthy.

Brooke Jenkins, Chapman University
John Hunter, University of California, Irvine
Michael Richardson, Macquarie University
Tamlin Conner, University of Otago
Sarah Pressman, University of California, Irvine

Affect Variability and Predictability: Using Recurrence Quantification Analysis to Better

Understand How the Dynamics of Affect Relate to Health

Changes in affect over time have been associated with health outcomes. However, previously utilized measurement methods focus on variability of affect (e.g., standard deviation [SD], root mean squared successive difference [RMSSD]) ignoring the more complex temporal patterns of affect over time. Recurrence quantification analysis (RQA) may help alleviate this problem by assessing temporal characteristics. RQA metrics, such as determinism and recurrence, can provide a measure of the predictability of affect over time, indexing how often patterns within affective experiences repeat. In Study 1, we used simulated cases (N = 900) to contrast RQA metrics with commonly used measures of variability to demonstrate that RQA can further differentiate among patterns of affect (SD: $F(8, 891) = 163.77$, $p < .01$; RMSSD: $F(8, 891) = 106.21$, $p < .01$; RQA: $F(8, 891) = 392.96$, $p < .01$). In Study 2, using daily diary data (N = 1,482), we analyzed the associations between predictability, variability, and health, namely, depressive and somatic symptoms. We found that RQA metrics predicted health above and beyond mean levels and variability of affect over time. The most desirable health outcomes were observed in people who had high mean positive affect ($b = -0.48$, $p < .01$), low mean negative affect ($b = 0.56$, $p < .01$), low affect variability ($b = 0.31$, $p < .01$), and high affect predictability ($b = -0.16$, $p < .01$). These studies are the first to demonstrate the utility of RQA for determining how temporal patterns in affective experiences are important for health.

L Johnson Davis, Otay Institute, Chula Vista, CA.

Impending Extinction?: Why We Must Re-frame Climate Change in terms of Complex Human Adaptive Systems

As we enter an emergent human existential crisis, we must face the complex problems that climate change will have, not only on the biodiversity of our planet, but on the human capacity to work through the fear of the unknown and to develop an increasing understanding of the impact of these changes on an individual and community-wide sense of meaning and living. This paper presentation will dive deeper into the emergent framework for complex human adaptive systems describing the theoretical underpinnings of the liminal chaotic phase transition and discussing behavioral building blocks such as attachment and acceptance, that may help humanity respond as a multi-layered adaptive system.

Adam Kiefer, Division of Sports Medicine, Cincinnati Children s Hospital
Henry Harrison, Division of Sports Medicine, Cincinnati Children s Hospital
Anoop Sathyan, Department of Aerospace Engineering, University of Cincinnati
Ryan MacPherson, Division of Sports Medicine, Cincinnati Children s Hospital
Kelly Cohen, Department of Aerospace Engineering, University of Cincinnati
Joey Facciolo, Division of Sports Medicine, Cincinnati Children s Hospital
Brooke Gadd, Division of Sports Medicine, Cincinnati Children s Hospital
Paula Silva, Department of Psychology, University of Cincinnati

Predicting Athlete Decision Making in Simulated Sport via a Genetic Fuzzy Inference System

The ecological behavioral dynamics approach provides a radically embodied and embedded perspective to understand the emergent behavioral processes that allow an athlete to maintain stable, adaptive performance across a dynamic environmental landscape. The present experiment leverages this approach to understand athlete decision making in the context of goal-directed navigation and obstacle avoidance. Twenty-nine high school soccer athletes navigated to a virtual waypoint while avoiding dynamic non-player characters (NPCs) in virtual reality. An interaction event was identified for every instance in which an athlete came within 2 m of an NPC and the athlete s selected passing side (i.e., right versus left) relative to the NPC was indexed for each interaction. Fuzzy inference system (FIS), trained using FuzzyBolt, was used to post-hoc predict the passing-side classification for time $t = -2000$ ms $< t \leq 0$ ms of the athlete-NPC interaction. The FIS exhibited 75% classification accuracy at $t = -2000$ and exhibited minimal change through $t = -1400$ ms). However, at $t = -1200$ ms, the FIS reached 86% accuracy and continued to improve to 97% classification accuracy through $t = 0$. These results indicate that information-based ecological variables of performance are adequate to accurately predict athlete decision making in a sport-like goal-directed navigation task without the need for behavioral trajectory generation, as these variables provide relevant information about the actual environment due to the athlete-environment interactions from which they emerge.

Akio Matsumoto, Economics, Chuo University
Ferenc Szidarovszky, Mathematics, Corvinus University

Time Delays and Chaos in Two Competing Species Revisited

This paper reexamines the Lotka-Volterra competition modelwith two delays. The steady state is shown to be locally asymptotically stable without delay. If the two delays are identical, then the model becomes a one-delay system. The critical value of the delay is determined when stability might be lost. If the delays are different, then the stability switching curves are analytically defined and numerically verified. It is demonstrated that the unstable two-delay system may exhibit periodic behavior, multistability, quasi period-doubling cascade and even complicated dynamics depending on model parameters.

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

Experiential Balancing Therapy (EBT): Central Goals and Useful Concepts

Experiential Balancing Therapy (EBT) is an integrative theory of psychotherapy grounded in complexity science. EBT encompasses the predominant constructs, strategies and techniques from each of the numerous schools of psychotherapy within a single, coherent, empirically testable framework. The basis for integrating the seemingly varied and disparate approaches rests in the understanding that all psychotherapies share two complementary structural goals: experiential flexibility and experiential integrity. As such, everything in psychotherapy can be boiled down to increasing the flexibility of habits, emotion, cognition and relationships while simultaneously increasing connectivity. This talk will briefly unpack these theoretical concepts and their empirical support, and will conclude with a description of the most useful applications of complexity science to contemporary psychotherapy.

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

Romantic resilience: An empirical investigation of fractal conflict dynamics and relationship satisfaction

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 56 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 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.

Barkley Rosser, James Madison University

Reflections on Reflexivity and Complexity

Reflexivity has a considerable history as an idea in the social sciences, with many specific meanings and applications, generally involving mutual interaction between separate agents or groups. Complexity has many meanings, often involving emergence of higher level forms. It has been argued that dynamic interactions in reflexive systems can bring about complex emergence. This is studies especially in connection with artwork by Escher and Velasquez in this paper. A central new idea is that indirect self-referencing in some forms of reflexivity are more likely to bring about this complex emergence.

Janice Ryan, Attunement Solutions, LLC, President

In Support of Quantification of Nonlinear Shifts Toward Prosocial Behavior in Psychotherapy

Promotion of prosocial behavior during psychotherapy requires a nonlinear approach that shifts continuously between big and small picture thinking. This is required because, open and closed system thought processes each have their advantages and disadvantages. Based on feeling oriented theories, positive avoidance coping can be recognized as an open system process for relieving tensions that naturally emerge during shifts in previously biased perceptions. Warm glow theory and the negative relief model can be viewed through this lens as affective system attractors that keep people unconsciously bound within deeply held but disempowering beliefs. Based on empathy theories, positive approach coping is the self-organized state in which negative tensions have been relaxed for autonomous decision-making that dampens boundary divisions constructed by early life group influences including kin selection, social influence, ingroup-outgroup dynamics, and moral norms. Positive approach coping is also the self-organized state in which negative

tensions have been relaxed from tightly controlled early life rules that had developed out of individual differences related to genetics, age, personality, and personal beliefs. Through this affective system self-organization process, nondualistic thought processes can be promoted to replace deeply embedded dualistic thinking that blocks development of prosocial behaviors across the boundaries that are socially constructed by natural ecosystem diversity. Quantifiable proof of this recognized therapeutic process has positive psychotherapeutic implications.

Janice Ryan, Attunement Solutions, LLC, President

Quantification of Nonlinear Shifts Toward Prosocial Behavior in Context of Societal Evolution

Individual creativity is quantifiable as a trait of societal change agents whose behavior patterns are in opposition to survival-based behaviors typically analyzed for Nash equilibrium using the Prisoner s Dilemma. Social justice change-agent patterns in spiritual leaders including Jesus and Gandhi, demonstrate the ability to shift into the unstable game of Rock-Paper-Scissors when a society s reward and punishment system has become hyperstable. Based on psychotherapeutic and compassion mindfulness practice experience, promotion of societal change from a low position of power requires a nonlinear process shifting continuously between big and small picture thinking for context-specific adaptive strategy development and intentional execution. In these individuals, negative approach and avoidance coping is overcome after it is observed to be survival-based behavior patterns emerging from selfish motivations. Positive avoidance coping can be recognized as an open system process for relieving tensions that naturally emerge during shifts in previously biased perceptions during development of mature spiritual wisdom. Based on empathy theories, positive approach coping is the self-organized state in which negative tensions have been relaxed from tightly controlled early life rules for nondualistic decision-making. Through this affective system self-organization process, wisdom maturity allows spiritual leaders to move past the power of boundary divisions constructed by their own early life group influences including kin selection, social influence, ingroup-outgroup dynamics, and moral norms. Current faith-based and social justice organization practice applications will be discussed.

David Schuldberg, University of Montana

Leveling up and leveling down: A meta-heuristic for seat-of-the pants system identification

When first discovering nonlinear dynamics, people generally see the behaviors of nonlinear dynamical systems first, how they can unpredictable, bifurcating, patterned, self-organizing, etc. The butterfly effect and fractals are identified as nonlinear phenomena. Later, people may learn about specific mathematical relationships, the smaller-scale nonlinear functional relationships, equations, and models often fairly simple ones that can account for and even explain complex behavior. The prior, macroscopic, approach can obscure an important advantage of nonlinear methodologies: Complex dynamics can sometimes be understood through models that are only somewhat complicated but that contain nonlinear terms. An important component of a systems program within any discipline is to level down to consider underlying systems. However, this confounding of a nonlinear system s complex behavior and its mathematics points to something else as well. The output of one nonlinear system can provide the nonlinear input of another dynamical system that includes it. In modular and hierarchical models we find this larger system by leveling up. The all or none response of a nerve s firing, leveling up, contributes as a component to larger systems involved in say -- a response on a reaction time task. Leveling down, the nerve s threshold response is itself a product of more microscopic, also likely nonlinear, biochemical processes. Choosing one s level of model represents an important problem in choosing the methodology for a particular research problem. This is discussed in relation to similar concerns, including sociology s looking up and looking down.

Dirk Schulze Kissing, Deutsches Zentrum für Luft- und Raumfahrt
Carmen Bruder, Deutsches Zentrum für Luft- und Raumfahrt

Gaze data provide sensitive metrics of attention-synchronization in teams

Teams of three can be conceptualized as nonlinear dynamic action systems with coordination activities reflected in attentional synchronizations emerging between the individual cognitive systems. A team's coordination function might be impaired when the communication is prohibited or when there is conflict in the team. Successful communication is reflected in patterns of coupled visual attention. It is tested if an integrated gaze-measure for N=3 generated by bivariate cross-recurrence analyses is sensitive to established treatment effects, and thus can provide objective assessment of coordination processes within small groups. A 2 Communication [R/T on vs. off; within] x 2 social context [dissonant vs. non-dissonant; between] mixed design was chosen. In a Synthetic Task Environment (STE) comprising detection and decision tasks, small groups have to react to critical events and

decide about investments for remedy. During the detection task a group can draw simple inferences based on disjunctive information to reduce uncertainty. In the R/T-off condition the communication channel is deactivated during the signal detection task. For a dissonant social context a social dilemma plus competitive priming (by role description and incentive structure) is induced into the collaborative decision task. Gaze behavior of each participant is measured with an Eye-Follower® remote system (120 Hz). The coordination indicator percentage of integrated cross recurrence rate (%iCRR) is calculated based on the synchronized gaze-data utilizing . Only measurements on a signal detection task performed in the context of a synthetic-task environment are reported. 144 participants (age: M=23.01; SD=5.03; gender: 51.4% female, 48.6% male) were grouped into 48 teams (15 ab-initio ATCo candidates, 33 students). During a 3,5h session 2 scenarios are performed, each comprising 48 signal-detection trials with 3 malfunctions forcing a collective decision. Experimental conditions were balanced. A Mixed-Model Analysis of the %iCRR values produced a main effect for R/T [$F(1, 679.2)= 92,21$, $p> .05$, $\eta p^2= .0841$]. The magnitude of %iCRR was higher when the communication channel was open (cf. figure 2). A main effect for social context [$F(1, 679.2)= 6,69$, $p> .05$, $\eta p^2= .006$] indicates lower behavioral couplings for groups performing under dissonant conditions (cf. figure 2). A significant interaction [$F(1, 679.2)= 4,47$, $p> .05$, $\eta p^2= .004$] indicates a mediation of the social context effect by communication (cf. figure 2). Resume and practical implications Indication is provided that with focal goals in conflict (dissonant social context) behavioral coupling decreases. We assume the metric of integrated gaze cross-recurrence to be a sensitive objective measure for the assessment of the macrocognitive process of coordination within small groups.

Kotaro Shoji, Trauma, Health, & Hazards Center, University of Colorado Colorado Springs
Aaron Harwell, Trauma, Health, & Hazards Center, Psychology, University of Colorado Colorado Springs
Charles Benight, Trauma, Health, & Hazards Center, Psychology, University of Colorado Colorado Springs

Testing Self-Regulation Shift Theory with Hidden Markov Model

Self-regulation shift theory (SRST; Benight, Shoji, & Delahanty, 2017) provides a model for nonlinear dynamic process of trauma adaptation. SRST suggests that some portion of trauma-exposed people experience a sudden shift from one state of trauma recovery to another state. Coping self-efficacy (CSE) is a catalyst for this shift. The present study tested whether people who experienced wildfires had this shift in their posttraumatic stress symptoms (PTS). We measured PTS and CSE for the wildfires among people (M age = 38.33 [SD = 16.45], 70.4% female) who had experienced the wildfires in California between 2018 and 2019. We asked them to complete the questionnaires for PTS and CSE every day for 30 days using an EMA app. We performed hidden Markov model with two states on PTS with CSE as a factor affecting the transition between two states (N = 23). The model for six participants did not converge. Results showed that AIC for a two-state model was smaller than AIC for a one-state model in 8 out of 17 participants (47.1%), suggesting that the shift in PTS from one state to another happened among these 8 participants. The correlation between AIC for the Markov model and time since the wildfires indicated a medium effect size (r = .37). This might suggest that a nonlinear shift in PTS happens more frequently when time elapsed since a traumatic event is shorter. The results are consistent with the previous findings supporting the shift in PTS can happen with CSE as a catalyst.

Rahul Soangra, Chapman University

Does lateral stepping gait and dual tasking affect variability of healthy young and older adults?

Lateral stepping gait has demonstrated decreased variability and decreased the involvement of the central nervous system s active control in the direction of progression. Additionally, the performance of the secondary task, i.e. dual task affects certain aspects of gait, but the relationship between gait variability and dual tasking is not well known. This study explores human gait variability of stride interval time series (SIT) and signal magnitude difference time series (SMD) while forward and lateral walking using an inertial sensor mounted at the sternum. Seven young (age 22.6 ± 2.5 years) and seven old participants (age 71.14 ± 6.5 years) were recruited into this study. Participants performed forward and lateral walking on a treadmill at their preferred speed with and without dual tasking. Since cognitive task such as mental arithmetic tasks (for example, counting backward by subtracting three digits) are self-generated and performed with selected spontaneous rhythm, so are used as a secondary task while walking. We found that the complexity of SIT and SMD decreased significantly during lateral walking among young and older adults ($p=0.01$). We also found significant interaction effects in the complexity of SMD signals between the direction of progression and age groups. Furthermore, it was also found that dual-tasking affected both forward and lateral walking and both age groups by decreasing fractal properties in SMD ($p=0.02$). Contrastingly, we found that dual-tasking significantly increased complexity in SIT signals among healthy young and older adults ($p=0.01$). In conclusion, the findings of this study elucidate that lateral walking and dual-task related changes in gait compensate with

movement variability. Further studies are needed to understand whether these variability changes do predispose healthy young and older adults to falls.

Ron Stevens, UCLA School of Medicine/ The Learning Chameleon
Trysha Galloway, The Learning Chameleon, Inc.

Training Machines to Recognize Neural Correlates of Team and Team Member Uncertainty

Objective: In this paper we describe efforts to train machines to recognize neural correlates of team and team member uncertainty. Background: Every human decision has its origins in uncertainty. Despite its ubiquity, and theoretical understandings, there are few ways of dynamically tracking moment-by-moment human uncertainties. Knowing when a team or one of its members was beginning to experience uncertainty would provide a basis for assessment-intervention loops enabling machines to better support human activities. Method: Second-by-second symbolic representations of EEG power were created from each team member and quantitative estimates of their neurodynamic information were calculated from the Shannon entropy of the symbol streams. Neurodynamic information was isolated from thirty-one 71-127s segments where speech indicated surprise or uncertainty by team members. The first 70s of these segments were classified by self-organizing artificial neural networks to provide profiles of the onset of uncertainty. Results: The thirty-one segments were classified into six artificial neural network categories based on dynamic profiles and the levels of neurodynamic information. The categories were sufficiently distinct to suggest that alternative forms of feedback could be developed for each category. Conclusions: Computer machines can be taught to recognize the onset, and possibly the duration and magnitude of periods of uncertainty in STEM problem-solving, healthcare and military teams. Application: The ability of machines to recognize neurodynamic correlates of uncertainty will provide the ability for real-time feedback and scaffolding of teams and team members in complex task environments.

Ayme Tomson, Cognitive and Information Sciences, University of California, Merced, CA
Teenie Matlock, Cognitive and Information Sciences, University of California, Merced, CA
Suzanne Sindi, Applied Mathematics, University of California, Merced, CA

Understanding Percent Cognition Via a Dynamic Systems Framework

Numerical and mathematical cognition are integral components of math education, decision-making, and risk literacy. One pervasive challenge to these fields is how people understand rational numbers, and this challenge is often exemplified by percent cognition. To address this concern, we review percent errors across relevant literatures and develop a theoretical argument that this limitation is partially based on the dynamical concept space of percent. We construct this dynamic percent concept space using known errors with percent cognition, both in childhood and college-aged adults, which situate percent cognition within an unstable regime of rational number and ratio concepts of multiple attractor types. We formulate this dynamical percent concept space based on math skills testing, cognitive linguistics, and behavioral experiments from current literature. We show that trajectories within this state space reflect non-mutually exclusive attractor basins as well as linguistically constrained saddle-points. By constructing a theory of a dynamical percent concept space, we contribute to the understanding that cognition, even in a constructed realm such as numbers and mathematics, is dynamical in nature. Thus, teaching and communication of percentages should reflect the nonlinear nature of percent cognition. This dynamical systems theory of percent cognition supports current theories regarding the complexity of rational number learning and risk literacy and also provides a framework for future empirical testing via nonlinear behavioral methods.

Michael Wegener, Antalya Bilim University

The Good, the Bad, the Well-Connected

We analyse a variation of truel competitions in which each prospective player is represented by a node in a scale-free network. Without the inclusion of any particular spatial arrangement of players, traditional game theory suggests that in many truel settings the strongest player often has the lowest probability of survival, a result which has been popularised by the term survival of the unfittest. However, both our single run and the Monte-Carlo simulations suggest that this particular notion does not hold in scale-free networks. The spatial structure and arrangement of players are crucial for the outcome of truels, as in scale-free networks the number of players surviving the competition positively depends on their marksmanship (i.e. the strongest players indeed have the highest probability of survival).

Toru Yazawa, Tokyo Metropolitan University
Hiroyuki Kitajima, Kagawa University

A life-threatening pulse, alternans, lowers the scaling exponent: A heartbeat interval time series analysis study using mDFA from invertebrates to humans

My persimmon tree bears rich fruits every other year; a climatologist reports that global atmospheric oxygen concentrations are bistable. Period-2 is such an intriguing rhythm in nature! The cardiac *alternans* is an arrhythmia exhibiting alternating amplitude or alternating intervals between heartbeats, first documented in 1872 by Traube. Recently, alternans has finally been recognized as a harbinger of a cardiac disease; physicians noticed that an ischemic heart exhibits alternans. However, the fundamental question of causality regarding this arrhythmic state and mortality cannot be answered. We scoured unhealthy-alternans-data from our data storage resources accumulated over thirty years and conducted a heartbeat interval time series analysis of electrocardiograms recorded from the general population (human), and from various invertebrate model animals (crustaceans, insects, etc.) Using an analytical method, modified Detrended Fluctuation Analysis (mDFA) recently developed by our group, we show that unhealthy alternans rhythm lowers scaling exponent values computed by mDFA. Since a healthy value is 1.0, this reduction in scaling exponent might provide evidence that the alternans state could be a universal pathophysiological phenomenon across lower and higher creatures with hearts, including humans. Additionally, using Luo and Rudy numerical models (myocardial cell models with ion channels, such as the sodium and potassium channels), we show that one set of parameters in the model equations -- the permeability of sodium ions (G-Na) and extracellular concentration of potassium ions ([K]out) -- is one of the largest contributors to the generation of alternans.

Mikhail Zimin, 2554620 ONTARIO LTD.
Olga Kumukova, Alpine Geophysical Institute
Maxim Zimin, 2554620 ONTARIO LTD.

Practical Application of Composed Functions in Method of Structural Minimization of Risk for Avalanche Forecasting

Practical Application of Composed Functions in Method of Structural Minimization of Risk for Avalanche Forecasting M. I. Zimin, O. A. Kumukova, M. M. Zimin Avalanche forecasting is an important scientific problem. Now, In Russian Federation technique, based on fuzzy sets analysis, is used. But it permits to estimate current situation, whereas changes of avalanche risk over time may have chaotic character. To get rough idea about situation in future, dependences of degrees of membership in different categories of avalanche risk on time are built. Different composed functions are used. Their application permits to find qualitative behavior. It is very important in practice of avalanche risk forecast. For example, if this risk increase, it is possible to recommend artificial avalanche triggering. If snowslide danger is low and stable, regular operation may be permitted. So, using estimation of avalanche risk in the future, more accurate forecast can be carried out. It increase safety of operation and decrease financial damage.

Mikhail Zimin, 2554620 ONTARIO LTD.
Taras Gavrilenko, Surgut State University
Dmitriy Gorbunov, Surgut State University

Uniformity and Non-Uniformity of Parameters of Willed and Non-Willed Individual"s Movements

Uniformity and Non-Uniformity of Parameters of Willed and Non-Willed Individual s Movements Mikhail Zimin, 2554620 ONTARIO LTD., Toronto, Canada Taras Gavrilenko, Surgut State University Dmitriy Gorbunov, Surgut State University The founder of thermodynamics of no equilibrium systems I.R. Prigogine and his followers actively tried to describe systems of the third type in the framework of a deterministic approach. In this paper, we analyze the values of Shannon s entropy in assessing human movements, and also evaluate the recorded samples for uniformity. It should be noted that the problem of sample homogeneity has not been solved yet. There is no exact mathematical apparatus for establishing the uniformity of the parameters obtained. Moreover, for the term homogeneity has no concrete definition in the field of natural science. One person was selected for study. Registration of was performed in the mode of multiple repetitions (at least 30 samples). Theory of chaos and self-organization was used to process experimental data. Calculation of parameters of willed and non-willed individual s movements in the framework of the theory of chaos-self-organization permits to check possible homogeneity or heterogeneity of samples. It is found that probability density functions may chaotically change. Wherein, parameters of two indicated types of movement are considerably different. Such approach allows catching minor changes in the parameters of homeostasis, which is important in investigation of biological systems.

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Practical Application of Composed Functions in Method of Structural Minimization of Risk for Analysis of Abnormal Behavior of Animals before Earthquakes and Mud Flows

Practical Application of Composed Functions in Method of Structural Minimization of Risk for Analysis of Abnormal Behavior of Animals before Earthquakes and Mud Flows Svetlana Zimina, Mikhail Zimin Short-term

earthquake and mud flow forecast is an important scientific problem. Biological precursors form one of significant group, showing possibility of seismic event. However, their occurring has chaotic dynamics. Therefore, developing suitable techniques for their estimation is of interest. To estimate presence of biological precursors, dependence of degree of their expressiveness on time is built. If there is abnormal behavior of some specimens no more than 5 of each species or any specimens of only one species, this degree equals to 1. If there is abnormal behavior of animals of two or three species, wherein no less than 6 specimens of each species have clinically significant abnormalities of actions, this degree is equal to 2. If there is abnormal behavior of animals of more than three species, wherein no less than 6 specimens of each species have clinically significant abnormalities of actions, this degree equals to 3. Piecewise constant dependence y is used as a composed function. After that method of structural minimization of risk is applied. Optimum form of y is found. In this way it is possible to obtain dependence of degree of expressiveness of biological precursors on time and make reasoned opinion about their presence. In such a way, addition chance for true estimation of seismic and mud flow risk occurs.

...and our Guest Speakers' Abstracts:

Dr. Kevin Dooley
Arizona State University and *The Sustainability Consortium*

2050 – Musings from a Complexity Lens

2050 is the iconic year that all futurists point to. It is the year we expect to the earth to house 10 billion people, and when climate and social change will make us muse about the old days when the world was more predictable. 2050 is just a generation away, and the children born today will be reaching the early adulthood then. Thus, the time is opportune to polish the looking glass and ask: What are the possibilities for our world in 2050? For historical perspective, I'll first look at how well futurists in the past have been at predicting what would happen 30 years into their future. I'll then propose that in the past, society has attempted (and largely succeeded) to separate human, environmental, and technological systems. In the future, these systems will converge like at no other time in history. I'll use a complexity lens to examine what might happen under these conditions of convergence and tight coupling.

Bio: Kevin Dooley is a world-known expert in sustainable supply chain management, complexity science applications in business, and qualitative research methods. As Chief Scientist at The Sustainability Consortium, Dooley leads a global research team that works with over 100 of the world's largest retailers and manufacturers to develop tools that allow companies to identify and track progress on critical product sustainability issues. The Consortium's tools are the basis of the Walmart Sustainability Index, which was recognized by Scientific American as a "world-changing" innovation. He has published more than 100 research articles and co-authored an award-winning book, "Organizational Change and Innovation Processes." In 2011 he was named the ninth most impactful researcher in business research. He was awarded two patents for "centering resonance analysis", a novel form of network text analysis that is used by numerous academics. He has created or led initiatives to support the application of complexity science to business research, including the Center for Supply Networks and the Society for Chaos Theory in Psychology and the Life Sciences.

Rick Dale
Department of Communication, University of California, Los Angeles

The integrated dynamics of natural language performance

Natural human communication is a highly complex multimodal performance. In mere seconds of spoken language, we gesture, modulate vocal energy, organize social attention, choose our words, stream them into sentences, sustain topic of conversation, and more. These behaviors happen concurrently. They are the ingredients of all the moments that compose natural language performance. I will discuss prior research my collaborators and I have conducted that quantifies this integrated performance, and will argue that there remain a number of open questions about how this integration occurs. This integration involves combining behaviors from a millisecond timescale (e.g., vocal energy) into complex performances that span many minutes (such as giving a conference presentation). How do humans do this, and often with impressive ease? I will argue that a theoretical framework grounded in self-organizing systems can expand our understanding of multimodal complexity, and will showcase several recent projects with collaborators that use analyses imported from the study of complex dynamic systems. This theoretical perspective on language and communication reorients the central scientific questions, which have focused on syntactic generativity and computation rather than multiscale complexity.

Bio: **Rick Dale** is a cognitive scientist of communication. He is currently a Full Professor in the Department of Communication at UCLA. His bachelor's degree is in Linguistics from the University of Toronto (Scarborough Campus), and his doctorate in Experimental Psychology from Cornell University. In his research, Rick and collaborators use conceptual and quantitative tools from the study of complex dynamic systems to investigate human communicative behavior. Prior research has explored the dynamic patterning of verbal and non-verbal behavior during interaction in a variety of contexts. With collaborators, he has studied bodily dynamics of deception, the non-verbal dynamics of debate, the synchrony of seeing during interaction, and multimodal coordination during conversation. Recently, he has been exploring various computational models to facilitate analysis and simulation of interacting systems. He has also held Associate Editor positions at the journals Cognitive Science, Behavior Research Methods, and currently, Discourse Processes. Rick runs the Communicative Mind Laboratory (Co-Mind Lab) at UCLA. For more information and downloadable tools and articles, visit http://co-mind.org.