Some Highlights from the 3rd International Nonlinear Science Conference, Tokyo

By Stephen Guastello, March 25, 2008

The 3rd International Nonlinear Science Conference was held in Tokyo, Japan, March 13-15 at Chuo University. A total of 85 members participated in the event, which is a strong turnout for this SCTPLS conference series. Special applause go to Yuji Aruka for orchestrating the comfortable and well-equipped facilities for this event, the Japanese Association for Evolutionary Economics for bringing so many agent-based systems researchers to the program, and the Faculty of Commerce of Chuo University for special touches such as the conference bags, arrangements for tea ceremony and the menu for the gala banquet that we all enjoyed on Friday evening of the conference. Another round of applause goes to Ivy Lazzarini and Dimitrios Stamovlasis for all the program logistics, and the numerous members of the scientific review committee.

This report captures some of the substantive contributions to the conference. Inasmuch as there were three tracks going on most of the time, and note-taking being what it is sometimes, the following is only a sampling of what transpired. A full set of abstracts is available on the SCTPLS web site, and the abstracts will be included in the American Psychological Association's *PsycEXTRA* data base for search and retrieval.

Technological change. In neo-classical economics macroeconomic processes are simple extrapolations of individuals' interactions with markets. Real macroeconomic processes work differently as Dore and Rosser (2007) explained to us recently. Masano Aoki, the first plenary speaker of the INSC, modeled the statistical arrival of two macro processes in an economy to represent forms of technological change. Whereas the typical modeling procedure would use mean/variance ratios, or only means, the results are very misleading such that the behaviors of the 100 largest firms in an economy produce a distorted interpretation of the economy as a whole. The actual distribution of new technological entries of different types is a power law distribution instead. The odds of a new technological entry, given an array of technologies that already exists, depends on whether the new entry represents a new technology altogether or attaches itself to an existing cluster. Further analyses indicated that less technologically advanced societies could develop as the same rate as the more advanced societies. Further theory and research can be found in Aoki's new book (Aoki, 2007).

Synchrony in Psychotherapy. In two adjacent presentations Wolfgang Tschacher and Fabian Ramseyer studied the role of synchrony in clinical psychology applications. In the first study patients and therapists completed questionnaires regarding their interpretations of what transpired in the sessions regarding the patient's coping capacity, psychopathology and symptoms, aversive interpersonal behavior, and pro-social interpretations of behavior. Synchrony was captured by Lansfield's Ω index, which is a formal measure of entropy that is widely used in ecology and biology. There was a strong effect for synchronicity on therapy outcomes.

In the second phase of their work, Tschacher and Ramseyer examined the synchronicity of body movement between therapists and clients, noting that the patterns could be different in the early, middle, and later phases of each session. The early phase establishes some stability between the two people as they catch up on events since the last session. The middle portion is devoted to exploring issues in depth, and in the third phase they reconsider and assimilate what has been learned. Digital videotapes of sessions were analyzed for the amount of pixel overlap and transition between the client's and therapist's movement envelopes. Once again, there was a strong association between synchrony and good therapeutic outcomes at the end of a series of sessions. Patients with more social problems, or more security issues, tended to exhibit less synchrony with the therapists. The therapists, meanwhile, tended to be unaware that their movements were synchronizing with their patients'.

Motor learning. Gottfried Mayer, our second plenary speaker, examined learning processes in complex movements, using the front tuck in gymnastics as an example. An important point is that a movement such as a front tuck is never executing exactly the same way twice, even by professional gymnasts, and referees engage a little or a lot of judgment as to whether a particular example meets the prototype movement. Bistability and hysteresis can be observed in the learning process as shown in Fig 1, which is the frontal slice of a cusp catastrophe model.

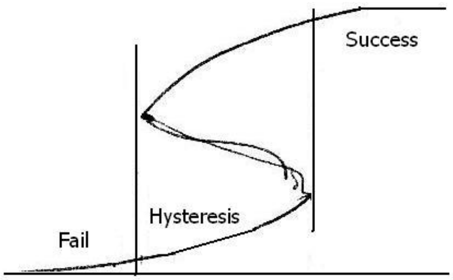

Fig. 1. Bistability and hysteresis in motor learning.

Hysteresis between critical points is the result of two forces on the person (gradients). Difficulty pushes the behavioral outcome toward the fail threshold, and skill pushes the behavior toward success, as shown in Fig. 2. Csikszentmihalyi's concept of flow is useful as an explanation for the a continuous fluid behavioral sequence, whereby the learner masters a level of success and then proceeds to a more demanding level of challenge. A rule of thumb seems to be that 20% more demand results in a 50% success rate, which provides optimum challenge for the individual.

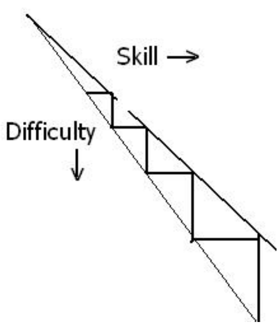

Fig. 2. Hysteresis in behavior produced by challenge and skill while learning.

It is parenthetically noteworthy that cusp and butterfly catastrophe models have been useful in modeling learning processes since 1978 for animals and humans (Guastello, 1995, 2002). Another approach to learning dynamics involves chaotic processes leading to self-organization (Li, Krauth, & Huston, 2006). In either case it is gratifying to see new research built on nonlinear foundations.

Emergency response. In a later session, Stephen Guastello presented the latest installment to the swallowtail catastrophe model of leadership emergence. The new application pertained to emergency response situations, where the ER teams were assumed to be working relatively independently of any command and control hierarchy. The experimental groups played a board game (The Creature that Ate Sheboygan) where an ER team of police, military, and firefighting personnel worked to contain the damage in a city produced by a Godzilla-type monster. Teams and adversaries made dynamical decisions during each turn of the game. Coordination among the players was necessary, but unlike previous studies on coordination and leadership, ER teams worked within a Stag Hunt utility structure instead of an Intersection structure.

Once again the social structure of the teams self-organized into primary and secondary leaders and non-leaders. Leaders separated from non-leaders as a result of a broad range of traits that would correspond to Kauffman's K in an N|K distribution; prominent among these characteristics was a strong competitive behavior against the adversary. Within the zone of leadership, leaders came to the foreground in situations where group sizes were larger (9 to 12 teams members compared to 4 to 7); the larger groups tended to perform better against the adversary than smaller ones. Primary leaders distinguished from secondary leaders to the extent that the group was indeed successful.

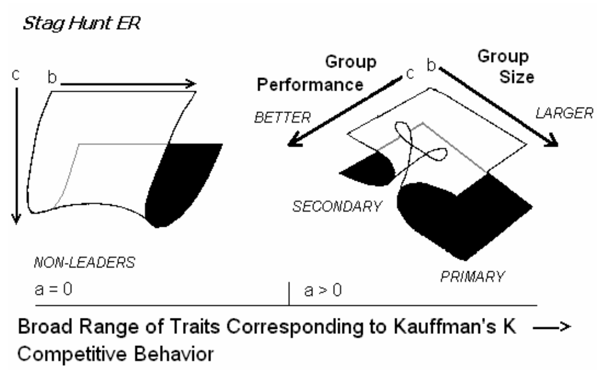

Fig 3. Swallowtail catastrophe model for leadership emergence in emergency response teams.

Gaming utilities. Masuda Naoki investigated the best means of setting utilities in games to promote maximum cooperation in the long run. There is apparently a trade-off between cost to participate and utilities affecting cooperation such that situations with lower entry costs promote more cooperation than higher entry costs, all other things being equal. The effect of entry costs was more pronounced in Prisoners' Dilemma than in Stag Hunt.

Episodic memory. In our third plenary session for the weekend, Ichiro Tsuda presented the progress in the understanding of the role of the hippocampus in episodic memory. Chaos and fractal principles are both involved. One type of study involved the activity of place neurons. Rats first learned they way around a square terrain and a round terrain. The previous learning facilitated their movement around an intermediate shape, such as an octagon. Here there was a notable phase transition between the previous and new learning.

Fig. 4. Basic phase transition.

We are accustomed to thinking of memories in a network, such as the one in Fig. 5. A retrieval cue activates one memory node, which could activate others adjacent to it to greater or lesser extents. The formation, dissolution and reformation of memory nodes have never been explained particularly well, and Tsuda appears to be unraveling the mysteries of the process with alacrity.

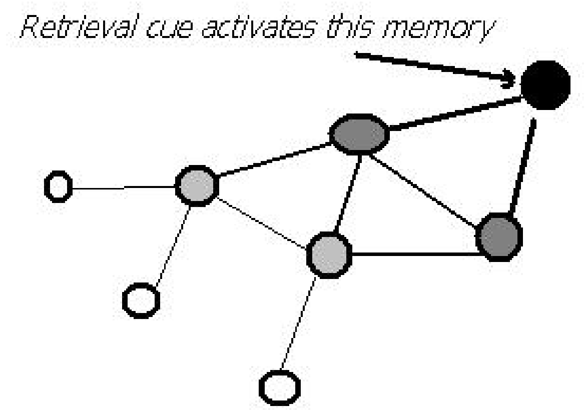

Fig. 5. Standard image of a memory network.

Each memory nodes acts as an attractor to other memory nodes. Each memory item is best described as a Milnor attractor, which has a leak in its basin as shown in Fig. 6. The leak is needed to form the link between one node and another to form a network. A simulation in a 2-D array shows that point clusters form, similarly to the cluster in the middle of Fig 7, with points clustering elsewhere in the field. The clusters naturally form and dissolve in the course of the iterations.

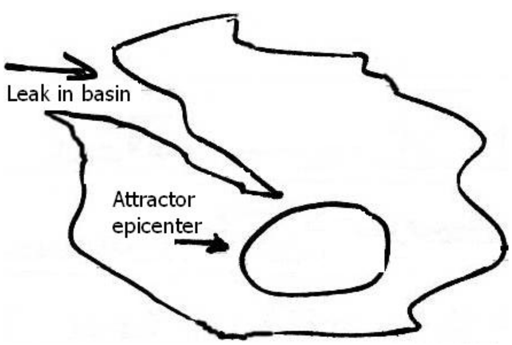

Fig. 6. Milnor attractors form the basis of memory nodes.

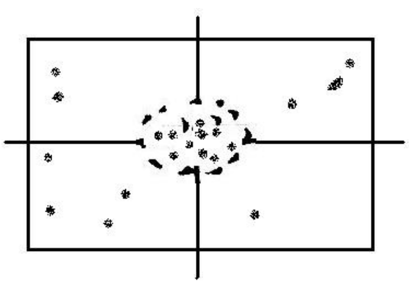

Fig 7. Attractor clusters form and dissolve.

We usually think of the depolarization and repolarization of neurons during the firing process as simple discrete events, such as the textbook-type rendition in Fig. 8, solid black lines. There is considerable variability taking place over time during the period that are usually assumed to be solid, which in turn may contain the information necessary to explain encoding and decoding content or thoughts. If we expand the array in Fig. 7 to 3-D, Tsuda surmises that episodic memories are encoded as Cantor sets of the membrane potential shortly before neurons fire. Episodic memories are then decoded in the pulse trains of the post-firing phase.

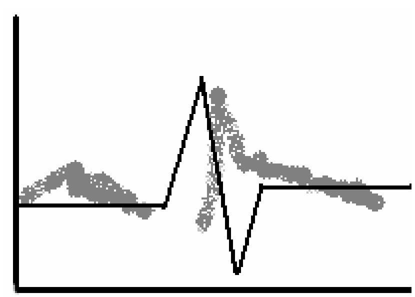

Fig. 8. Traditional neuron firing representation may contain more information than previously assumed.

Traffic in Boston. Moving on to other types of networks, Haoong Jeong examined other types of networks, with particular attention to traffic patterns in the city of Boston, USA. The legendary six degrees between any two people or places can be hard to identify sometimes, and there is often a cost associated with accessing a link. As a result, a traffic pattern that might look optimal from the vantage point of the global system can be seriously suboptimal with regard to individual utilities. Thus traffic flows can become very clogged in spite of the best intentions of designers.

Aging Processes. This reporter will not fathom a guess regarding how many years one takes off one's life being stuck in traffic, but Tarynn Witten's presentation on genetic networks and aging processes suggests that we might be able to figure out the answer someday soon. There seems to be a tendency for people to think of genes for this and that acting independently of other genes, yet at the same time we know that multiple gene explanations for biological outcomes are often needed where single-gene explanations are inadequate. According to Witten, genes are actually organized in networks. If one applies some basic graph theory, one can readily notice that some nodes are more central than others. Genes that are located in more central positions will have a larger impact on physiology if their connections to other genes are disturbed.

The number of connections per gene follows a power law distribution. The $1/f^a$ relationship is more prominent in healthy systems. With aging, the distribution conforms less to a power law. At the present time it is not conclusive how much of the deviation from a power law is represented by poor statistical fit overall (R^2), or by the particular values of the shape parameter. The research team has been using nonlinear regression with their small samples to assess these two metrics, so their approach does allow a separation between the effects of the two values, which is not possible using the linear regression method.

Service Sciences. In a unique contribution to the program, Kozuyosh Hidaka from IBM Japan Ltd. Explained IBM's interest in developing university curricula on service sciences. He noted the growth in the service industry sector in recent decades, and the role of an IT-related knowledge base in contemporary services. Service businesses differ from durable goods in that the product is intangible, and more closely related to the providers' actions than to products per se. There is also a simultaneity of production and consumption, which is decoupled in the production of durable goods.

Hidaka presented a long list of topics that could be studied in a service science curriculum, including data quantity and quality issues, real-time computing, stochastic modeling, client innovation, self-service technologies, service support, and scientific approaches to design and analysis. Complexity theory was implicated at the point of scaling a service from small to massive; SCTPLS members could probably brainstorm numerous ways in which nonlinear science would be relevant to data-oriented services and information flows.

The educational goal of a service science curriculum is to develop "T-shaped people:" People with a broad spectrum of knowledge on the one hand, but with a specialty in something particular. This idea is not appreciably different from the educational strategy of most Arts and Sciences colleges – broad knowledge and distribution of requirements alongside a major discipline – but with the content more centered on operations management themes.

The conference program also contained two more symposia on service sciences chaired by Akira Namatame. Agent-based modeling and network analysis were prominent in those sessions.

Cognitive processes in aiming movements. It's not as simple as pushing a button. Psychologists have known since the late 19^{th} century that two velocities are involved in aiming movements, such as pushing a button on a control panel or positioning a tool to a target. The first portion of the movement is relatively fast, and the second is slower as the person comes in for the proverbial landing. The process was codified as Fitts Law in the mid-1950s, whereby movement speed was the result of distance to the target and the width of the target. Complex targets make the analysis all the more complicated and movements less concisely predictable, according to Jagacinski and Flach (2003).

It now appears that Andre Valdez and Eric Amazeen have made some important headway in explaining the change in movement speeds. Their experiment showed $1/f^a$ distributions of movement time when participants could work at their preferred speed, but the $1/f^a$ pattern dissipated when they were compelled to move more quickly. The two cognitive processes of planning followed by control explain the phenomenon, such that unhurried movements allow for an overlap of the planning and control features giving rise to the $1/f^a$ distribution, whereas hurried movements do not engage the same overlap. Valdez and Amazeen's study is now published (2008).

Collective Intelligence. Bill Sulis made the case that early decision models and those based on Simon's concept of bounded rationality did not go far enough to explain the type of cognition that appears to take place at the collective level. Using ants, which are social insects, as a model, Sulis captured the growing number of principles behind collective intelligence. Here it is best to refer to his forthcoming book chapter (Sulis, in press) for extended explications.

Temperament and Personality. In the final session of the conference, Irina Trofimova described her research program in temperament and personality. After a brief run-though of trait theory from Allport to the Big Five, she explained a research program initiated by Pavlov that is less widely known in the West. Pavlov was studying types of nervous systems, which differ according to their excitability, a heating effect, and their inhibition types, a cooling effect, which is manifest in social and motor systems. One is reminded of the Bernard cell. Types undergo bifurcations with learning and development, giving rise to development in what we recognize as an adult personality. The empirical task is to connect characterizations of excitability and inhibition to the Big Five personality traits.

There is reason to believe that Trofimova is on the right track. Grigsby and Stevens (2000) offered a similar thesis based on the temperament types identified by Thomas as Chess, and the nonlinear studies of the development of stability in neural pathways with learning and experience, as developed by Walter Freeman.

Sashimi deluxe. The banquet Friday night featured a wide range of classic Japanese recipes, and a breathtaking presentation. The sashimi display, shown on the back cover of this *Newsletter* (photo by Dimitrios Stamovlasis) was perhaps the visual centerpiece. Yuji Aruka explained that the presentation was designed as Japanese rock garden, which we have recently learned has an implicit fractal structure (van Tonder, 2006).

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