The Complexity Zoo: three complexity-related book reviews
Originally published on the Synthetic Daisies Blog
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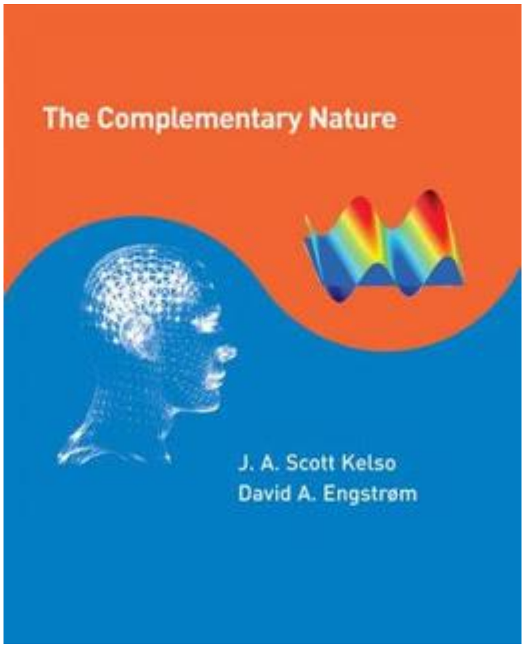
Review of: Kelso, J.A.S. and Engstrom, D.A. (2006). The Complementary Nature. MIT Press, Cambridge, MA.

Original version: http://syntheticdaisies.blogspot.com/2008/12/review-of-complementary-nature.html



Introduction

This is a potentially momentous book. That being said, it is far from a synthesis. From a superficial perspective, it seems more like a long-winded manifesto with nice headshots of famous people. Nevertheless, the core idea is clear; namely that mentally-represented physical phenomena come in "complementary pairs", and that they form an interstitial and heterogeneous continuum between them. There is even a pairings glossary at the end of the book; each set of concepts is modified by a tilde (~) which denotes the link between two discrete states represented by linguistic titles.

The universal tilde designation is my major objection to this approach. The pairs actually seem to come in one of three varieties: binary oppositions, causal pairs, and hierarchical nestings. This enables higher-level mathematical operations, and scalable models to be constructed. Yet pairs of all categories are annotated in much the same way. Think of the tilde as a mathematical operator, which I'm sure was the authors' ultimate intent given their tone. Following this logic, if pairs come in qualitatively different types, then the authors should have used different operators for each type. It would make the entire enterprise much more straightforward, especially when mapping pairs to a phase space as occurs later in the book.

Conceptual Taxonomy and Functional Information

Binary oppositions (linear~nonlinear) are by far the most straightforward. People tend to be most comfortable the outcome of such pairings, and can most intuitively analyze their outcomes.

Consider the physical and mental aspects of hot~cold. Conditions in a physical system range from hot to cold; indeed, not only is there a linguistic dichotomy, but a physical one as well. Because the mapping between the two is relatively seamless, we can easily quantify "hot" vs. "cold" using both a dichotomous representation coupled to quantitative instruments. It is the pairings that do not fall cleanly into this category that cause potential confusion. For example, causal pairs (reaction~anticipation) and hierarchical nestings (individual~society) might be considered differentiated states in a superficial sense, but treated as such may not map to a formalized phase space well.

One of the most intriguing ideas in the book is the way in which the authors conceptualize functional information. One example from brain science involves the specificity of COMT expression in prefrontal cortex. The initiation of gene expression at certain points in life history relies on the correct environmental conditions; interactions with surrounding proteins lead to specific types of emergent structures and specific phenotypes. No surprise there; classifying such processes as the flow of information is increasingly commonplace. The potential food for thought offered here is that this is part of an emergent process. In general, complex systems use functional information to build complexity. While information is a necessary prerequisite for emergent complexity, it is most powerful when coordinated by concurrent processes.

Treatment of Complexity

Their treatment of emergence (micro~macro) is one of the best I've seen, and is at once mathematically rigorous and intuitive. They treat "individual" and "collective" as a metastable system (two local minima on opposite sides of a metastable "saddle point"). The system is driven by the values of a few key parameters; these parameters represent the reciprocal forces of downward and upward causation. Instability in these parameters drives the system towards a phase transition; more intuitively, the system climbs out of one stable state to a metastable plateau. At this point, it is free to return to its original state, remain unstable, or change to a new state. Dealing with the effects of causality on the initiation of phase transitions front and center makes for a much cleaner model than many of the other approaches out there.

Conclusion

More formal complex systems models becomes the thrust of this book's second part. Readers not familiar with Kelso's 1995 book "Dynamic Patterns" would do well to go there for a formal mathematical treatment. Once you understand the underlying concepts of coordination dynamics, go back and read "The Complementary Nature" again. Fresh eyes will provide you with a new perspective on the pairings. For example, pairings might be viewed as the boundary conditions of an n-dimensional phase space, or as discrete states in a multistable system. In any event, it is the space between the discrete states that are of interest to the authors. The take home message seems to be that this space is complex, unstable, and potentially fertile ground for the gray areas that humanities, brain science, and complexity scholars alike must understand.

Review of Barabasi, A-L. (2010). Bursts: the hidden pattern behind everything we do. Dutton Press, New York.

Original version: http://syntheticdaisies.blogspot.com/2009/04/intelligent-movement-machine-review.html

Introduction

If you recollect your daily routine, what adjective would you use to describe it? What did you do today and in what order did you do these things? You probably engaged in an automatic routine, with many events being the same and some of those events occurring at roughly the same time from day to day. You also probably do things at the same time as your neighbor. Part of this is based on the way society is organized. Indeed, people tend to have similar schedules or engage in the same essential activities. But an alternative hypothesis suggests that statistical laws govern aggregate human (and natural) behavior. When processes such as travel across human transportation networks or e-mail correspondences unfold over time, they do so in a statistically distinct manner. In his previous book "Linked", Barabasi got ahead of the social networking curve to demonstrate the power of connectedness to a general audience. Yet connectivity has two components: the static topology, and the dynamic, less-understood process of connection. In "Bursts", the argument is made that dynamic behavioral patterns (such as connecting to a network) can be characterized using a series of non-uniform statistical distributions. These models reveal that traffic jams, long check-out lines, and even crime waves are indeed not unpredictable events, but rather can be understood as "bursts" that occur at relatively infrequent intervals. Yet the very nature of their burstiness (in that they involve synchronized, collective behavior) makes them predictable.

Your daily schedule might involve brushing your teeth at a different time than your neighbor, but going to work at the same time. This is one kind of behavioral burst that is featured in Barabasi's book. But we can also think of bursts as excitable events that occur against either a random background. We are all familiar with the excitability exhibited by exploding fireworks, popping popcorn, or even neurons firing an action potential. All of these events have one thing in common: nonlinear behavior governed by a threshold. In the case of both popcorn and neurons, a constant stimulus is applied that eventually triggers a change in state. In the case of both popcorn and neurons, these bursts only become useful in the context of collective behavior (one is immensely enjoyable, the other essential to your survival). Physicists sometimes refer to this type of response as a first-order phase transition. In the classic sandpile model of Bak, Tang, and Weisenfeld, the gradual growth of a sandpile is sometime punctuated by large-scale displacements in the structure of the sandpile. These large-scale displacements occur at low frequencies relative to the more uniform small-scale displacements. In many cases, the distribution of these events over time can be scaled to a power law (or 1/f) distribution, meaning that they are fundamentally distinct from a uniform diffusive process resulting in a Gaussian distribution of events. Any good book in statistical physics can put the significance of 1/f processes in context in addition to providing a wealth of specific examples in nature. But how do these well-characterize physical processes map to and help explain human behavioral bursts?

An Underlying Phenomenon

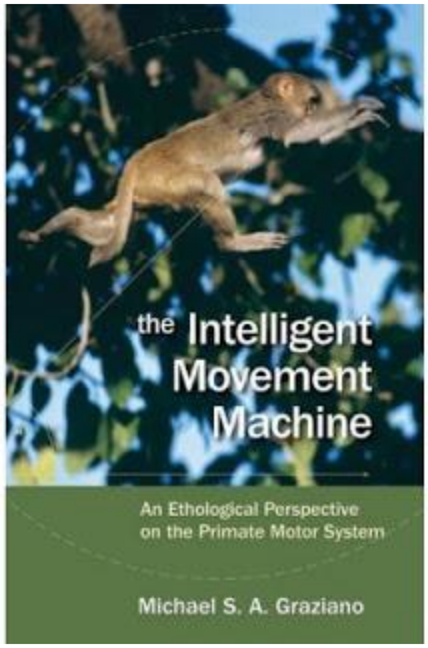
One undercurrent of this book is that excitable events, synchronized, collective behavioral processes, and power law behavior are all part of the same subject. This subject is the manner in which bursts unfold, which is according to a Poisson process. While excitable events, collective behavioral processes, and power law behavior all set the stage for bursty events, it is the Poisson process that distributes these events stochastically with respect to time. In addition, power law behavior should be expected of a Poisson process that can be observed at all timescales. The investigation of e-mail archives demonstrates this: most e-mail arrives at specific times of day or on specific days of the week, with smaller clusters or singleton events occurring in the interim. The difference between e-mail archives and physical avalanches, however, is instructive. In the case of the former (e-mail), the "bursts" are due to large-scale events driven by intention. In the case of the latter (physical avalanche), the "bursts" are due to large-scale events driven by a buildup of forces that exceeds a threshold. In both cases, linear inputs act collectively to produce a nonlinear output. One could argue that the "flash crash" of May, 2010 was caused by the bursty nature of the stock market, a system that phase-space-wise resides in between the collective intention of e-mail communication and the pure stochasticity of physical avalanches.

Barabasi writes "Bursts" as a hybrid historical/scientific narrative: he switches back and forth between medival Hungarian history and contemporary scientific stories as to how bursts can be discovered in the data we all produce. By the data we all produce, I mean that his examples focus on social phenomena such as e-mail transactions and human mobility patterns. Besides his own work, the book also features the work of Dirk Brockmann, a physicist who did an experiment tracking the movement of dollar bills around the United States. The outcome was that dollar bills diffuse according to a Levy process, or a 1/f form of diffusion. In a Levy flight, which has also been observed for albatross foraging behaviors, short and randomly oriented trips are punctuated by rare, long-distance trips. As with e-mail communications, these bursts are driven in part by intention. It is only when these intentions are joined to chance events and then placed into the context of a process that unfolds over time that the burstiness of behavior becomes apparent.

Conclusion

But what can be learned from the sojourns into history? There is a strong undercurrent of historical contingency in the stories Barabasi selects. Intentional or not, the point is made as to the "burstiness" of how history unfolds. Historical contingency, which refers to the dependence of current events on the trajectory of past events, is not a purely a deterministic process. While the path history takes is constrained by past events, those defining events occur in a background of chance events. Often when people tell stories about how they got a particular job or how they met a spouse, it often involves the phrase "as luck would have it". But perhaps bursts, made manifest by dating websites, commuter trains, and scheduling constraints, are more responsible for these chance events than has traditionally been recognized.

Review of: Graziano, M.S.A. (2009). Intelligent Movement Machine: an ethological perspective on the primate motor system. Oxford University Press, Oxford, UK
Original version: http://syntheticdaisies.blogspot.com/2010/06/bursts-review.html



Introduction

The field of human, animal, and robotic movement, portions of which have gone by many names in the literature, is a vast and moderately synthesized area of study. Part of the problem is that only a few people bridge the multiple areas of specialty that are essential for a truly comprehensive understanding of movement. Michael Graziano is one of these key people. Graziano works on the electrophysiology of primate motor cortex, but also has an interest in how this translates into animal behavior. This explains the subtitle of the book: an ethological perspective. Graziano's synthesis is actually two-fold: one is to organize the literature on movement in a systematic manner, and the other is to unite observations of animal behavior with what we know about the underlying neural mechanisms.

Structure of the book

Since the field of movement as defined in the last section is only moderately synthesized, Graziano devotes a large section of the book towards bringing evidence to bear from the literature. The focus is on electrophysiology in Primates, so those hoping to understand movement phenomena outside of simple limb movements and feeding behaviors might come away disappointed. However, he does spend some time discussing personal space and movement behavior, which draws from his work on defensive postures. Despite his somewhat diverse choice of topics, he certainly does not make a unified field theory-type proposition.

While he may spend a few too many chapters on reviewing the current state-of-the-art, it sets up the last few chapters of the book. In this portion of the book, Graziano explains how he spent some time at the Bronx zoo to better understand what he was observing in electrophysiological experiments. Anyone who was spent time at a zoo realizes that non-human Primates exhibit many complex and sophisticated physical behaviors, even in captivity. In this sense, Graziano's approach is a sorely needed addition to the literature.

Heart of the neuroethological approach

Ethology is different from approaches to human behavior in that the former focuses on fixed action patterns. These action patterns can range from preening to arm waving to head shaking. Typically, such behaviors are relatively easily quantifiable in that they are discrete and repetitive. In this way, fixed action patterns are also thought to have a relatively simple neural basis. Graziano uses this framework to explain how behaviors observed in nature are produced at the single-cell level. This is one way of resolving a frustration from earlier in his career that involved the constricted behavioral repertoire observed during traditional electrophysiological recordings.

One criticism of this approach, of course, is how complex movement observed in naturalistic settings map to electrophysiological results collected in highly-artificial environments. This returns us to Graziano's early-career angst and how these two approaches can be reconciled in the first place. On the one hand, he has certainly succeeded at thought-provocation. This work adds a critical missing piece to the story behind movement, and how it relates to both species differences and symbolic behavior. However, we must keep in mind that movement involving many different components is not simply additive, and that what might explain an isolated movement might not be the whole story when naturalistic movements are taken into account.

Conclusions

One statement that particularly resonated with me was a statement to the effect that some electrophysiologists think Graziano's approach is crazy. I think this statement sums up one of the biggest unsung problems in science today: although "interdisciplinary research" is a popular buzzword, most scientists have no idea how to appreciate the approaches of their colleagues in other fields. This has been an ongoing frustration in my own life, and I am not entirely convinced that such skills can be taught. Aside from sociological griping, the scientific basis of the book is most definitely sound. I find it a reasonable and innovative approach to a problem that has in some ways been studied to death, yet in other ways is still vaguely understood.