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Regularities in Human Actions

A Review of *Bursts: The Hidden Pattern behind Everything We Do* by Albert-László Barabási (Dutton, 2010).

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This is a joint review by two authors. Its first part was written by An ZENG who is a PhD student at Beijing Normal University and a researcher in network science. The second part was written by Bertrand ROEHNER who is a physics professor at the University of Paris and a visiting scholar in the Department of Systems Science of Beijing Normal University. Written from two different perspectives, the two reviews should complement one another.

If you are a researcher working on complex networks, it is almost impossible for you to escape hearing about Professor Albert-László Barabási. A leading scientist in network science, he proposed the well-known scale-free networks that not only attracted wide attention but also lead to great advances in many scientific fields. Seven years ago, Professor Barabási introduced complex networks to us with an easy-to-read *Linked*. What does his new book bring us?

We live in a complex world and focus on our affairs every day, seldom noticing the underlying laws governing our behaviors. When it comes to such topics as human mobility and the sequence of human actions, people tend to consider them to be simply random. However, Professor Barabási believes that we are far more predictable than we think. After several years' exploration into the statistical properties of human behaviors, his research group achieved several breakthroughs. *Bursts* introduces these scientific achievements to the general audience. The book mainly focuses on the hidden patterns behind human behaviors, yielding a deeper insight into human actions.

By recording and analyzing human's tracks from mobile phones, Internet, and e-mails, Professor Barabási's group discovered that human behavior follows predictable laws. As an example of "bursty" phenomena, the time interval between consecutive e-mail replies follows a power law distribution. This observation suggests that most e-mails are replied immediately while several e-mails could wait for a long time before being handled.

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Professor Barabási is an excellent writer. He can explain the elusive theories in such an effective way that even laymen can comprehend it well. If you have read his previous book *Linked*, you will find that *Bursts* continues in the same writing style: connecting theoretical material with interesting examples and attractive stories. For instance, the discussion of people's mailing patterns is started with the old story about correspondence between Einstein and Kaluza. Similarly, the interpretation of the research results on albatross mobility is integrated with the experiences of Sergey Buldyrev, a friend of the author. Thus, this book is accessibly written for a general audience and quite pleasant to read.

Bursts can teach us much, not only in the material that it presents, but also by revealing how Professor Barabási conducts his research. Professor Barabási is a scientist who understands the deep structure of empirical reality and most of his findings are related to the real world. In *Bursts* he describes the trajectory leading to each major finding – one can almost see him discussing research with his colleagues in front of us. This aspect of the book is particularly valuable to scientists at the very beginnings of their careers.

In short, *Bursts* is an interesting and enlightening book; it will not leave readers unsatisfied.

Every time in physics new and better data became available there was a major progress as a result. This seems to be true in the social sciences as well. In the middle of the 19th century statistical data about births, marriages, and deaths began to be collected in most industrialized countries. Researchers in Britain, France, or Germany were amazed to discover clear patterns behind these events. For instance, anywhere in Europe suicide rates were highest in April-May and lowest in December. Another example is the so-called Gompertz law which tells us that for anyone over 40 years old the probability to die in the current year doubles every 8 years. This law still holds nowadays in spite of a significant fall in death rates.

There is an obvious parallel with the explorations described by Prof. Barabási. As in the previous case, the progress came from new data – this time huge datasets provided by Internet networks or cell phone operators. Just as the sociologists like Emile Durkheim back in the 19th century, Barabási was amazed to see regularities emerge. In this case they take the form of power laws for the distribution of the times between Internet connections or for distances traveled by people. However, let us observe that power laws are a broad class of functions so this result is much less specific than the suicide patterns or the doubling law of death rates that we mentioned above. As a matter of fact, it turns out that many datasets that contain vastly different orders of magnitude can be described by a power law. For instance, the areas

of lakes across the world are described by a power law. Yet, these lakes are completely independent from one another. This example underlines the fact that the power law property does not give us an insight into the actual mechanisms which are at work.

The account that the author gives us of the research done in his group is most invigorating because it is not a string of achievements and successes. On the contrary, quite as in real research, the path to discovery includes many setbacks, dead ends, or outright mistakes. Barabási tells us the story of Lewis Richardson who was a pioneer in the scientific study of wars. Yet, his findings were mostly of a negative kind in the sense that he was able to show that many of the factors that people commonly correlate with the outbreak of war were nothing but circumstantial factors. An even clearer sign of Richardson's apparent failure was his inability to attract any interest from others. No publisher wanted to publish his book. It came out only after his death.

As a more recent example *Bursts* relates a vivid account of what may be called the albatross story. In 2004 it was realized that the flight of the albatross is not a Levy-flight as was thought for almost a decade. As a matter of fact, it seems there had been a gross misinterpretation of the data. When the device attached to the albatross leg detected no water the bird was just sitting in its nest instead of flying over the ocean all around the Antarctic as was thought initially.

This story in fact raises two additional questions that the author indeed mentions but only incidentally. First, it shows that, contrary to what is standard practice in physics, where each discovery is checked and rechecked by different groups, in this case it was not deemed necessary to check the evidence provided by the London group which tracked the albatross flight. To trust one single piece of evidence seems to become more and more a characteristic of science in our time. Is this not a dangerous and most unwelcome trend?

The second question concerns the Levy-flight characterization. In the wake of the publication of the initial (and mistaken) evidence, there were numerous statistical studies about the mobility of animals. Many of them found the distribution of path-lengths to follow a power law and from this concluded that the animals' trajectories were Levy-flights. However, as Prof. Barabási tells us, for a Levy-flight the probability of returning to the vicinity of the departure point is equal to zero. This is in clear contradiction with the trajectories of most animals who indeed repeatedly come back to their colony, nest, or home territory. How can one solve this contradiction? A simple solution is to observe that although a Levy-flight is indeed characterized by a power-law distribution of path lengths, the converse is not necessarily true. Levy-flights are but one class of spatial stochastic processes with a power-law distribution. In other words, one should perhaps not jump too quickly to the conclusion that animal

trajectories are Levy-flights, even if such a conclusion sounds well in the abstract of a paper!

About one third of Barabási's book is devoted to the story of a peasant uprising in Transylvania which is the home region of the author. As this story is told in many successive episodes, there is no doubt that it provides a thread which goes through the whole book. That is one of the reasons why, once begun, the book is difficult to put down. Personally, I was much interested in this story because I knew very little about peasant uprisings and even less about those which occurred in this region of Europe. In addition, the story is so well written that it is a delight to read it. However, while reading it, I did not forget that I am a physicist.

Physics, as is well known, never studies *single* events. For instance, physics does not study the fall of oranges. Instead, physicists make experiments and observations with many different falling bodies (e.g. steel balls, drops of water, snow flakes). As a result, they eventually succeeded in building a theoretical framework that applies to *all* falling objects. Should we not do the same for peasants uprisings? In other words, should we not study several uprisings in parallel? There have been numerous peasant uprisings in Europe (and probably also outside Europe). I would suggest that if Prof. Barabási's group can collect a comparative dataset for, say, twenty or thirty of such events in different countries he will again be amazed to discover very definite patterns behind them. Without doubt such a database would be quite useful for the understanding of collective behavior in general and I am even convinced that it would give us a broader and better understanding of the episode that occurred in Transylvania. By the way, this is what Lewis Richardson has done for wars. Although he took an active part in World War I he did not limit his investigation just to one war.

Linked was about connections, *Bursts* is about short-term actions of people. Will there be a third book which would tackle the historical dimension that was outlined in *Bursts*? We hope so. After all, history is nothing but a great compendium of human behavior. So, if we wish to understand how (rather than why!) people act, react, join forces, or split, it is history that we must interrogate.

Both reviewers enjoyed *Bursts* and it is with much impatience and great eagerness that they look forward to reading the next book by Prof. Barabási.