Is there a connection between self-organized criticality and human cognition?

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Abstract
This article is a summary of discussion in researchgate.net. In a rather old paper, Wagenmakers, Farrell and Ratcliff (2005) suggest that it is difficult to introduce Self-Organized Criticality and nonlinear dynamics to explain human behavior. They write: "the absence of a specific model for how self-organized criticality produces the observed behavior makes it very difficult to derive testable predictions. The authors conclude that the proposed paradigm shift is presently unwarranted." See the paper included here or find their paper in this link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1404501/pdf/nihms2267.pdf.

Introduction
In a rather old paper, Wagenmakers, Farrell and Ratcliff (2005) suggest that it is difficult to introduce Self-Organized Criticality and nonlinear dynamics to explain human behavior. They write: "the absence of a specific model for how self-organized criticality produces the observed behavior makes it very difficult to derive testable predictions. The authors conclude that the proposed paradigm shift is presently unwarranted." See the paper included here or find their paper in this link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1404501/pdf/nihms2267.pdf.
However, in a more recent paper, Ramos, Sassi & Piqueira (2011) argue that SOC can be used to predict human behavior. (see http://cbpfindex.cbpf.br/publication_pdfs/RamosSassiPiqueira2010.2010_07_05_11_50_10.pdf). Therefore, it seems that there are two different opinions, i.e.: (a) SOC cannot be used in the field of human cognition and psychology and general, (b) SOC is useful to predict human behavior. In this regards, perhaps we can also consider that there are special circumstances where human being can experience critical phenomena, for example there are some people who can jump on high fences or walls when they are in danger (for example running from fire or dogs etc). So it seems that in certain circumstances, it is possible to use SOC to explain human behavior.

Answers
[1] **Andrew Messing**
As the human brain is practically the quintessential self-organizing system, and human behavior an outcome of brain function, it would seem to be trivially true that self-organizing criticality is necessarily characteristic of human cognition. The only way in which it could not be would be if, contrary to the dynamics of virtually all complex systems, the phase space of the human brain or subcomponents thereof contained no critical points. This is intrinsically and obviously unlikely if not clearly false. However, the problem is whether the realization that a complex, self-organizing system has critical points is one thing. The ability to identify these in such a way as to further the psychological & cognitive sciences is another. Unfortunately, there is a distinct lack between our understanding of SOC in general and our ability to predict, explain, or even use standard mathematical formalisms behind descriptions of SOC in e.g., granular physics to do anything meaningful when it comes to human psychology or behavior. In part this is due to the relative simplicity of systems which exhibit SOC. In part it is due to the general lack of necessary mathematical proficiency in the

psychological, behavioral, cognitive, neuroscience, and other brain sciences.

[2] **Vesna Berec**
Second model does not consider important aspect of the social cognition model (social learning and reciprocal determinism) which is active even in the absence of motor reproduction or direct reinforcement. Thus, a changes in the environment do not automatically mean that a human behavior changes too, also a diverse biological aspects (hormonal, genetic etc.) raise a complexity of the topic.

[3] **Carlos Eduardo Maldonado**
I agree with Andrew, and he' s provided a significant answer. Therefore, I would like to move on to a complementary tun, thus:

I have my doubts about the necessity of predictability in science. Scientists do something else quite more difficult and sensitive than just predicting. Scientists are devoted to understanding. Now, when a good or satisfactory undestanding is acheived, then, as a consequence, as a kind of surplus, some predictability can be reached.

SOC is one of the approaches in complexity science. And the joinction between Lorenz and Bak's contributions allows us to safely say that SOC is no so much a predictive rod, as a marvelous way to explaining things otherwise, namely without the need to causality.

A solid research is the one that reaches high or deep understanding as then, only then, some prediction can be proposed...

[4] **Victor Christianto**
Dear Andrew, Vesna, Carlos, for your answers. Perhaps part of the question in this regard is: is it possible to use physical model/analogy to describe human behavior? Perhaps Per Bak's sand pile model has advantages, but perhaps it has limitations too.

[5] **Andrew Messing**
Dear Victor:

In response to your query, my personal (and naturally biased) opinion is "not yet." Our ability to model complex systems is fairly limited in general, and by "complex" I include the classical pendulum (N=1 body) problem. Maybe we will be better able to quantify human behavior using mathematical models in the future. Certainly, we can identify general trends, characteristics, etc., of human behavior and capture the essence of these using mathematical models. This does not mean books like "The Mathematics of Marriage" actually do so. They don't. Models from granular physics can be applied with deceptive success because much of what is captured is defined by the models used and involves their predictive power to tell us what we already knew, but add just a little mathematical polish.

Like I said, though, biased opinion (so much so I don't believe there is any other kind of opinion).

[6] **Vesna Berec**
Dear Victor,
The closest are attempts associated to mathematical modeling of neural networks. All mental and motoric pictures created by the brain come from activities of neurons in the neural network.

Here are some introductory information:

http://web.mit.edu/people/amliu/Papers/PentlandLiu_NeuralComp99_v11n2.pdf

[7] **Victor Christianto**
@Andrew, thank you for your answer. Yes it seems possible to come up with mathematical models of human behavior someday, at least based on some kind of analogy.

@Vesna. Thank you for your file. I will read it soon, but i am no expert in neural network. May i ask a question: is it possible to model the Universe as a brain?

@Carlos, i see that you want to distinguish SOC from causality. I am going to pst another question related to connection between SOC and causality breakdown, but alas i cannot find any paper on this issue. Sl if you have one or two files supporting your idea that SOC means causality breakdown, please kindly let me know. Thanks

[8] **Vesna Berec**
Dear Victor,
There is an idea on the basis of the Boltzmann Brain model (which includes self-aware brains with memories) . It is an argument based on the claim that even in a near-equilibrium state, there will be stochastic fluctuations in the level of entropy, addressed to ordered structures with its low-entropy conditions and consequential arrow of time. Boltzmann proposition was that we and our observed low-entropy world are a random fluctuation in a higher-entropy universe. This question automatically triggers the question of causality of origin of life, which by the presented model can only develop in low entropy domens as a fluctuation.

[9] @Vesna, thanks for your answer. Is it possible to arrive at a model for universe based on boltzmann brain? Can you give me a link or send me a paper on this issue? Thanks

[10] **Vesna Berec**
@Victor, some of the links:

Andrea De Simone, Alan H. Guth, Andrei Linde, “Boltzmann brains and the scale-factor cutoff measure of the multiverse”, PRD 82:063520, 2010; arXiv:0808.3778
Don N. Page, “Return of the Boltzmann Brains”, PRD 78:063536, 2008; arXiv:hep-th/0611158
Andrei Linde, Vitaly Vanchurin, and Sergei Winitzki, “Stationary Measure in the Multiverse”, JCAP 0901:031, 2009; arXiv:0812.0005

Concluding remarks
It seems possible to use SOC to study human behavior and human cognition, although one should also be careful of its limitations as a model.

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