Complex systems research in Psychology

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Foreword

This book is intended for psychologists and social scientists interested in the modeling of psychological processes using the tools of complex systems research.

The book has three primary objectives. The first is to provide a comprehensive overview of complex systems research, with a particular emphasis on its applications in psychology and the social sciences. The second is to provide skills for complex systems research. Lastly, it strives to foster critical thinking regarding the potential applications of complex systems in psychology.

For many decades, scientists have been studying all kinds of complex systems made up of many smaller subsystems interacting locally on fast time scales. Well-known examples include lasers, tornados, chemical oscillations, ant nests and flocks of birds. Scientists have built mathematical models of these complex systems and developed techniques to study them. The application of these techniques requires a great deal of mathematical and technical knowledge, but also a deep understanding of the nature of the system. You don't just create a mathematical model off the top of your head. In addition, testing such models requires extensive and reliable quantitative data. The application of complex systems theory to the behavioral and social sciences is therefore not straightforward. Theories are often verbal, and quantitative measurement in these sciences is a longstanding issue. While there has been some reasonable progress over the past 150 years, it is fair to say that the behavioral and social sciences are less mature than the "hard" sciences.

The application of complex systems theory to the behavioral sciences is challenging but, in my view, also essential. Whether we consider humans in isolation, the billions of interacting neurons in the brain, or the social networks in which we find ourselves, complexity is everywhere. Humans, with their complex brains embedded in various hierarchies of social systems, are the ultimate complex systems.

I believe that we can only succeed in exploring this system by understanding its complexity. We need to apply the tools of complexity science to our field of science, which is in desperate need of breakthroughs. After all, the modern world revolves around human beings who, through language and thought, have created an unimaginably complex world. The greatest danger now is man himself, and progress in the field of psychology is necessary and urgent.

This book requires study. Running the simulations, studying these examples, and solving the exercises will contribute to a deeper understanding of the material. I have used the content of the book in a master's level course for students in the research-oriented field of psychology.

I expect quite some background in psychology and its research methods. I assume only pre-university knowledge of mathematics and refer to basic sources where there is quite a bit of mathematics.

A lot of theoretical ideas will be illustrated with real examples. This is a theory and a practice book at the same time. An important prerequisite is a basic knowledge of the programming languages R or Python. **The book is originally written using R, but Python code is also provided.** Many exercises in the book require R or Python. There are many online resources for learning the basics of these languages. I also assume some knowledge of statistics and data analysis, at the level of a Master's in psychology. **In addition to R and Python, we will use NetLogo, but no prior knowledge of NetLogo is expected. NetLogo is a multi-agent programmable modeling environment for the simulation of complex natural and social phenomena.**

It is also good to say that this book is more a book for psychologists who have very limited knowledge of complex systems research than the other way around. Experts in complex systems who wonder how it can be applied in psychology may have to wait for another text.

I have written this book based on 35 years of scientific work in collaboration with fantastic colleagues and co-authors of the many papers. I'm part of the ecosystem of the Psychology department, especially the wonderful methods section, of the University of Amsterdam. Also important is the Institute of Advanced Study in Amsterdam, which has complex systems research as a central theme. In recent years I've also been an external faculty member at the renowned Santa Fe Institute in New Mexico. I am indebted to all of them and to many other colleagues around the world.

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References