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Book review

Review of *Dynamical Cognitive Science*, Ward, L.M., The MIT Press, Cambridge, MA, 2002

The author of *Dynamical Cognitive Science* had a daunting task in writing this introduction to theory and methods in the field. Not only was the task made difficult by the breadth of the methods dynamical systems theory finds in cognitive science, but also he was challenged to make the material accessible and relevant to a general cognitive science audience. In sum, Lawrence Ward completes this task with adequate facility in all respects and the result is a book that will prove useful to many who are not familiar with the methods and theory of dynamical cognitive science.

One of the strong points of this introduction to the field is the commitment to making a connection to application. In virtually all cases, the author describes the theory behind the method and then goes on to describe the method in enough detail that the reader can immediately apply the technique, assuming a modicum of previous statistics or calculus experience. The level of detail is usually kept such that the reader does not become over-involved with the specifics of the example. The specificity of the explanation, however, retains enough structure that applications to the reader's own research and/or theory will be readily apparent.

Dynamical Cognitive Science begins with a discussion of the difference between dynamic and static models of cognition and elucidates the importance of both kinds of models. This discussion, while relatively straightforward, helps set the framework for what the author means by dynamical and what the book will be about. This reviewer did not really realize that he was doing dynamical cognitive science until he read this section. This is an interesting aspect of ''dynamical cognitive science.'' It is an offshoot of dynamical systems theory that has branched into applications to cognitive science. This reviewer works in a tradition of production system cognitive modeling that has always been deeply concerned with the time course of cognition, but seldom makes reference to dynamical systems theory. However, it seems that the approaches have the same concern with time and may have much to learn from each other.

Readers may find the section on Markov processes interesting. A Markov process is any time process that moves between categorical states as a function of time and a probability matrix. The author shows some useful applications of this sort of modeling and it serves as a good introduction to dynamical processes in general. Most of the other sorts of analyses in the book require data that can be indexed on a continuous scale; one advantage of Markov process analysis is that it is more appropriate for discrete state changes.

The chapters on noise analysis were an important part of the book. This reviewer found these chapters quite interesting, since most of his research has dealt with noisy reaction time data, and the dynamical cognitive science approach the author described was for the most part new to his experience. These chapters begin with a discussion of the ARIMA method of noise analysis, which involves first subtracting out trends from learning or other sources before investigating the noise for true randomness. There was a useful section on the differences between white and pink noise (also known as $1/f$ noise) and the prevalence of pink noise in nature. Using just

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the information in this book and some computational tools, it is possible to complete some rather complex analyses using examples in the book as a templates.

Of less applicability, but perhaps of great interest will be the sections on Chaos. These sections may be less applicable, because as the author admits, examples of low-dimensional chaos in cognitive systems are few. While this section was lucid, and one can learn a great deal about what deterministic chaos is, it is unlikely that most readers will ever use this information. The technical aspects of these chapters were the most difficult in the book, and it appears that some special software is necessary to run the type of analyses done in these sections. It is quite likely that these sections will be of the most utility to a researcher with a neurophysiological orientation. If low-dimensional chaos is likely to be found anywhere with frequency, this reviewer suspects it will not be in behaviors so much as direct outputs from the neural substrate.

Also informative is the discussion of stochastic resonance. In simple terms, this could be described as the ability of random noise to perturb a signal above a threshold that would be otherwise unachievable. Stochastic resonance is used in the modeling this reviewer does, and he found this discussion of the mechanism in a context unrelated to his research to be enlightening. The author made a strong argument for the importance of stochastic resonance in many cognitive phenomena.

This book may be especially relevant to cognitive scientists who deal with noisy psychophysical data, but likely will be useful for anyone working with time dependent psychological processes. While the introduction claims that the book "has no serious mathematics" and therefore should be approachable by those with relatively weak mathematical backgrounds, the reviewer found that some knowledge of calculus was necessary. It is likely that the author's mathematical background is very strong and therefore he underestimates what many outside of more mathematical areas of psychology may find "serious." The book will be most well received by researchers dealing with the above issues in their current research. It is appropriate for graduate students and higher, but may be well enjoyed by anyone with a mathematical background and an interest in cognitive science.

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