

## INTRODUCTION

The past two decades have seen a tremendous increase in explorations of the mind. Understanding the working of consciousness and cognition ranks high on the agendas of science and society. Cognitive science and neuroscience have developed into a completely new interdisciplinary field, where numerous ‘classical’ sciences have begun to invest their best resources. Notable among them are psychology, (neuro-) biology, physics, and philosophy. These are the professional backgrounds of the authors united in this volume.

This volume provides an account of a principal approach to cognitive science: the *dynamical systems approach*. The common denominator of the dynamical approach to cognition is very simple—we wish to explain the (‘intelligent’) functioning of cognition by observing the *processes* that generate and sustain such functioning. If we go into more detail, we may detect a handful of convictions as the foundation of the dynamical approach; they are shared by most if not all of the proponents of dynamical cognitive science.

- (1) A first conviction is: Functional (‘intentional’, ‘goal-directed’) cognition is not a single, elementary attribute of the mind which might be discovered in some specific location in the brain, or pinned down as a special computational module of higher cognition. Instead, a *synergy*, i.e. a working together of multiple simpler processes is proposed as the basis of cognition and action.
- (2) A second conviction is this: To understand the mind one must not focus exclusively on the mind. Instead, cognition is *embodied* (the mind has a brain and a body).
- (3) A third, related conviction is: Cognition is *situated* (i.e., the mind is embedded in environmental constraints and is driven by energetic gradients).
- (4) A fourth conviction elaborates on the second and third; it is the *interactivist* conviction. The circular causality which synergetics conceptualizes to be at the heart of self-organizing systems permeates not only the mind, but also the world. Thus, if we speak of ‘embodied cognition’, we should also consider the ‘cognitive body’. Analogously, as the mind is situated and therefore driven by environmental affordances, the dynamical view encompasses also the complementary effect of the mind on the affordances it is driven by. Francisco Varela coined the term ‘enactive cognition’ for such reciprocities.
- (5) The fifth conviction is probably the most opaque: It is the notion shared by many proponents of the dynamical approach that self-organized dynamics may help explain *intentionality*. Intentionality and the questions concerning consciousness become topics demanding explanation as soon as conviction (1) is put forward.

The shared theoretical background of the contributions to this book is described by these assumptions that appear in different shapes throughout the chapters. The book is divided into three sections. Section I 'Embodiment' gives an introduction to the three main perspectives of dynamical cognitive science. It is initiated by *Hermann Haken's* treatment of intelligent behavior. He points out the deep analogies of the building blocks of intelligence and how they can be modeled by the self-organization approach of synergetics. *Esther Thelen's* topic is a developmental view on the emergence of skillful sensorimotor coordination that grounds an individual in the world. The introductory section I is concluded by *Scott Kelso* who shows that the way towards a dynamic cognition and behavior lies in coordination dynamics that investigates how patterns of coordinated behavior emerge, persist, adapt and change in human beings (and brains).

The second section, 'Coordination Dynamics', seizes Kelso's thread by showing that the dynamical approach to cognition is best exemplified by the established coordination dynamics paradigm of movement science and psychology. Empirical findings of the leading research groups in this field are reported here. *Franz Mechsner and Wolfgang Prinz* put forward, based on bimanual coordination studies, their hypothesis of a common perceptual-cognitive code that governs motor behavior. *Jean-Jacques Temprado* reviews a series of dual task investigations of the role of attention and attentional cost in bimanual coordination dynamics. *Kerstin Witte, Holger Bock, Ulrich Storb, and Peter Blaser* give an account of the synergetic modeling of cyclic sports movements, such as walking-to-running transitions. *Tin-cheung Chan, Xiaomin Yue, Zhuanghua Shi, and Bo Hong* report their work on synchronization of brain areas using EEG data in reaction time tasks. *Till Frank and Peter Beek* propose their mean-field approach as an appropriate model to study self-organization in spatially extended perception-action systems such as rhythmic movements, as well as neuronal and psychological processes.

The chapters of the third part of the volume, titled 'Intentionality', discuss how the first-person, intentional perspective and the third-person, behavioral or physical, perspective may be integrated. A particular, philosophical as well as practical, problem here is cognitive representation. *Wolfgang Tschacher, Jean-Pierre Dauwalder, and Hermann Haken* claim that an essential property of self-organized pattern formation lies in its functionality to reduce gradients; this may explain intentionality. *Scott Jordan* offers a broad review of cognitive and neurobiological research showing how the 'disembodied' approach is transformed into an approach that embodies consciousness and intentionality while avoiding epiphenomenalism. *Pim Haselager* addresses the representation problem by exploring 'representation-hungry' tasks finding that even here the cognitivist representational account may be put into question. *Fred Keijzer's* 'self-steered self-organization', conceptualized in a biological context and in psychology, provides a non-representational understanding of perception-action couplings and their neural modulation. *Laurent Pezard* discusses non-linear methods by which the dynamical approach of brain functioning can be

applied to neurobiological data, e.g. those that reflect so-called dynamical diseases. *Juval Portugali* adapts the ideas of embodied cognition to behavior in cities, i.e. artifacts generated by cognitive acts that feed back on cognition in circular causality. The final contribution by *Jane Abraham* describes how the dynamical view of cognition shapes novel concepts of teaching and learning, and thus the practice of pedagogy.

The 'Herbstakademie' conference we organized in Ascona, Switzerland, in October 2000 was the inspiration for compiling this thematic volume. We are confident that the serene atmosphere of Monte Verità overlooking Ascona and the Lago Maggiore, a venue with a history of extravagant and innovative cognition and action, has found its way onto the pages of this book. We cordially thank all the participants of the Ascona conference for their intellectual and emotional involvement, which made those days up on the Monte an outstanding experience. In an illustration of this large group of people, one marvelous man would be in the center, namely Hermann Haken, to whom we extend our thanks for his stimulating ideas and warm personality, as well as for his support in the realization of this book.

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This presents our second book project on the dynamical systems approach to cognition and action. Kim Tan of World Scientific and the series editor Bruce West were again the pleasant partners we have appreciated years ago when editing '*Dynamics, Synergetics, Autonomous Agents: Nonlinear Systems Approaches to Cognitive Psychology and Cognitive Science*', published in 1999. It may be interesting to compare that volume to the present. To allow for bibliographical study, we included all entries of the indexes of 1999 in the new indexes (on top of many novel items). Finally, we acknowledge the valuable contributions of Simone Wassilevski-Seiler, Martin Wehrle, Christoph Glasmacher, and Zeno Kupper during the final stages of the editing process.

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Wolfgang Tschacher  
Jean-Pierre Dauwalder