Introduction

As the title testifies, this book suggests a conjunction between three components: *Complexity, Cognition and the City*. The first two – complexity theory and cognitive science – refer to relatively young scientific domains, while the third – the city – is an old, or rather ancient, entity and artifact.

The first component – Complexity – refers to Complexity theory or rather *theories*, that is, to several theories that originated in the 1960s when physicists such as Hermann Haken and Ilya Prigogine became aware of, and started to study, physical-material systems that exhibit phenomena such as emergence, self-organization, history and the like; phenomena that previously were regarded as typifying organic or even socio-cultural systems, but not material systems. These resemblances between phenomena in the animate and inanimate domains were one of the reasons that soon after its emergence complexity theory became a general paradigm that was applied to a variety of domains ranging from physics, to life sciences, social sciences and the study of cities, too.

The second component – Cognition – refers to cognition as perceived by cognitive science, that is, the science of mind that emerged in the mid-1950s as a rebellion against the paradigm of behaviorism that dominated the study of animals and human behavior in the first half of the 20th century. At the core of this rebellion was the demonstration that behaviorism's postulation that all behavior can be explained by externally observed factors fails and that in order to explain behavior one has to take into consideration the role of the mind.

The third component is the city. Cities and urban society exist with us for more than 5000 years; however, the academic study of cities is not as old. It started mainly in the early 20th century, on the one hand, out of the recognition that the cities that entailed the industrial revolution are qualitatively different from older cities; while on the other, by the emergence of scientific world view, namely, by the view that science provides the key for the understanding of the dynamics of cities as well as for the appropriate handling of cities. The result was the domains of urban studies, planning and design that started as branches of established disciplines such as economics, sociology, geography, engineering or architecture, but gradually became disciplines in their own sake.

While the conjunction suggested in this book between complexity theories, cognitive science and cities is novel, links between pairs of these three entities do

exist. There are already strong links between complexity theories and cognitive science as well as between complexity theories and cities; there are also weak links between cognitive science and cities. The strong links between complexity theories and cognitive science are not surprising: the brain as a network of billions of neurons connected in complex feedforward and feedback loops is regarded by many as the ultimate complex system, and the answer to the question of *How Brains Make Up Their Minds* (which is the title of Freeman's book from 1999) is often answered: 'by means of the property that brain and cognition are complex systems capable of self organization'.

There are also strong links between complexity theories and the study of cities and urbanism. These links started when Prigogine, one of the founding fathers of the complexity paradigm, was referring to the city as a metaphoric example by which to convey his notion of dissipative structures to his fellow physicists; it continued when physicist Peter Allen took this city metaphor seriously and reformulated the central place theory of cities in terms of complexity; studies of cities as complex self-organizing systems then grew exponentially when students of cities and urbanism became attracted by the new paradigm of complexity and self organization. The result is that we now have a whole domain to which I'll refer below as *complexity theories of cities*, or in short: *CTC*.

And what about the links between cognitive science and cities? According to Gardner's (1987) historical account of *The Mind's New Science*, six disciplines were specifically active in building cognitive science as the new science of mind: psychology, philosophy, linguistics, anthropology, neurosciences and AI (artificial intelligence). The study of cities was not among them. The links developed in the 1960s when students of cities became interested in the *Image of the City* (Lynch 1960) and students of cognitive science in "cognitive maps of rats and man" (Tolman 1948), spatial cognition and behavior. For the latter cognitive scientists the city was mainly a convenient environment and arena within which one can study the various aspects of spatial cognition and behavior; the dynamics of the city was not and is still not in their research agenda.

Why to link complexity, cognition and the city? The answer to this question follows my personal impression is that CTC has reached a state in which it becomes subject to the 'law of diminishing marginal utility', and, that in order to further grow and develop it needs to create new links; one such promising link is the link between CTC and cognitive science. Let me explain.

This book is my second attempt to look into the domain of CTC. The first was *Self-Organization and the City* that was published some ten years ago (Portugali 2000). In these ten years the domain of CTC has flourished: the number of practitioners grew dramatically and with them the number of studies on the various aspects of cities as complex self organizing systems, the field became recognized and even fashionable, it has become a permanent and popular topic in many international conferences that directly or indirectly deal with cities (a situation that typifies many other disciplines in the social sciences and the humanities). Looking deeper into the developments of the last decade, a change of emphasis can be observed in both complexity theories and CTC: from long-term complexity

theories and CTC that explore the whole life path of complex systems (fast *emergence* → long *steady state* → short *chaos*/collapse → and back again), to short-term approaches that emphasize and explore the process of emergence. One sign of this shift of interest, in the domain of CTC, is the growing popularity and use of cellular automata and agent-based urban simulation models. The relative mathematical simplicity of these models made the field of CTC accessible to many urban scholars that previously were refrained from this field because of the complexity of its mathematical models and argumentations.

My impression is, as noted, that we are approaching a situation by which the current influx of studies becomes subject to the law of diminishing marginal utility. The reason is that so far CTC have been fully applicative in their structure, that is, they have applied complexity and self-organization to cities by studying the various cases in which cities behave like complex systems in physics and life sciences. The benefit from this is the influx of studies noted above; the cost, however, is twofold: Firstly, CTC have almost lost their connection with the core of urban studies, that is, they have become more a branch of complexity theories as studied in the sciences and less a partner in the overall study and discourse on cities in general and on the cities of the 21st century in particular. Secondly, by treating cities as inanimate physical complex systems, CTC can verify existing complexity theories but cannot add to them new dimension that might typify human complex systems but not inanimate physical systems.

The aim of this book is to show how can CTC become a full partner in the discourse on cities and how it can contribute to mainstream complexity theory. The key to both as we'll see below is to link complexity, cognition and the city.

The Structure of the Book

The book contains 20 chapters grouped into four parts. Part I provides the context. Looking at the domain of cities from the perspective of Snow's thesis regarding science's two cultures, it portrays the history and evolution of urban studies in terms of a tension between two urban cultures: *culture one* that attempts to create a science of cities inspired by the hard sciences, and *culture two* that promotes a study of cities inspired by social theory and philosophy (Chap. 1). The next two chapters describe in some detail the shifts between these two cultures. Chapter 2 starts with the *quantitative revolution* that gave rise to the first culture of cities that during the 1950s and 1960s attempted to build a science of cities, while Chap. 3 commences with a second paradigmatic revolution promoted by people who have criticized the first culture of cities from Marxist, structuralist and humanistic points of view thus building the second culture of cities as social theory oriented urban studies.

The first entry of complexity theories to the domain of cities was made by physicists who applied notions of complexity and self-organization to urban theories of the first culture of cities. Chapter 4 that describes this process serves two purposes: on the one hand, it introduces the various complexity theories as they evolved since the mid-1960s, while on the other, it surveys in some detail the

history and evolution of the domain of CTC. Finally, Chap. 5 concludes Part I by looking at what has been achieved by CTC in the last three decades. It does so with a lot of appreciation but also with sober criticism. Based on the latter, the chapter concludes by looking ahead at potentials that have yet to be realized – in particular at the possibility and necessity to link complexity, cognition and the city.

Part II, is the theoretical heart of the book. It starts, in Chap. 6, with an overview on the existing and potential links between Cognition, Complexity and the City. It continues in Chap. 7 that introduces the notion of SIRN (synergetic inter-representation networks), which is at once an approach to cognition and cognitive mapping at the level of individual agents, and a cognitive theory of cities as complex self-organizing systems. According to SIRN the city is an artifact that comes into being out of the interaction between internal representations constructed by, and in, the mind/brain of people and external representations produced by them in the world. This view in its turn raised a question as to the nature of external representations. Commencing from a distinction between *Shannonian information* (Shannon 1948) and Haken's (1988) *semantic information*, Chap. 8 demonstrates that external representations such as cities and the various elements of which they are composed convey and transmit information that can be measured by means Shannon's information *bits*, while Chap. 9 further demonstrates that this ability is preconditioned by the city semantic information that comes into being by means of self-organization. Chap. 10 further looks at the city from the perspective of cognitive science's discourse on categories and categorization, while Chap. 11 concludes Part II by considering the various aspects of the city as a *complex artificial environment*.

Part III entitled *Complexity, Cognition and Planning*, explores the implications of CTC to the domain of urban, regional and environmental planning, which has evolved as the applicative facet of urban studies. This shows up in Chap. 12 that locates the CTC implications and approach to planning in the context of *the two cultures of planning* that developed hand in hand with the two cultures of cities as described in Chap. 1 above. Chap. 13 approaches planning from the perspective of cognition demonstrating that planning is on the one hand a basic cognitive capability of humans while on the other, a profession and academic discipline. It then makes a distinction between solitary planning and collective planning that provides the link to the academic-professional process of planning. Chap. 14 uses paradoxes as means by which to learn about the limitation of planning predictions in cities as complex self-organizing system. This finding is significant as the study and practice of planning are heavily based on the assumption that the ability of prediction is almost unlimited. Chap. 15 makes a link between CTC and social theory oriented planning theory, specifically communicative and strategic planning that currently dominates critical urban studies, while Chap. 16 concludes Part III by illustrating SPCity (self-planned city) as a city the planning system of which is built on the principles of complexity and self-organization. That is, a planning system in which every urban agent is a planner at a certain scale and whose planning process is not based on predictions but rather on planning rules.

Urban simulation models provide an important medium by which to study complex systems. This shows up very clearly in the domain of CTC in which

many, probably most, studies are based on pedagogic, abstract and/or empirical urban simulation models (USM). Part IV studies the implications of the link between complexity, cognition and the city to USM. Two kinds of cognitive USM are presented and discussed: agent based (Chaps. 17, 18) and synergetic (Chaps. 19, 20). Chapter 17 is, in fact, a revisit in two models that have already been described in SOCity (*Self-Organization and the City* – Portugali 2000). They are revisited in order to explicate the cognitive dimension that in the past was essentially implicit. The first makes use of the notion of Festinger's (1957) *cognitive dissonance* while the second on Dawkins' (1986) notion of *memes* as memory units. Both models illustrate the way cognitive properties revealed by cognitive science can be employed in, enrich and improve, standard USM. Chapter 18 goes one step further and presents CogCity (cognitive city), which is an explicitly complex and cognitive urban simulation model. The next two chapters model the process of decision making in the context of cities from the perspective of synergetics and SIRN. Chapter 19, which is a descriptive account of quantitative Chap. 14 in SOCity, makes a link to Tversky and Kahneman's (1981) notion of decision *heuristics* and reformulates SIRN as a decision-making model. Chapter 20 continues this line of thinking by presenting an USM model that is novel in two respects: it explicitly considers the competition between decision-making agents, and, the role of time in that competition. The discussion in the book closes with concluding notes regarding the research directions that are implied by the present study.