Chapter 17
Revisiting Cognitive Dissonance and Memes-Derived Urban Simulation Models

17.1 Introduction

In previous chapters we've suggested SIRN as a cognitive approach to urban dynamics. In the present chapter (and in the one that follows) the aim is to explore the implications of SIRN to urban simulation models (USM). This is done, firstly, by an examination of four interrelated properties that typify SIRN and distinguish it from most CTC approaches of urban dynamics: (1) it is a comprehensive CTC; (2) it is a cognitive CTC in an innovative way; (3) it suggests perceiving urban agents as a complex systems; (4) it implies a separation between agents' intention and behavior. Secondly, by revisiting two USM originally developed in SOCity, that is, *Self-Organization and the City* (Portugali 2000, Chaps. 7, 8): The first makes use of Festinger's notion of *cognitive dissonance*, while the second employs Dawkins' notion of *memes*. In SOCity the emphasis was on the insight these two models add to our understanding of cities as complex systems. In the present "visit" the aim is to explicate two properties that were implicit in the models, namely, the fact that they are SIRN USM and as such cognitive. The discussion in the chapter evolves in three steps: Sect. 17.2 elaborates on the basic principles of SIRN USM; Sect. 17.3 on cognitive dissonance-derived USM, while Sect. 17.4 on memes-derived USM.

17.2 Principles of SIRN USM

17.2.1 A Comprehensive CTC

SIRN is a comprehensive, circular causality CTC in which the local interaction between the urban agents gives rise to the global structure of the city, which then feeds back and prescribes the behavior, interaction, and action of the agents, and so on. As we've seen in previous chapters, this is not the case with the majority of USM currently in use: Guided by Simon's Ant Hypothesis of *simple* → *complex* relations, standard urban simulation models have become excellent tools to simulate the first part of this loop – the bottom-up process by which local interactions

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give rise to a global structure – but they fail to describe the second part of the loop – the top-down process by which the global structure of the city affects its agents' cognition and information and as a consequence their behavior in the city.

Cognitive science, and in it the domains of spatial, environmental and geographical cognition, is a science that scrutinizes the second part of the above process: the way the interaction with the environment shapes the agent's mind/brain and internal representation and the entailed behavior. In the case of space and cities, theories of cognitive maps, for example, theorize about the way agents' cognition emerges out of their interaction with their environment and how this cognition affects behavior. However, confined within its disciplinary boundaries as the science of cognition and not of artifacts and their production, cognitive science never went one step further to ask how spatial behavior affects the production of artifacts and the structure of cities.

17.2.2 A Cognitive CTC

SIRN is a cognitive CTC in that it derives agents' behavior from first principles of human behavior as explored and revealed by cognitive science. Thus for example as we've seen above, it is an approach that follows the way cognitive maps of agents are created out of agents' encounter with the urban environment, the way (ones created) cognitive maps affect agents' behavior that then gives rise to the global structure of the city that feeds back to agents cognitive maps and so on in circular causality.

However, as a cognitive approach SIRN goes one step further beyond "conventional" cognitive science and in this respect it is an innovative approach to cognition: unlike cognitive science that refrains from including the production of artifacts as part of cognition, SIRN insists on doing so. Accordingly, it treats the city as a large-scale collective artifact that, similarly to artifacts in general, came into being in a process of production; in the case of cities it is a process of collective (social, cultural, . . .) production. SIRN thus integrates the process of cognition with the process of the production of artifacts – small like lamps and large like cities.

17.2.3 Simple vs. Complex Agents

In previous chapters we made a distinction between *cognitively simple* and *cognitively complex* agents or in short, between simple and complex agents. We've suggested that from the SIRN perspective urban agents (individuals, families, firms etc.) are all complex self-organizing systems – hence the notion of dual complexity discussed above.

This cognitive complexity of urban agents shows itself in a variety of ways: Firstly, several cognitive tasks such as pattern recognition and cognitive mapping evolve as complex SIRN. Secondly, urban agents are capable of changing their original properties as a consequence of learning and/or as a consequence of socio-spatial pressure such as the pressure of cognitive dissonance as discussed below. In terms of complexity, they have the capability of undergoing cognitive phase transition. Thirdly, urban agents are multi-dimensional rather than one-dimensional – each has several "personal" properties (rich, poor, cultural affiliation, professional affiliation and so on) that might potentially affect its location behavior when the choice is made by the environment – very much like the process of evolution. Fourthly, urban agents never come to the city *tabula rasa*; they always have and use cognitive maps even of cities they have never been or seen before. Fifthly, urban agents can take decisions in situations of uncertainty by heuristics, for instance. Finally, urban agent can plan and many of their actions are influenced by their plans and by the plans of others. The notion of SIRN, in particular its *public with a common reservoir* submodel, introduced above, is an attempt to take these properties into consideration.

17.2.4 Intentions vs. Behavior

Mainstream CTC approaches to urban simulation models are currently dominated by the implicit assumption that agents' intention and behavior are causally related: intention is taken for granted as the cause of behavior, or alternatively, behavior is understood as some product of the optimization of intentions. According to SIRN, intention and behavior are two relatively independent entities, which might affect, complement, negate, or compete with, each other as elaborated in Chap. 14 above and below in Sect. 17.3. By departing in this respect from the approach of mainstream CTC, we in fact follow classical social theory as well as the inner logic of complexity theory. We also follow disciplines such as psychology or cognitive sciences.

17.2.5 Classical Social Theory

The interrelation between the individual's intentions and value system, his/her actual behavior, and society, forms a central theme in social theory and philosophy. The notion of ideology, for example, is directly related to the tension created between a person's value system and the person's actual behavior and action (Larrain 1982). Such a tension often leads to what Hegel and later Marx have called "ideological false-consciousness" which obscures people's vision from their real conditions of existence. A central controversy in social theory is between Marxists who claim that a person's value system (including intentions) is dialectically determined by his/her conditions of existence (i.e. actual behavior), and liberal humanists who consider human action as an outcome of human intentionality. Giddens' (1986) theory of *structuration* aims to synthesize the two views: on the one hand, the individual is a free agent whose intentions determine his/her actions; on the other hand, the individual is acting in a relatively autonomous social structure with its own rules and thus the individual's actions and behaviors might have "unintended consequences".

In the last decades, mainstream urban studies were strongly influenced by social theory and by Giddens' structuration, and are thus very critical of behaviorism and its application to regional science (Thrift 1983). Arguing from the perspective of social theory, they accuse behaviorists of blurring the dialectical relations between the human agency and his/her socio-spatial structure. That is, the refusal of behaviorism to consider the subjectivity of the individual with his/her wants and intentions, and to study the ways socio-spatial structures such as cities, determines individuals' intentions and ideas (for a discussion and bibliography see Jackson and Smith 1984, Chap. 3; Gregory and Urry 1985). SIRN thus provides a basis to reintegrate social theory oriented urban studies with the quantitative science of cities – an issue we've already discussed above.

17.2.6 Complexity Theories

The very ideas of complexity and self-organization with their property of nonlinear relations implies, almost by definition, a gap between intentional causes and behavioral effects, as well as various forms of unintended consequences. The very notion of *emergence*, which is central to complexity theory, implies that the emerging properties of the global system differ from those of its local parts. When the global system is a city specifically divided into ethnic groups or collectively behaving pedestrians in the city, we, in fact, have a separation between the intentions of the individual agents and their actual behavior. This is specifically prominent and explicit in Haken's synergetics approach to self-organization in which the order parameter enslaves the individuals' behaviors. As illustrated above (Chap. 6 and Figs. 6.15, 6.16) within the domain of human behavior this was beautifully illustrated in a series of experimental and theoretical studies designed by Kelso who has used Haken's synergetics approach to self-organization as his framework (Kelso 1984, 1990; Haken, Kelso, and Bunz 1985; Haken 1990). In Kelso's experiments intention and behavior are found to be methodologically and scientifically separated though dialectically related (see also Stadler and Kruse 1990).

17.2.7 SIRN

While in the above cases the separation of intentions and behavior is a somewhat implicit property, in SIRN it is an explicit principle resulting from the interplay between intentions as internal representations and behavior, action and production as external representations. This is so with respect to our interpretation of the urban process and the dynamics of cities and this is so with respect to SIRN USM. Two such models were developed in the past in the context of SOCity. In the latter, however, the SIRN nature of them was rather implicit; in what follows it becomes explicit. The first makes use of Festinger's notion *cognitive dissonance* and applies it to the context of cities, while the second applies Dawkin's notion of *memes* to the realm of cities. These two models serve also as an illustration to the way general cognitive processes that are not related specifically to space or cities, can be used in, and benefit, urban simulation models. In Chap. 18 I present a cognitive maps'-derived USM. Cognitive maps, as we've seen in the previous chapters, were from the start directly related to space and cities.

17.3 Cognitive Dissonance-Derived USM

17.3.1 Cognitive Dissonance

Unlike social theory and Giddens' structuration theory whose main concern is society, Festinger's (1957) theory of cognitive dissonance focuses directly and exclusively on the cognitive processes of the individual. The idea is straightforward: a cognitive gap or dissonance between an individual's intentions and his/her actual behavior and action, is cognitively unbearable – it creates a cognitive tension which eventually will have to be resolved either by a change of behavior and action, or by a change of intentions and value system. Festinger's theory was examined in various laboratory experiments as well as in real life observations and is now generally accepted. The theory got further support by Gazzaniga's studies on the modular structure of the brain. In his *The Social Brain* (Gazzaniga 1985, p 80) he writes the following:

> *"... the new brain science [adds to Festinger's theory] the knowledge that [cognitive dissonance is related to the fact that the brain] is organized in ... relatively independent modules that are capable of initiating disparate behavior in the first place".*

Cognitive dissonance as formulated by Festinger and elaborated by Gazzaniga provides the starting point to the notion of spatial cognitive dissonance that stands at the center of our discussion below.

17.3.2 Spatial Cognitive Dissonance

As illustrated in Fig. 17.1, Festinger's theory can easily be described by means of a bifurcation diagram. That is to say, from the perspective of the individual, a situation of cognitive dissonance drives the individual into a cognitive bifurcation point: to change behavior, or to change intentions and value systems.

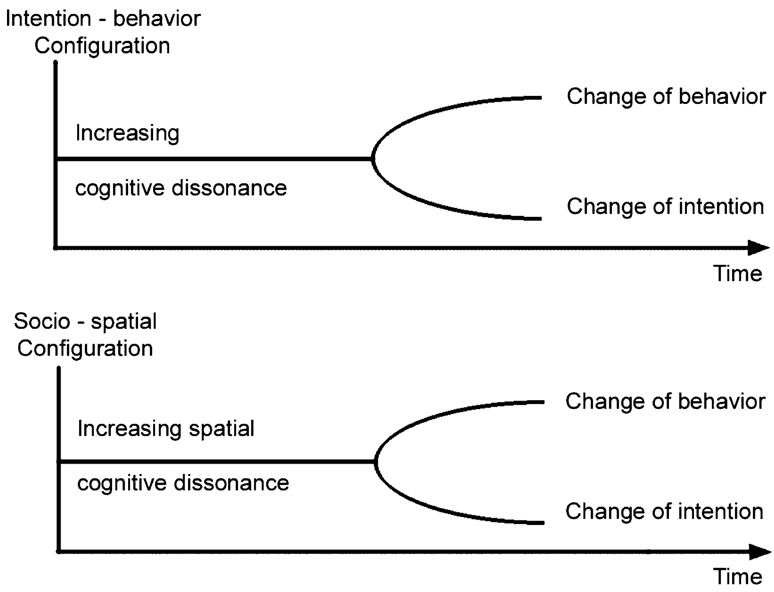

Fig. 17.1 Cognitive dissonance formulated in terms of a bifurcation diagram. *Upper*: general. *Lower*: spatial cognitive dissonance

A typical case within a city would be that of an individual living in a neighborhood where he or she does not want to live. This frustrating situation can be resolved either by a change of wants, or else by migration. An empirical examination of the intention-behavior gap, within a city context, seems to support this view (Portugali 2000, Chap. 7). It suggests that with time, people's reaction to the intention-behavior gap becomes polarized: people living for long periods of time (18+ years) in a neighborhood of another cultural group (Jews among Arabs and vice versa), become either integrative (i.e. change of intentions), or extremely segregative in their value judgment of their actual situation. This is illustrated in Fig. 17.2.

17.3.3 Cognitive Dissonance, Chaos, and Emerging Urban Boundaries

The dissonance between intention and actual behavior was also implicitly obtained as a by-product from several CA urban simulation games studies in SOCity (Portugali 2000, Chap. 5) and discussed in Chap. 4 above in relation to what we've termed "chaotic cities". The urban simulation model upon which these simulation games were based was a cellular automata (CA) model termed *City*. In the latter we have examined socio-cultural spatial segregation as resulting from two groups of individual agents (Greens and Blues) divided into various configurations according to their intentions: Blue or Green *Segregatives* who want to spatially

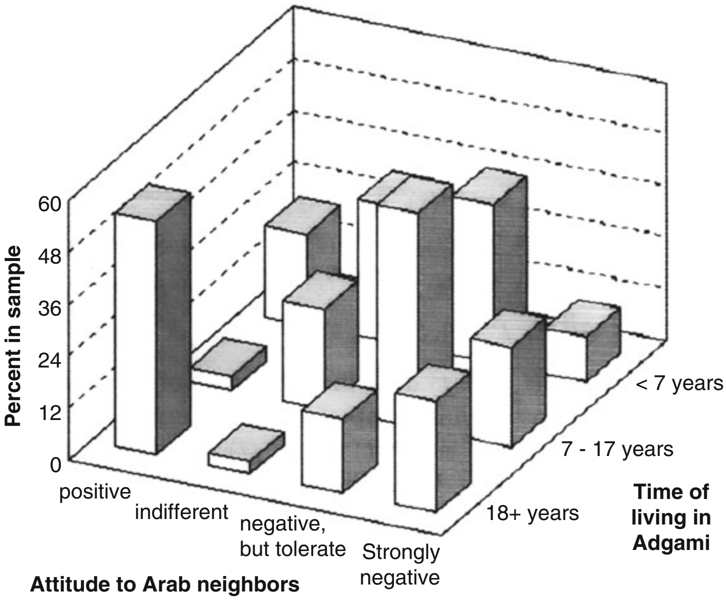

Fig. 17.2 The changing reaction in time of Jewish inhabitants living in Ajami (the Arab community of Tel Aviv–Yaffo) to their Arab neighbors. Four attitude groups were found: positive attitude about living among Arab neighbors; people indifferent as to their neighbors; negative attitude – prefer to live among Jewish neighbors; strongly negative – strong objection to live among Arabs

reside among their own kind, and Blue or Green *Neutrals* who are indifferent as to their location in the city.

In the various games played it was found, first, that in all the simulations there were always individual agents who actually behaved (i.e. were located in space) counter their intentions (e.g., a segregative Green located among Blue neighbors). Such agents live in what we termed above as ‘spatial cognitive dissonance’. Second, in the majority of the simulation games these individual agents were spatially segregated in the city. The emerging city landscape was thus a highly segregative urban landscape of relatively stable Green vs. Blue areas, characterized by low level of spatial cognitive dissonance, and in-between areas of intense spatial cognitive dissonance. Third, the latter areas formed, in fact, the boundaries between the various Green and Blue urban areas. This latter finding sheds a new light on the nature of urban boundaries.

Boundaries are commonly perceived as lines separating territories. There is a rich literature on the various forms of boundaries (political, municipal, economic, natural; see Biger et al. 1995). However, implicit in the vast majority of these studies is a static view on boundaries – as the static lines that separate otherwise homogeneous areas. One of the interesting outcomes of our *City* model (that has only partly been discussed thus far) is the finding that the boundaries that emerge in our USM are in fact the most dynamic areas of the city. More specifically, they are chaotic areas characterized by high levels of spatial cognitive dissonance.

The link between chaos, boundaries and urban dynamics was already made above in Chap. 4 in connection with the model *City*. In *City* the boundaries are emergent entities that in a process of self-organization leads the city into a steady state. The central aim of *City* was to study residential segregation in cities and indeed we were able to demonstrate that the self-organized steady state took the form of a city that is spatially segregated to different cultural areas that in the model *City* represented different cultural groups. However, the really interesting finding came when we zoomed-into the boundary areas that separate relatively stable homogeneous (cultural) Green and Blue areas: we realized that unlike the rest of the urban landscape the boundaries remain chaotic. This was illustrated by means of the stability-instability surface (SIS) measure we've developed in connection with *City* (Figs. 4.22, 4.23 above). The latter represent an interesting process of 'order out of chaos': At the beginning of the process the city as a whole is chaotic and then when it is demographically growing and crossing a certain threshold, it self-organizes into a stably ordered landscape, with unstable-chaotic boundaries. Our interpretation in Chap. 4 above was that this chaotic boundary is necessary in order to keep the rest of the city stable. In the context of the present discussion we can add that Figs. 4.22 and 4.23 represent also a process by which at the beginning the city as a whole, that is, the vast majority of its inhabitants, is in a state of high spatial cognitive dissonance; but then, as the process of spatial segregation develops, spatial cognitive dissonance levels off in the highly segregated areas, but remains relatively high in the boundary chaotic areas. Chaotic areas in the city are thus areas of high spatial cognitive dissonance.

17.3.4 The Model

In the above example of the model *City*, the phenomenon of spatial cognitive dissonance was a by-product of a model whose major aim was to study cultural spatial segregation in cities. The model *City-2* in SOCity (Portugali 2000, Chap. 7) was specifically designed to study the various aspects of cognitive dissonance in the context of cities. In this section I describe in brief the model *City-2* and some of the main results as they emerged from the various simulation runs. The description below is done in a nonmathematical fashion; a detailed description of the mathematical formalism and the results, can be found in Portugali (ibid).

Similarly to other FACS models, *City 2* is built of two layers: a CA layer that simulates the relations between the various urban objects (houses) and an AB layer simulating the location behavior of urban agents. The model commences from the notions of spatial cognitive dissonance, the captivity principle and the nature of urban boundaries as elaborated above. In a typical scenario, agents belonging to two cultural groups (Blue and Green) come to the city in order to find a residential location in it. All agents are segregatives in the sense that they prefer to live near neighbors of their own kind. Every iteration, each agent examines its situation in the city: if it is satisfactory, that is, if its neighbors are like itself, it will stay in its location; if not, it will attempt to improve its location by moving to a better place in the city. If it fails, it leaves the city.

The SIRN component is enfolded in this iterative process by which every agent examines its location situation (the externally represented city) and takes (internally represented) location-action decision accordingly and so on.

17.3.5 Results: Spatial Cognitive Dissonance and Socio-Spatial Emergence

As the process in *City-2* evolves we in fact get two kinds of Blue and Green agents: *immigrants* who come to the city for the "first time in their life" and veteran *residents*. They differ in the options they confront: The immigrant tries to find an appropriate location and if it fails it leaves the city. The resident examines its location situation and if it is unsatisfactory it will try to relocate by finding another appropriate location in the city. If it fails for several iterations it enters a situation of spatial cognitive dissonance: either to altogether leave the city, or else to change its location preferences, namely, to become integrative instead of segregative.

Figure 17.3 illustrates a set of snapshots of a typical simulation. As can be seen, very quickly a segregative city landscape emerges with Blue and Green homogeneous areas, and boundaries in between. As already noted, the emerging boundaries become boundaries by virtue of their property as the most unstable/chaotic (linear) areas in the city; this instability, in its turn, is due to the fact that here many of the neighbors of every resident are not of its own kind. Many agents in the boundary thus attempt to relocate and to move to a better location in the city and as a result the boundary is never at rest: there are all the time agents that leave it and agents that unwillingly find themselves in it – after their nearest neighbors who created a buffer between them and the boundary managed to move away.

As can be seen in Figs. 17.3, up to a certain stage nothing dramatically happens and the city maintains its steady state as a segregative city. But then, as the density of the city reaches its limit and there are not enough vacate locations for the residents who try to relocate, more and more residents enter a situation of spatial cognitive dissonance the result of which is that at least some of the agents change their preference and instead of segregatives become integratives. In order to identify the agents who enter this state we've marked them Yellow. As can be further seen in Fig. 17.3, not surprisingly the vast majority of Yellows are located in the boundary areas, in other words, previously Blue and Green agents now share a common property and as a consequence agree to live together.

As the number of Yellows in some area of the city crosses a certain threshold, we see a phenomenon of socio-spatial emergence – a new cultural group emerges in the city and out of the city's specific dynamics. The result is that the city's cultural landscape is now composed of Blues, Greens, Yellows (i.e. Neutrals) and Reds, that is, the new cultural group that, in a process of self-organization, emerged is some parts of the city (Fig. 17.4) out of its very dynamics.

This situation of socio-spatial emergence, that is to say, a phenomenon by which a new socio-spatial cultural group emerges out the very dynamics of the city is

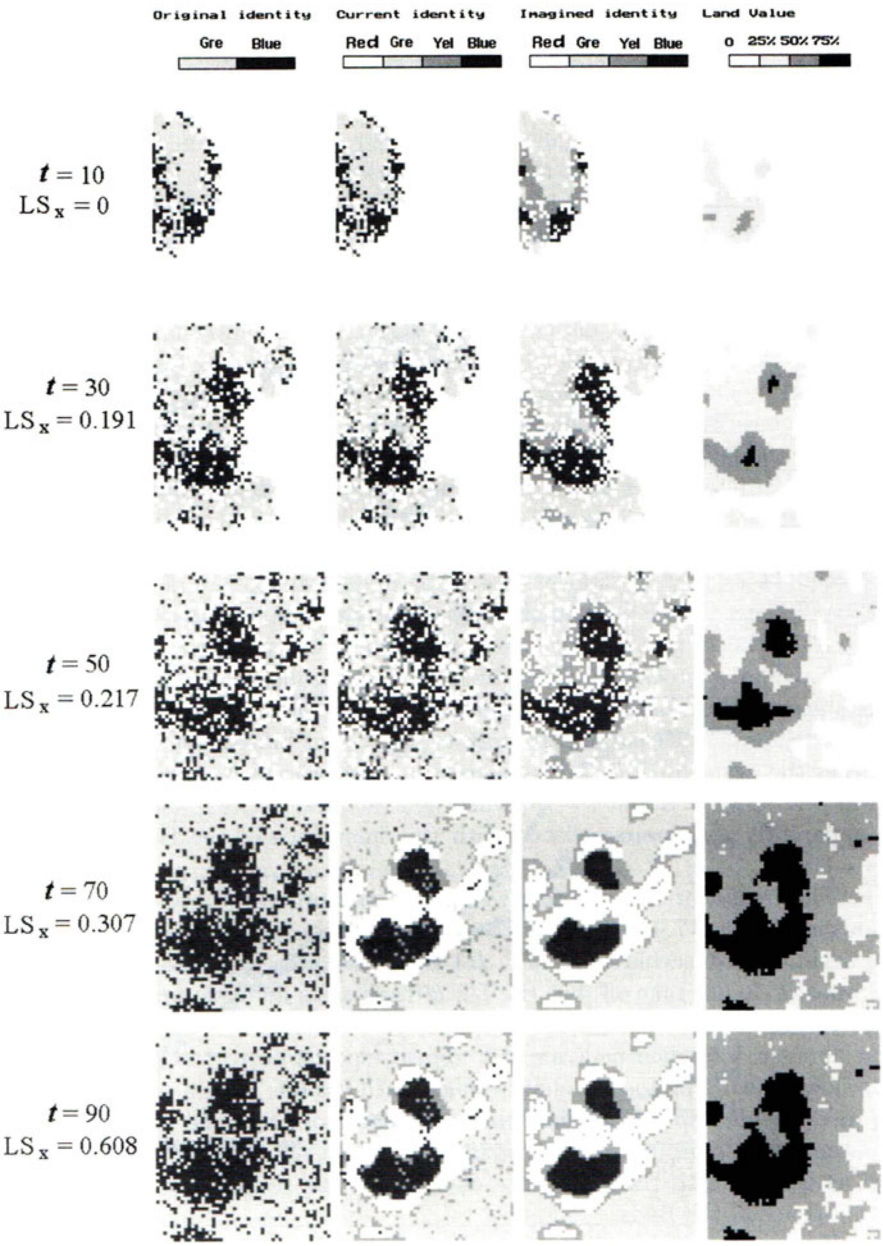

Fig. 17.3 Several snapshots illustrating the impact of spatial cognitive dissonance on the evolution of a FACS city. Green, Blue, and Red are three cultural groups; Yellow symbolized Green and Blue neutrals
Source: Portugali 2000, Fig. 7.7

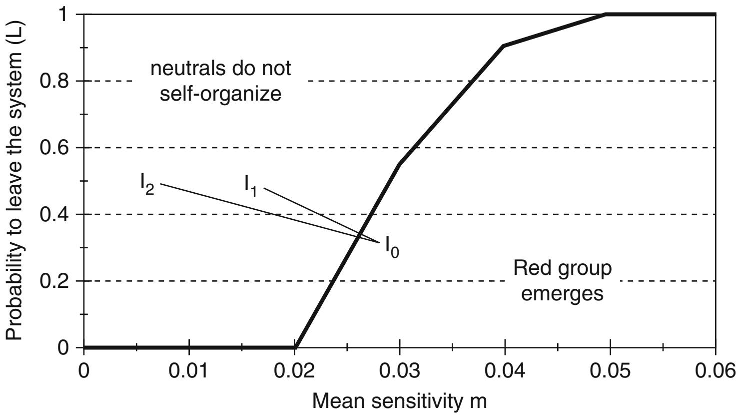

Fig. 17.4 A phase-space of the probability of leaving the city and the mean sensitivity: The domain where Neutrals self-organize and transform into a new cultural group, Reds – and the domain where they do not.
Source: Portugali ibid Fig. 7.11

typical of many modern or rather postmodern cities. It is specifically typical of cities that in recent decades have become subject to fast population growth and spatial expansion due to internal migration and international labour migration. Such cities have become multi-cultural and their spatial structure a mosaic of different socio-cultural relatively homogeneous areas. Some of these spatio-cultural areas are occupied by old cultural groups (little Italy, China town) while others by groups that emerge out of the very dynamics of the city. As already noted in the previous section, urban areas of high spatial cognitive dissonance correspond to areas of high instability or chaos – a property that gives the notion of chaos in the city a new spatial and socio-cultural interpretation and dimension.

17.4 Memes-Derived USM

The central aim of a cognitive approach to USM is to capture the nature of the city as a dual self-organizing system, that is, the property by which the city as a whole is a complex system and each of its individual urban agents is a complex self-organizing system, too. In the previous section that was the first step toward such an USM, the complexity of the agents showed up in their ability to undergo identity change. We've seen how the complex process of cognitive dissonance at the level of individual agents, in conjunction with the urban dynamics, gives rise to two phase transitions: at the local scale to the agent's change of identity, while at the global scale to the emergence of a new cultural group in the city.

In the above model, agents were still somewhat "simple" in the sense that they came to the city with a rather fixed identity – Green and/or Blue. In the model presented below we increase the complexity of agents in the sense that now they do not come to the city with fixed identities but rather with a potential. That is, with a set of properties that in conjunction with the global dynamics of the city participate in two phase transitions: one at the global scale – the emergence of a new cultural group; and one at the local individual scale – the process by which urban agents acquire their cultural identity (that at a later stage might change as a consequence of cognitive dissonance as above).

It is important to note, firstly, that in this new exposition the individual and the collective phase transitions emerge directly from the very urban dynamics without the intervention of a driving force such as cognitive dissonance. Secondly, that the previous model of spatial cognitive dissonance is a special case of this more general memes derived urban simulation model.

There are two main sources of inspiration for this new model: the first is the notion of the *genetic code*, while the second is Dawkins' suggestions regarding his notions of *memes* and *extended phenotype* as interpreted in SIRN proposition five (Chap. 7).

17.4.1 The Genetic Code Metaphor

From genetics we learn that each human individual enters the world with an inherited genetic code, which affects, among other things, a person's potential to behave and interact with other individuals. Taking the genetic code as a metaphor we suggest, first, that each individual agent is defined by, and thus comes to the city with, a personal *cultural code*, reminiscent in its properties to a *genetic code*. Second, that the cultural code defines the potential of that individual to interact with other individuals and locations in the city, and in the process give rise to two phase transitions: one at the level of the individual agent by which its cultural identity in the city is created, and another at the level of the city as a whole by which a new cultural group in the city is created.

17.4.2 Memes and the Extended Phenotype

The metaphoric connection between genes and socio-cultural traits that we propose here is not new and was discussed above in the SIRN proposition five of Chap. 7. As noted there, a rather amplified voice is Dawkins (1976) in his *The Selfish Gene*. The central thesis of this "gene-eye-view" on nature and evolution is that at the core of Darwinian evolution stand not whole animals, which are usually selfish but sometimes also altruistic, but the genes. According to Dawkins, the latter are the only biological entities that always tend to replicate themselves and as such are genuinely "selfish". "Selfish genes" do not interact directly with each other, however, but indirectly through their phenotypes. In a second book – *The Extended Phenotype* – Dawkins (1982) further suggests that, regarding animals, the notion phenotype should include in addition to the immediate bodily properties, also some of their products such as the bird's nest, the beaver's dam and the spider's web.

Towards the end of his *Selfish Gene*, Dawkins speculates with the idea that Darwin's theory of biological evolution enfolds the principle for a general theory of evolution, biological or otherwise. The fundamental evolutionary principle as he writes, is

> *. . . that all life evolves by the differential survival of replicating entities. The gene, the DNA molecule, happens to be the replicating entity that prevails on our own planet. There may be others. If there are, provided certain other conditions are met, they will almost inevitably tend to become the basis for an evolutionary process* (Dawkins 1986, p 192).

Are there such new replicators? Yes, answers Dawkins, "a new kind of replicator has recently emerged . . . still in its infancy" (ibid), it is the *meme* – the replicator at the core of human cultural evolution. The memes are new replicators that only recently have appeared on the stage of the world, as a by-product of biological evolution, and are already moving fast with their own independent evolutionary process.

Examining the various examples of Dawkins' memes, it can be seen that they are, in fact, concepts, categories, cultural traits, schemata, generally held ideas, and the like. Common to all those entities and notions is that they are all public – all were selected and accepted by culture or society. The latter implies that in order to qualify as a meme, a personal idea, trait etc. must "go public" – it must be publicly and culturally accepted. A case in point is the notion "meme" which was originally Dawkins' personal idea, has proved to be culturally very successful and became itself a meme: it has invaded many brains and has resided there as an internal representation, has invaded the *New Oxford English Dictionary* and has resided there as an external representation; so much so that today we have a whole research domain of *Memetics* (Heylighen and Chielens 2009).

Dawkins' meme and extended phenotype were subject to an enthusiastic re-interpretation by Dennett (1991) in his book *Consciousness Explained* (see also Dennett 1995). Dennett's main concern in this book is consciousness, but in the way to explain it, he elaborates also on the meaning of the *Self*. According to Dennett the *Self* is the *Homo sapiens*' center of gravity of its extended phenotype. Like the individual spiders who protect themselves by making a web, we humans create a *Self*:

> *Out of the brain it (the Homo sapiens) spins a web . . . this web protects it [the person].. stripped of it, an individual human being is as incomplete as a bird without its feathers, a turtle without its shell* (Dennett 1991, p 416).

Each person thus builds a web, which is the person's cultural and social extended phenotype. This web, then, becomes the medium through which the memes that have invaded and occupied that person's brain externalize themselves in public. Writing from the perspective of our FACS-SIRN cities, I've suggested adding two points to Dennett's *Self*. First, that internal and external representations (mimetic, lexical and artificial) are part of humans' extended phenotype, and as such part of the web that defines the human *Self*. Second, that the innermost intimate element of humans – the one that makes the *Self* of each of us, is defined by means of our extended phenotype. That is to say, by means of our interaction with the environment around us, which includes our clothes, cars, houses, friends, neighbors, the neighborhoods we live in, our cities, countries . . . (Portugali 2000, Chaps. 2, 3, 14 and Chap. 7 above). And so, a typical answer to the question ‘who are you?’ or ‘what is your identity?’, might be, ‘I’m an Israeli’, ‘Parisian’, ‘New-Yorker’, ‘citizen of the world’, etc. My/Your individuality is defined by means of your connection to the world.

The preliminary theory and model proposed here provides a conjunction between, on the one hand, our SIRN approach to the city, and on the other, Dawkins’ and Dennett’s memes, extended phenotype, and *Self*. The process modeled below starts with a set of concepts, categories, cultural traits, schemata, generally held ideas, in short, memes, internally represented in an agent’s memory and defining its *Self*, that is to say, its personal-cultural identity. This set is termed *memetic*- or *m-code*. In the model, these personal memes do not interact directly, but only indirectly through the interactions between the agents who carry them. In the model these are the interactions between the free urban agents in their attempt to find an appropriate house in the city. These interactions give rise to urban cultural groups, which are groups of agents with identical or similar m-codes (see discussion below). Each group can thus be also defined by its *collective m-code*. This grouping process is the mechanism through which memes are environmentally selected, or in other words, ‘replicate themselves’. This is so because when an agent becomes a member of a cultural group, the memes that compose its m-code, enter the group’s m-code (or pool of memes). If, on the other hand, the agent lives in a “foreign” neighborhood, it might either preserve its previous m-code (Self), or else acquire a new one – for example, by means of the process of spatial cognitive dissonance discussed above.

The notion of m-code thus tells us how cultural groups are determined as a result of the interplay between m-codes and the dynamic of the city. The next question is: once created, how change can still take place? In what follows it is shown that the same urban dynamics that gave rise to a certain memetic/cultural configuration of the city can once again bring change. More specifically, that in certain circumstances the dynamics of the city involves the synergetic process of enslavement (see definition above) by which, in the first stage, urban agents are enslaved by the emerging structure of the city in the sense that they change their identity and in the second, this personal change feeds back to the global structure and dynamics of the city. The general question here concerns morphogenesis: the way a new spatial socio-cultural entity is born. The answer to this question takes us back to the process of cognitive dissonance discussed above: Namely, that the process of spatial cognitive dissonance in the city is a special property of the m-codes in the city.

17.4.3 The Model

Computationally, this model is built in line with the FACS (Free Agents on a Cellular Space) models as the previous one. However, the model presented below differs from standard CA/AB USM in two respects. First, it is a SIRN model in two of its aspects: The aspect by which the interaction between the agents gives rise to a global city that then shape/transform the properties of the agents and so on in circular causality; and the aspect by which agents' properties are being transformed by means of an interplay between their internal representation and the externally represented environment. Second, the model differs from standard USM in its definition of the cultural identity of the agents – this is the novel feature of this model. That is to say, in the model the cultural groups are not pre-determined, but from the start of the game they emerge out of the dynamics that takes place in the city.

17.4.4 The Definition of the m-Code

In genetics, as well in studies of artificial life, it is common to represent the individual's genotype by means of a high-dimensional binary vector (Banzhaf 1994). In the present model the mcode of an individual agent is defined in the same way. An important property of the agents in this model is that each is an adaptive self-organizing system in the sense that it can change itself in line with the dynamics and evolution of the system it belongs to. That is to say, the m-code of an agent and its residential behavior can change through its interaction with its (externally represented) nearest neighbors, neighborhood, and/or the city as a whole.

17.4.5 Cultural Groups

The definition of cultural groups in the model is inspired by the cognitive discourse on categorization as elaborated in Chap. 10 above with respect to cities. From the latter follows three kinds of categories: classical categories, family resemblance categories and family resemblance with prototype categories. Taken in conjunction with the definition of individuals' m-codes as above, there are four basic ways to derive cultural groups. One is to say that similarly to a classical category, a cultural group is a collection of individuals with *identical* cultural codes. Second, to say that it is a collection of individuals with similar cultural codes. Third is to say that a cultural group is a collection of individuals with m-codes that form a family resemblance network, and fourth, with prototypical family resemblance as their grouping process. These four ways refer to four grouping principles, which might be termed the *identity, similarity, family-resemblance* and *prototypical family-resemblance* principles.

For simplicity, the illustrative examples below refer only to the first grouping principle according to which there can be a maximum of $\mathbf{2^K}$ different cultural identities in the city, when K describes the dimension of each urban agent's **A** m-code. Thus, $K = 1$ refers to a situation by which the m-code is defined by one property and there can be two cultural groups in the city, $K = 2$ refers to a case where the m-code is defined by two properties and there can be four cultural groups and so on. In the case of the other grouping principles, the number and nature of the groups depend on the specific similarity measure according to which individuals can join the group.

17.4.6 Local and Global Information

In the model, agents take decision in line with a conjunction between the local and global information they face, when *local information* refers to the (externally represented) properties (e.g., cultural m-codes) of an agent's nearest neighbors, whereas *global information* to the (externally represented) properties of the city as a whole. Local cultural information is related to the notion of *local spatial cognitive dissonance* of free agents as discussed above. Applying this notion to the multidimensional m-codes of agents, we define local spatial cognitive dissonance of agent **A**, occupying house $\mathbf{H_{ij}}$, as an average of the differences between **A**'s identity and the identities of its nearest neighbors.

The role of global information is treated in the same way: If individuals similar to **A** in their m-codes are spatially segregated in the city then, beyond a certain threshold their spatial distribution might affect the behavior of **A**. For this purpose we define the *global cultural information* available (or, afforded) to agent **A**, about residential segregation of individual agents of identity $\mathbf{C_A}$.

Local and global information influence the agent's cultural identity in opposing ways. High local cognitive dissonance might push agent **A** *to change* its (internally represented) cultural identity, whereas high global level of segregation of individual agents of identity $\mathbf{C_A}$, pushes **A** to preserve its current identity. The change in an agent's cultural identity thus depends on these two opposing tendencies. The cultural identity of an agent **A** can be changed when the local tendency to change an identity exceeds the global tendency to preserve it.

17.4.7 Some Results

Given the above considerations it is now possible to examine the spatial process of socio-cultural emergence in the city, when the urban agents vary in their m-codes and when in order to qualify as a newly emerging socio-cultural entity, the individual members of the group must fulfill three conditions simultaneously: At the individual level the members of the group must have the same cultural identity, at the local level most of the group members should be located within neighborhoods of their own, and at the global level the number of group members in the city and their spatial segregation have to be sufficiently high.

Figure 17.5 shows three different cultural landscapes of the evolving City model with three different m-codes, after some 500 iterations. In order to represent the

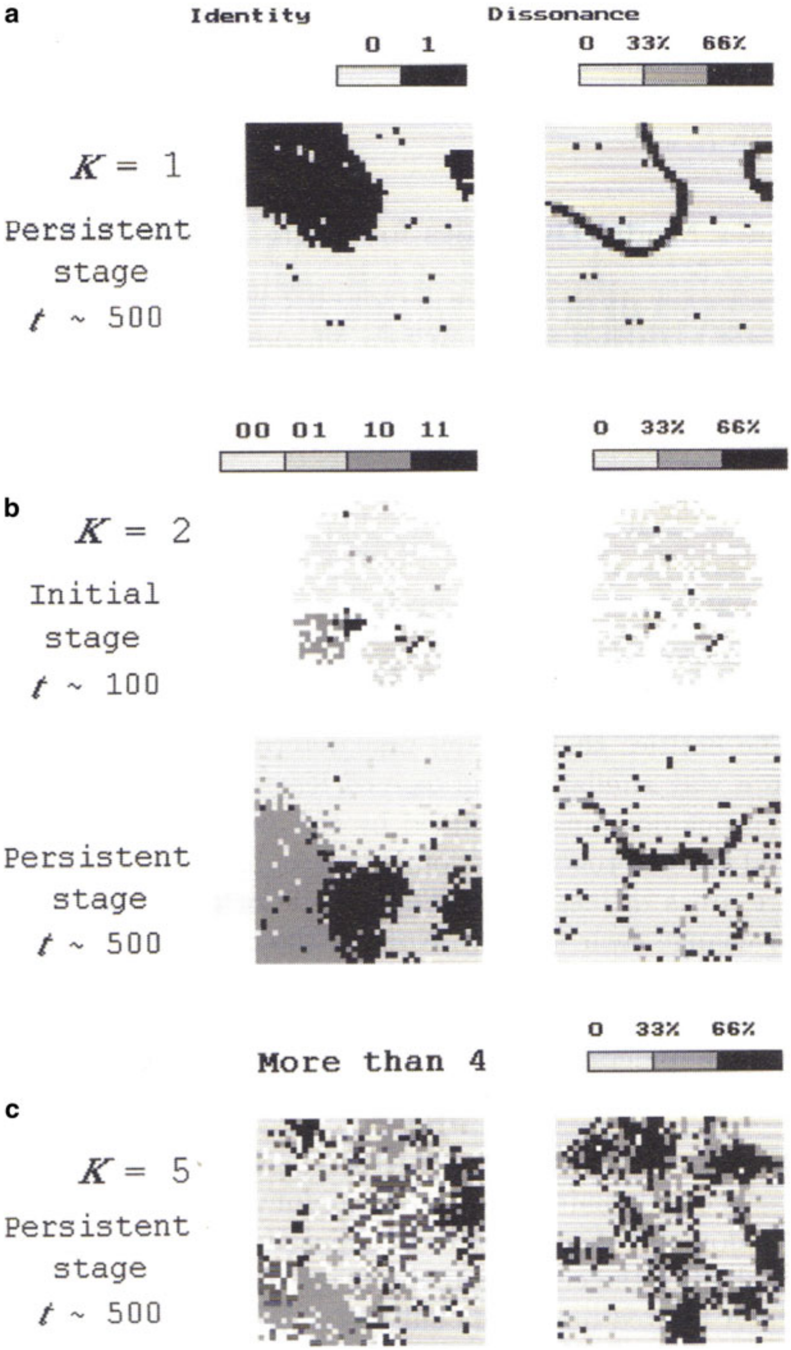

Fig. 17.5 Three different cultural landscapes of the memes-derived urban simulation model, after some 500 iterations with three different definitions of the m-code: **(a)** in the first scenario $K = 1$, **(b)** in the second $K = 2$, **(c)** and in the third $K = 5$

changing properties of the city we use below two kinds of maps. First, as in the previous model, we have here a map showing the distribution of agents' cultural identity, with each identity marked by its own color. This presentation is the most detailed one, but because of the high number and nonlinear ordering of identities, it cannot be constructed for m-codes of more than two traits ($K > 2$). The second map shows the spatial distribution of cultural cognitive dissonance of residents. This map is a surrogate to the Stability-Instability Surface (SIS) discussed in Chap. 4, Fig. 4.22. As in Fig. 4.22 here too, the higher the dissonance is, the higher is the chance that the state of a given house will change.

17.4.8 Model Dynamics for Low-Dimensional Cultural Identity: $K = 1$ and $K = 2$

The case of $K = 1$ (Fig. 17.5a) corresponds to our previous analysis of residential segregation between two cultural groups (Chap. 4, Fig. 4.21). The city dynamics in that case entailed a fast self-organization of two identities in two or several segregated patches. The boundaries between the homogeneous patches are the areas of instability/chaos, characterized by high cognitive dissonance and as a consequence intensive exchange of individuals.

When K equals two (Fig. 17.5b), the number of possible identities is four. The city in this case evolved in two steps: At the initial iterations of the simulation the evolving city still resembles some of the previous model results with two cultural groups. However, in the long run (we stopped the simulations at $t = 2500$) the number of socio-cultural entities, existing simultaneously in the city fluctuates between three and four, and the life span of the entities is of the order of 500 iterations. Let us now skip the intermediate cases of K equals 3 and 4, and proceed with $K = 5$.

The number of possible identities for this case is $2^5 = 32$. However, as in the previous simulation, here too, the city evolves in two phases (Figs. 17.5c and 17.6): At the beginning of the simulation some 2 to 4 cultural groups emerge (we run the model five times). But then there is a phase transition (at iterations 150–200) and the number of cultural groups jumps to a higher level in which it fluctuates in a steady state at a level of 10 to 15 groups. In terms of synergetics we would say that from iteration 200 onwards (until iteration 2500), the city was dominated by an order parameter that kept its number of cultural groups and personal identities in between 10 and 15. A mixture of homogeneous spatial domains, the population of which forms distinct socio-cultural entities, and domains that are heterogeneous at different levels, thus characterized the city's cultural landscape during this long period.

Note, first, that while the number of possible identities of $K = 5$ is 32, this potential number was never realized (Fig. 17.6). This is due to the city dynamics, namely, the conjunction between the grouping principles and the specific properties

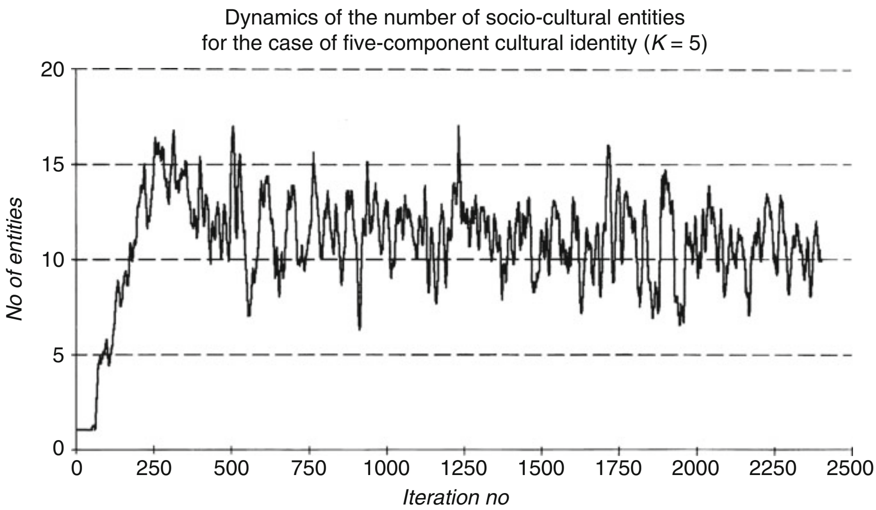

Fig. 17.6 The dynamics of the number of cultural identity in the memes-derived urban simulation model for a $K = 5$ m-code

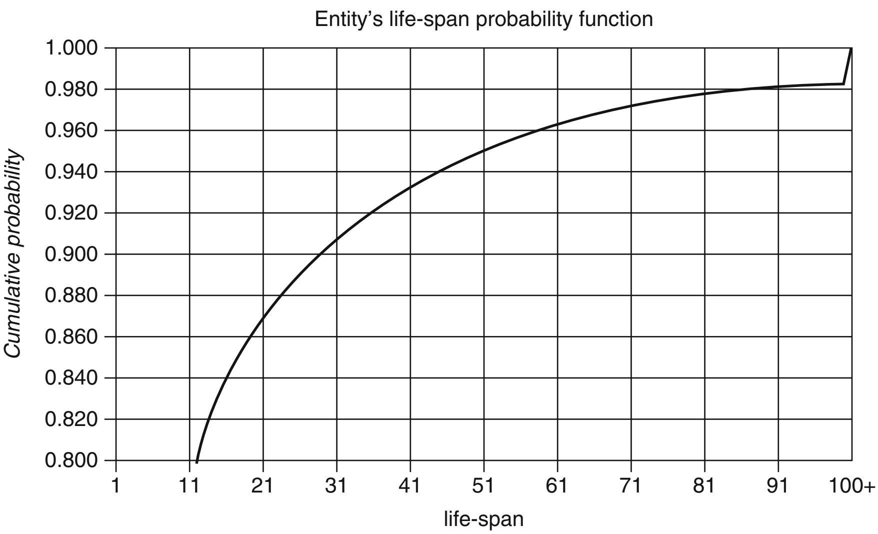

Fig. 17.7 The lifespan probability of cultural entities (groups) in the evolving memes-derived urban simulation model

of the city (e.g., the fact that its size and form were kept fixed during the simulation). Second, that the life span of the various socio-cultural entities in the city is finite so that the entities replace each other in the city space (Fig. 17.7). About 20% of the entities persist in the city for 11 iterations or longer and 10% persist for 25 iterations or longer.

17.5 Concluding Notes

The two models revisited in this chapter refer to an urban reality that is too often overlooked. Namely, they show that the city is not just an empty container in which other social, cultural and political processes take place, but a social force in itself. That is to say, a force that participates in the spatio-cultural processes by which collective and personal identities of individuals and groups are determined. In the first model we could see a process that starts when two cultural groups come to a city and then, out of the city dynamics, a third group is emerging. The second model simulated a scenario by which agents arrive to the city with their own personal properties and it is here in the city and out of its dynamics that their personal and group identities are determined. Such processes were typical of the urban dynamics of many countries that were subject to mass migration throughout the 20th century (USA, Canada, Israel ...) and they are still typical today, in the 21st century, in countries that are subject to massive labor migration.

As could be seen, at the core of the above two models stand the SIRN process with its sequential play between internal and external representations. However, in the above two model the SIRN dynamics is somewhat implicit; in fact, the aim of revisiting the two models was to explicate their SIRN nature. The model that is presented in the next chapter was designed from the start as a cognitive SIRN USM.