Studies in the Philosophy of Sociality 3

Virginia Dignum
Frank Dignum *Editors*

Perspectives on Culture and Agent-based Simulations

Integrating Cultures

Springer

Perspectives on Culture and Agent-based Simulations

Studies in the Philosophy of Sociality

Volume 3

For further volumes:
http://www.springer.com/series/10961

Virginia Dignum • Frank Dignum
Editors

Perspectives on Culture and Agent-based Simulations

Integrating Cultures

Springer

Editors
Virginia Dignum
Delft University of Technology
Delft, Zuid-Holland
The Netherlands

Frank Dignum
Department of Information and Computing
Universiteit Utrecht
Utrecht, The Netherlands

ISBN 978-3-319-01951-2 ISBN 978-3-319-01952-9 (eBook)
DOI 10.1007/978-3-319-01952-9
Springer Cham Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013953721

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

Chapter 1
Integrating Cultures: An Introduction

Frank Dignum and Virginia Dignum

In Sociology, the concept of formal model of culture refers to "an output from a quantitative study of collected data that seeks to describe, explain, interpret, or otherwise represent some feature, aspect, or content of culture. As a model, the output has been transformed into a summary or a representation (in reduced form) of the data that purports to be analogous (in some fashion) to the phenomena under consideration" (Mohr and Rawlings 2010). However, different disciplines in the Social Sciences take a very different approach to culture and to its influence in social behaviour. Thus it is difficult to compare and integrate the different models that are used in social science. It is also not easily possible to establish a reference model to which all the other models can be compared, because the requirements for such a reference model are very diverse, not precise and not agreed upon. Besides that the concept of culture is very abstract and vague and thus it will be impossible to give a model containing all relevant concepts (an ontology) explaining all possible relations and influences culture has on society. Therefore we advocate a more limited approach in this volume.

The aim of this volume is to analyse, from a *computational* point of view, how culture may arise, develop and evolve through time. As described in the different chapters, computational models of culture enable to represent and reason about different, possibly conflicting, social norms and practices arising from different cultures. This computational perspective enables to integrate concepts that play a role in culture but that originate from different research areas that study culture.

F. Dignum
Department of Information and Computing Sciences, Universiteit Utrecht, Princetonplein 5 De Uithof, 3584 CC, Utrecht, The Netherlands
e-mail: F.P.M.Dignum@uu.nl

V. Dignum (✉)
Faculty of Technology Policy and Management, Delft University of Technology, Jaffalaan 5, 2628 BX Delft, Zuid-Holland, The Netherlands
e-mail: m.v.dignum@tudelft.nl

V. Dignum and F. Dignum (eds.), *Perspectives on Culture and Agent-based Simulations*, Studies in the Philosophy of Sociality 3, DOI 10.1007/978-3-319-01952-9_1,

This collection has its origin in a conference in 2010 at the Lorentz center in Leiden, the Netherlands and contains a careful selection of the papers submitted afterwards. During that meeting the role of culture in computer-based systems and virtual environments was discussed in a multi-disciplinary environment with presentations by many leading researchers on the topic from both the Social Sciences and Computer Science. Evidently, the topic is challenging. Culture is usually regarded as something vague and qualitative and perhaps the least appropriate to deal with in a computational and formal setting. Although there are some theories that make "culture" more structured and measurable, notably the famous Hofstede framework, culture in general is something that within social science is related to almost anything, for instance, religious practices, national identity, habits and customs, art and technology and social relations.

Addressing culture from a computational point of view has a twofold risk: on the one hand, the risk of reductionism, that is taking a too simplistic approach to cultural influence on behaviour; on the other hand, the risk of trying to capture too much, hence not leading to useful computational tools. The contributors to this volume are sharply aware of these risks. Their approaches and insights taken collectively show different perspectives on the potential of cultural aspects to the development of better applications and to the use of computing systems to better understand culture.

1.1 Introduction: Culture?

The term culture in its original use comes from Cicero when he talked about "cultura animi" with which he denoted the improvement of the soul. Thus the connection with the biological (or agricultural) sense of culture lays in the idea of improving (or cultivating) something. In the eighteenth and nineteenth century the term culture started to be used more in the sense that we think about it nowadays. It is seen as the range of human phenomena that cannot be attributed to genetic inheritance. In anthropology culture becomes the human capacity to classify and represent experiences with symbols and to act creatively. The symbols and results of creative activities can be material such as paintings, fashion and buildings, but also intangible such as language, music and customs.

Although the above description of the concept "culture" is still quite vague we can already see several aspects that play a role in studying culture. One of these aspects is the creative process of producing symbols to represent experiences. This usually is studied in the arts. A second aspect is the differences in culture between different parts of the world (or in general between different groups of people). What are those differences, how do they influence the people, how are they perpetuated and transmitted? These are issues related to anthropology and social science in general. It is clear that the study of culture should be an interdisciplinary study as it spans many different aspects related to how people function in a society. However,

how culture is defined depends largely on the perspective that one takes and which highlights certain aspects of culture. For arts culture is related to the expression of experiences through symbols. For sociology culture might be seen as influencing social relations (like power) or as means to create a group identity.

One of the problems of precisely defining culture stems from the fact that culture in one hand is a human created phenomenon, starting from individuals, but in the other hand transcends the individuals and influences their behaviour (sometimes unconscious). This feedback of individuals to culture and back to individuals creates many complex relations and questions about purpose, origin, function and goal of culture. Moreover it makes it difficult to start with a number of basic (generally accepted) assumptions from which a general theory or model for culture can be created. Thus we will not attempt to perform this huge task within this introduction, but will limit ourselves to a more manageable pragmatic approach. We will indicate how computational models can support the comprehension of culture by creating simulations that show how societies evolve based on certain assumptions on the way culture influences behaviour. In the other hand we also need to be conscious of how our culture influences the design of computational systems. Our culture influences the way we perceive problems and their solutions with computational systems and thus which systems we create. Given these more practical issues that are studied in this volume we will in the next section describe some concepts that play an important role in our conception of culture.

1.2 What Is Culture?

Probably the most influential work trying to characterize culture is done by Hofstede (2001). Rather than actually trying to define culture in terms of other concepts this work tries to characterize culture through different dimensions of influence of culture on societies. Based on questionnaires taken in different countries about behaviour in social situations some consistent differences in the answers led to the abstraction of a number of cultural dimensions. All countries can now be given a score on each cultural dimension based on repeated questionnaires. Thus the dimensions are empirically derived. Using the cultural dimensions gives handles to explain the different type of behavioural patterns and reactions to (new) situations in different countries. Thus they form a very useful tool to study the influence of culture on societal behaviour.
The following five dimensions are distinguished by Hofstede:

- Power distance (PDI),
- Individualism (IDV),
- Masculinity/femininity (MAS),
- Uncertainty avoidance (UAI),
- Long-term orientation (LTO)

Power distance influences the expectation and importance given to power statuses. People in power positions are expected to set out directions and subordinates to obey and not take initiatives. For example: China, Russia (high PDI) opposed to Scandinavian countries (low PDI).

Individualism influences the definition of individual identity. The lower the IDV, the more one individual's identity is linked to his or her social context (e.g. relatives, colleagues). Thus, one's individual goals and actions (and the claim for this action) are more or less linked to him/herself or to his/her context. This context leads to a collective image that has to be preserved (helping each other, hiding errors, rejecting outsiders). Conversely, in high IDV cultures, individuals expect a treatment independent of any context. For example: USA, Great Britain (high IDV) opposed to South American countries (low IDV).

Masculinity indicates preferences on assertiveness, toughness, focus on performance and material success. Good performance should be recognized and rewarded, leading to competition. Conversely, low MAS cultures favour modesty, tenderness and high quality of life. Interactions focus on building cooperation and establishing consensus. For example: Scandinavian countries (low MAS) versus Japan, Italy (high MAS).

Uncertainty avoidance favours the desire for clear and explicit situations with predictable outcomes. This desire leads to establishment of rules (formal or not), making everything explicit with low ambiguity. Conversely, individuals with low UAI culture dislike the presence of rules. They tend to accept more easily situations with unspecified behaviour or unclear outcome. For example: Greece, Japan (high UAI) versus Sweden, China (low UAI).

Long-term orientation influences the time span considered when taking decisions. In high LTO culture, rewards can be sacrificed for better ones later, relationships are built on long-lasting trust and rules are flexible. Conversely, individuals in low LTO culture focus on immediate success, avoiding failure and decisions rely on dogmatic rules (e.g. total commitment, best profit commitment). For example: Extreme-Asian countries (high LTO) versus Canada, Great Britain (low LTO).

The above indicates more or less how the different cultural dimensions relate to different tendencies of behaviour. However, the dimensions do not explain why these influences work in a certain way. The closest Hofstede gets to giving a model of culture is by stating that culture is in the end based on value systems (that are shared by groups of people) and expressed in practices (rituals, norms, etc.) and symbols.

We concur that value systems can be seen as the basic drives for human behaviour (besides the biological drives). Thus in some way they will always consciously or subconsciously influence the decisions of individuals. When value systems are somehow synchronized within a group of people then their behaviour will also be similar in similar situations (note that we are not claiming that behaviour is identical, just similar). In order to facilitate the synchronization of behaviour groups will use rituals, norms and symbols that are shared between all people in the group and can thus easily be used to refer to certain value-based decisions.

Taking values and practices as the main features of culture also helps understanding how notions such as "organizational culture", "youth culture" and "subculture" relate to society culture. In each of these cases the practices that are used within the group are shared and meant to distinguish the particular group from other groups. There are also shared values, but these do not have to pertain to all facets of life, but can be confined to the part of life with which the group is concerned. Thus organizational culture is built on values that relate to how the business wants to function and be perceived. Secondly, people are not only part of an organization, but also member of other groups and the society at large. Thus they will not completely assimilate all practices and values (or only for tasks within the working context). In the case of youth culture the assimilation is bound to a certain period of life and thus also less seen as absolute. Consequence of these points is that these cultures are less pervasive and stable than society culture, but they do contain the same elements.

In the following section we will explore how culture is influencing the modelling and design of computational systems and how computational simulations can help understand culture.

1.3 Culture and Computation

The meeting of computational methods and the scientific study of culture has so far been lacking. Obviously "culture" is a theoretical term that is common to many sub-disciplines in the social sciences. However, given the lack of a common methodological framework in the social sciences, different traditions adopt a concept of "culture" that is often not compatible with the concept employed by others. Moreover, informal approaches to "culture" are unclear in their consequences and implications. Although it is not clear how a scientific approach should look like that integrated the cultural concept in the design methodology of computational systems it is clear that culture has a large impact on how systems should be designed and used. Let us just give a few anecdotal examples to make the scope of this claim clear.

Nowadays it becomes very easy to maintain and access large amounts of data locally. Within companies this leads to systems that keep track of the status of all kinds of processes and in which employees might find all kinds of information to support their task and to solve potential problems. However, storing all this information and making all this information available for all levels in the company can lead to a lot of resentment within management in high power distance cultures. In these cultures managers might feel that decisions that they are responsible for are now taken at a lower level and bypassing them, therewith threatening their status and power position. It might also lead to the fact that employees do not use the system, because they do not want to be responsible for taking the decisions. Thus the system would not render the benefits that were expected, due to the cultural biases.

In a similar way, systems that are based on argument based resolution of conflicts or systems based on individual utilities in order to coordinate tasks will function different in collectivistic and individualistic societies. Thus even the solution principles might be based on cultural biases that lead to very specific types of solutions that not necessarily work properly in other cultures. It is clear that designers should be aware of these cultural biases, especially in a world where systems are functioning world wide in many different cultures.

Of course, we could also see how computational systems help to understand culture. In particular agent based social simulation seems an interesting direction to explore the development of culture in different contexts and how different cultures can change the behaviour of a society (and e.g. its response to a new situation). Already some work has been done by Axelrod (1997) on simulations that indicate how culture disseminates and can lead to clustering behaviour. Although this work is a good starting point it illustrates nicely that the properties of culture are hidden in the functions that determine how people with different cultures mix or avoid each other. In the end culture is treated as an abstract array of features (without names) and people interact based on the similarity or difference of these arrays. Thus the fact that these arrays represent cultures is completely based on interpretation of the reader and not on any intrinsic property of the features listed in that array. On the other hand is must be said that simulations that give most insights are based on very simple principles. The interesting results come from the emerging properties from the individual interactions. Thus there is a fine balance between having too simple simulations that require immense interpretations in order to draw conclusions and very rich simulations for which so many parameters have to be set that results seem to depend on the particular parameter values. In this volume we will not solve this issue, but it includes some examples of simulations that illustrate well the state of the art and probably are starting points for further research.

When investigating the influence of culture on individual behaviour there is also possible support from computational systems. In specific agent systems seem to provide a nice basis for supporting simulations of culturally influenced behaviour. Of course, this more detailed issue has to be studied with agents that have some rules of behaviour that depend on their culture. Again one can take several approaches. One approach is to take something like the cultural dimensions of Hofstede and take the score on each dimension as the value of a parameter that influences individual decision making. It is possible to replicate culturally biased behaviour in this way by choosing the way the cultural parameters are linked to the other decision parameters carefully. However, this approach does not yet explain why people are influenced in this way. In order to answer that question more rich cognitive models are needed. These models should represent some aspects of culture and link those aspects to other factors that influence the decisions of agents (such as desires, goals, needs, etc.). There is some work done in e.g. Dechesne et al. (2013) and Mc Breen et al. (2011), but this is just the beginning of the research in this area. Some work in this volume on modelling culture could probably be used in this research, but is not in a stage yet where it could be directly implemented in the agents.

1.4 Organisation of This Volume

The chapters in this volume take different approaches to culture and can be classified along several dimensions. Together, the collection of chapters combines rigour and relevance. There is not one single simplified notion of culture, or an attempt to come to a narrow definition, but different papers address diverse aspects. Still, the coherence is high, as most of the papers focus on specific computational applications, thus demonstrating, by example, how culture can be dealt in agent systems.

Overall, this volume aims to provide an overview of the breadth and of this multidisciplinary research field, and to inspire both social and computational researchers, by describing methods, theories and concrete application results on the integration of cultural aspects into social simulations.

The first part of the volume focuses on Analysis and Modelling of Culture. The chapter "Modelling Culture with Complex, Multi-dimensional, Multi-agent Systems" by Morris, Ross, Hosseini, and Ulieru explores culture and cultural modelling from a complex systems, multi-dimensional, and multi-agency standpoint, presenting a seven-dimensional model to describe and encapsulate culture. The chapter introduces definitions, dimensions, and experiments that show the evolution and emergence of culture as a complex, distributed, social system from a computer science perspective. An extensive overview and discussion of the state of the art literature is provided. The model is used to simulate cultural interactions as a multi-agent system of high functioning agents that achieve an equilibrium of beliefs.

The chapter "Cross-Validation of Gaming Simulation and Multi-agent Simulation" by Hofstede, Jonker, and Verwaart proposes a method combining gaming and multi-agent simulation for the formulation of theories underlying trade network processes based on Hofstede's cultural dimensions (Hofstede 2001). The chapter addresses validation this type of approaches, which typically remains a problematic issue in this type of research. Two important sources of difficulties are the sensitivity of gaming simulations to the participants' cultural background and the complexity of the agent model. The proposed method enables to compare the behaviours seen in the gaming simulation with the agent-based simulation, and supports the verification that relevant sub-models of the agent-based model are valid with respect to real human behaviour.

The paper "Modelling Culture Through Social Activities" by Fuentes, Gómez-Sanz, and Pavón introduces UML-AT, a modelling language for social systems based on Activity Theory (AT). This modelling language proposes Activity Theory (Leontiev 1978) as a means to support social scientists and computer researchers to better analyse and represent the abstract requirements and computational features of social models. This framework supports the development, validation and analysis of results simulation framework. To reduce the effort in modelling, it introduces the concept of social properties as reusable specification fragments with a behavioural and organizational meaning. The use of the modelling language is exemplified by applying it to a "marital counselling" case.

The second part comprises chapters describing work on Group and Organization Culture. The chapter "Cultural Integration and Differentiation in Groups and Organisations" by Mäs, Flache, and Kitts discusses group formation and the conditions under which integration occurs. Using computational experiments, it is shown that different social forces lead to different patterns of polarization, radicalisation, and factionalism. By means of simulation, experiments are set to compare the strength and the effect of various social mechanisms, such as homophily and distancing. The focus of the chapter is on cultural homogeneity rather than cultural differences.

The paper "Modelling and Analysis of Safety Culture of Air Traffic Organizations in the National Culture Context" by Sharpanskykh and Stroeve focus on safety culture in organisations, including air traffic management, power plant control and healthcare. The authors propose an approach to systematically develop models that account for a large variety of organizational aspects, thus providing a different and structured view on safety culture from the perspective of the formal organization in relation with the variable behaviour of agents in it. The Hofstede's framework (Hofstede 2001) is applied to the problem of increasing safety in the air traffic organizations. Simulation results show how different safety measures have different effects, depending on cultural parameters.

The last paper in this part, "Monolingual Biases in Simulations of Cultural Transmission" by Roberts challenges an often-made assumption in language acquisition and uses simulation in a skilful way. It concludes that complex cultural phenomena, such as bilingualism, do not necessarily result from complex individual learning mechanisms, but much of the complexity in cultural phenomena stem from complex interactions between individuals. That is, the cultural transmission process itself can shape and influence the cultural practices it transmits.

Culture Simulation is the subject of the third part of this volume. Chapters in this part describe the use of simulation to analyse diffusion, cultural reproduction and social evolution. The paper "Towards Agent-Based Models of Cultural Dynamics: A Case of Stereotypes" by Pfau, Kashima, and Sonenberg analyse from a semi-formal perspective, the grounding model of cultural transmission, a social psychological theory that emphasizes the role of everyday joint activities in the transmission of cultural information. Their model postulates that cultural transmission happens during dialogue incidental to everyday joint activities, when interlocutors align their beliefs to a degree sufficient to carry out their joint activity. The model is based on intelligent agent research to explicate the link between agents' joint activities and the grounding process that is entailed by their task-oriented communication.

The paper "Matching and Mismatching Social Contexts" by Edmonds stresses the notion of context and context-dependence. Social Contexts are defined as specific types of recognised social situation for which specific norms, habits, rules, etc. are developed over time. The author explores the implications of social context to the problem of integrating cultures. The mapping of social contexts in different cultures greatly influences both the outcomes of meeting cultures and the steps that might be taken to facilitate their integration. That is culture is structured in a fundamental manner by social context. The chapter "The Role of Stability in Cultural Evolution: Innovation and Conformity in Implicit Knowledge Discovery"

by Bryson discusses the role and sources of innovation in generating culture, and also the role of norms in preserving it. It presents a conceptual approach relevant to culture research, as it explicitly addresses theoretical controversies in this area. In this chapter, simulation is used to test and discriminate hypotheses about social/cultural phenomena, rather than seeking applications.

Finally, the forth part focuses on Culture-Sensitive Technology Design. In the chapter "Socially-Oriented Requirements Engineering–Software Engineering Meets Ethnography" by Pedell, Miller, Vetere, Sterling, and Howard, a different view on culture is presented, that of social practice. The chapter outlines an approach for eliciting, understanding, and representing the cultural aspects of the domestic environment for the purpose of system design by using agent models as shared artefacts to represent the everyday cultural life of the home. Conclusions show that the approach described can assist ethnographers and software engineers in arriving at a shared understanding of social goals and the related interactions in a way that became useful in ongoing software development for the social domain.

The chapter "Cultural Broker Agents: A Framework for Managing Cultural Misunderstandings" by Gonzáles, Barthés, and Ramos presents a system intended at reducing the impacts of cultural differences in multi-cultural collaboration based on constructing quantifiable cultural profiles. The work is applied to the identification and management of conflicts in communication. The authors propose a platform based on cognitive agents for improving multicultural interactions. Agents manage cultural profiles and obtain contextual information about user interactions. The framework is based on a formalization of the Hofstede framework (Hofstede 2001) based on fuzzy logic.

The chapter "Culture Driven Game Design Method: Adapting Serious Games to the Players' culture" by Meershoek, Kortmann, Meijer, Subrahmanian, and Verbraeck clearly shows the relevance of culture in the design of serious games. When culture is not incorporated in the game design phase, it may still be discovered during the testing, but this may be too late. The paper suggests how this can be done differently and more efficiently.

1.5 Discussion

The contributions in this volume are a valuable contribution towards the understanding of culture and its relation to computational systems. The interdisciplinary nature of culture is reflected in the contributions which come from diverse disciplines and highlight different aspects of culture. They show how culture can be modelled from different perspectives, but also how culture influences models for computational systems. Given the complexity of culture we cannot hope to cover all aspects of culture or give a definite answer on the relation between culture, society, individuals and the computational systems that they use. We do believe, however, that this volume is a good starting point for research on integrating cultures and computational systems. Thus it can be seen as the start of an interdisciplinary

dialogue on culture where connections between the different perspectives are discovered and which forms a basis of understanding and proper use of culture in the systems that we build.

References

Axelrod, R. (1997). The Dissemination of Culture: A Model with Local Convergence and Global Polarization. *Journal of Conflict Resolution*, 41(2):203–226.

Dechesne, F., Tosto, G. D., Dignum, V., and Dignum, F. (2013). No smoking here: values, norms and culture in multi-agent systems. *Artificial Intelligence and Law*.

Hofstede, G. (2001). *Culture's consequences: Comparing values, behaviors, institutions, and organizations across nations*. Sage Publications.

Leontiev, A. N. (1978). *Activity, Consciousness, and Personality*. Prentice-Hall.

Mc Breen, J., Di Tosto, G., Dignum, F., and Hofstede, G. J. (2011). Linking Norms and Culture. In *Second International Conference on Culture and Computing*, pages 9–14. IEEE.

Mohr, J. W. and Rawlings, C. (2010). Formal models of culture. In Hall, J., Grindstaff, L., and cheng Lo, M., editors, *Handbook of Cultural Sociology*, pages 118–128. Routledge.

Part I
Analysis and Modelling of Culture

Chapter 2
Modelling Culture with Complex, Multi-dimensional, Multi-agent Systems

Alexis Morris, William Ross, Hadi Hosseini, and Mihaela Ulieru

2.1 Introduction: Modelling Organizational Cultures

> No single definition of a social science construct is likely to do justice to its complexity.
> —Hofstede (2001)

This chapter focuses on a new approach to model and discuss culture and explores the emergence and evolution of culture within organizations. This is a first step toward future studies on the interplay and eventual integration of different cultures in a shared environment. The primary theme throughout this work is that in order to understand, discuss, and measure culture, it must be recognized as a complex, multi-dimensional, and multi-agent system. These three aspects are the proposed foundation for experiments in culture beginning at the level of the individual unit and progressing toward how groups of such units form and influence a cultural system.

Culture plays a key role in organizations, both as a determinant of relationships among individual units of the organization and as a macro-level driver of its behaviour. It should be considered as one of the main points of analysis when modelling organizations (see Hofstede 2001, Chap. 8, for more on culture as it relates to organizations). Cultural modelling allows for incorporating knowledge

A. Morris (✉) • W. Ross • M. Ulieru
Faculty of Computer Science, Adaptive Risk Management Laboratory, The University of New Brunswick, Fredericton, NB, Canada
e-mail: alexis.morris@unb.ca; william.ross@unb.ca; ulieru@unb.ca

H. Hosseini
Faculty of Computer Science, Adaptive Risk Management Laboratory, The University of New Brunswick, Fredericton, NB, Canada
School of Computer Science, University of Waterloo, Waterloo, ON, Canada
e-mail: h5hosseini@uwaterloo.ca

V. Dignum and F. Dignum (eds.), *Perspectives on Culture and Agent-based Simulations*, Studies in the Philosophy of Sociality 3, DOI 10.1007/978-3-319-01952-9_2,

about the effect and influence of culture on an organization and predicting how the type of culture at work affects the ability of the organization to function, achieve its goals, and ultimately survive.

In order to adequately model and simulate organizational cultures, there are four key components explored in this work: first, a fitting and tangible definition of culture is required; second, a study of the key dimensions of culture is necessary; third, these key dimensions must be used to establish cultural parameters; and, finally, a method of simulating the organization with the defined cultural parameters is needed. Together, these provide the methodology, tools, and techniques for setting up and conducting experiments involving culture in organizations.

Contributions of this chapter are three-fold: (i) it adds to the literature of culture as a complex system, (ii) it presents a new seven-dimensional model to describe and encapsulate culture, and (iii) it models cultural interactions as a multi-agent system of high functioning agents that achieve a certain equilibrium in beliefs. These are elaborated further in the chapter: Sect. 2.2 discusses organizational modelling and presents a working definition of culture; Sect. 2.3 describes the notions behind a complex system and makes the case for culture as such a system; Sect. 2.4 proposes a new model for culture using seven dimensions and provides the reasoning behind this approach; Sect. 2.5 discusses relevant literature regarding culture models; Sect. 2.6 describes how to measure culture with high-functioning agents; Sect. 2.7 explores both the emergence and evolution of culture and discusses the experimental results; and Sect. 2.8 concludes the chapter.

2.2 Organizational Modelling and Culture

An organization is defined as a social arrangement which pursues collective goals, controls its own performance, and has a boundary separating it from its environment (Alvesson 2003; Hatch and Cunliffe 1997). As such, organizational models must account for not only the individual units, but also for the behaviour and interaction patterns of these units, which at a higher meta-level can be seen and described as a culture. Such models are useful in simulations of real-world organizations under a host of conditions, allowing for large volumes of experiments to be conducted in a controlled environment. To perform similar experiments in an in-vivo fashion would be expensive. The results from such studies allow for detailed analyses that can be useful in predicting organizational states and behaviours. This predictive capacity helps in translating simulation knowledge directly into the real world through targetted policy-making and best-practices based on the model.

Cultures are unique to organizations, based on the complex relationships between the parts of the organization and other factors such as environment or technologies (see Ashkanasy et al. 2000, Chap. 6, for more on how key relationships develop meaning and culture). These relationships at lower levels diversify organizations from each other in important and unique ways that can be compatible, complemen-

tary, or competitive. The effects of such relationships are seen in varying degrees within all systems, especially when considering the unique interplay between systems of systems, including human societies.

2.2.1 A Working Definition of Culture

Traditionally, culture is defined as a "set of shared attitudes, values, goals, and practices that [both] characterizes an institution, organization, or group" and emerges from and sets the behaviour of a group (Kroeber et al. 1952). It has also been considered by social scientists to be the "collective programming of the mind" (Hofstede 2001, Chap. 1). In Ashkanasy et al. (2000, Chap. 10), three perspectives of culture are defined: the integration perspective, where people share a common set of beliefs; the differentiation perspective, where different subgroups have different beliefs, but must learn to resolve conflict; and the fragmentation perspective, where, because of such ambiguity in beliefs, individuals continually fragment into ever-changing subgroups. In this work, it is the integration perspective that is being adopted, as well as the view that culture is an open system in a state of equilibrium (Von Bertalanffy 1968).

Our unique working definition of culture is proposed as *the holistic interaction among n agents, across seven distinct dimensions, that results in the stabilization of beliefs within these interacting agents over time*. This allows us to consider both the community of individuals as a whole (e.g. a country or an institution), as well as distinct parts (e.g. a province or a department) with their particular characteristics. This general definition can extend from a single, mono-cultural context to a more diversified, multi-cultural one. At the same time, it frames "culture" as a multi-agent system.

2.3 Culture as a Complex System

This section promotes the view of culture as a complex system, and makes the case that complex systems theory provides strong tools to capture and delineate culture. Culture has been studied in many works and contexts over a wide range of literature domains, and may be considered as one of the "fuzzy" human-factors which are well known, but largely intangible. The view of culture as a system promotes a focus on the emergence of culture from its tangible components, and how the relationships between these components openly affect the meta-level culture, and how the culture, in turn, affects these components.

A complex system may be understood from "the amount of information needed in order to fully describe the system" Bar-Yam (1997, Chap. 8). This includes information about the system states and component interactions at all levels (or scales) of

the system, from high-level to low-level. For culture, the system components are as follows. Elements are individuals within a system that are autonomous and belief-based. Interactions between these are seen as social communication, both verbal (spoken or written) and non-verbal (social or emotional cues, or levels of influence) channels. Other complex systems concepts like reproduction, growth, and feeding are also relevant, at the low-level (Bar-Yam 1997). Culture *reproduces* as the spread of beliefs from one system achieves stabilization within another system; culture *grows* as more individuals adopt/share the same beliefs; and culture *feeds* (or is strengthened) as beliefs are reinforced and become more resilient to change. The main complex systems concepts in this chapter are (a) emergence, (b) evolution, and (c) equilibrium. Emergence is the notion that "the whole is more than the sum of parts. . .that constitutive characteristics are not explainable from the characteristics of isolated parts. . .[but] appear as 'new' or 'emergent'" (Von Bertalanffy 1968, Chap. 3). Hence culture, once it has emerged, is something more than its elements. Evolution may be considered as the accumulation and advancement of high-level changes in a system over a period of time (Von Bertalanffy 1968). This accumulation of changes may occur across any significant property of the system, in any direction, as trends. In terms of culture, evolution is seen as the global trends of beliefs changing in both its high-level and low-level elements, across any of its dimensions over time. Finally, equilibrium is the balance, or "centeredness" within a system (Von Bertalanffy 1968), that stems not only from the interactions within the system, but also from the strength of those interactions. This equilibrium emerges from the lowest levels of the system. These, in conjunction with the factors mentioned above, can provide a strong ontology for discussing culture from the complex systems standpoint.

2.4 A Multi-dimensional Framework for Culture Modelling

Modelling culture requires a broad perspective that is capable of capturing its complexity while still being concrete enough for simulations. We propose an approach involving seven dimensions of culture for organizations. These extend upon our previous work on organizational modelling (Bicocchi et al. 2010) and include the physical, individual, functional, structural, social, normative, and information dimensions. These seven dimensions, each described below, provide a new way to discuss culture and its parameters. It should be noted that some factors appear in more than one dimension. This speaks to the interconnectedness of dimensions.

2.4.1 Physical

The *Physical* dimension of culture relates to its components in the actual world, ranging from the tools and technology in use, to the forms of its common assets (e.g.,

buildings, cars, and clothing). In every organizational system, environmental aspects such as size, location, physical distance, and quality of life affect the behaviour of agents within that system. Additionally, physical characteristics of the agents themselves are also important. For example, size and gender can play an important role in forming cultures.

2.4.2 Individual

The *Individual* dimension describes the component actors in the system and elucidates their unique characteristics, which eventually propagate throughout the culture. Individual factors, both physical and cognitive, highly affect a culture. Cognitive elements are beliefs and desires built up over time that form innate personality, degree of conformity, interests, and experiences. Other attributes are acquired by social interactions and what influential third parties (authorities or experts) believe. At this level, local and personal values are widely expressed within the organization and behaviour can be studied. These elements modify the attributes within the members and can influence the evolution of culture.

2.4.3 Functional

The *Functional* dimension associates a particular role to the individuals within the system, dictating their permissible actions. Similar functions between individuals encourage closer associations and group formations. For instance, medical-related professions such as doctors and nurses develop a similar culture to interact within their organizations. They share (some) knowledge about their domain and communicate through a known ontology. Such functional diversity influences the cultural cohesiveness among groups of individuals.

2.4.4 Social

The *Social* dimension is used to classify the type of interaction that takes place between system actors (e.g., the particular nature and medium of social communication) and the frequency of this interaction. It also refers to specific properties of the relationship between individuals, such as trust and reputation. This dimension determines the kind of social network that unfolds within the system and how resilient that network is to change and, in turn, how resilient the culture is to new beliefs.

2.4.5 *Structural*

The *Structural* dimension of culture characterizes the formal organizational network that exists within the system. Traditional organizations shape their structure based on hierarchical levels of authority (e.g., chain-of-command of superiors, subordinates, and colleagues). This not only affects the culture between different levels of the hierarchy, but also promotes the formation of sub-cultures. The form of the structure changes the behaviours, norms, and understanding of members and, in this way, affects the culture.

2.4.6 *Normative*

The *Normative* dimension characterizes policies and rules that govern the behaviour of individuals within a culture. These may evolve in a bottom-up manner (Hosseini 2010; Savarimuthu 2007) and can be formal, written for a certain environment, or informal, based on descriptive actions of the members of the organization and traditions. Culture emerges from the aggregation of norms that are common to a group of agents (Dignum and Dignum 2009) and can impact decision making and the degree of autonomy among individual agents (Conte et al. 1988; Dignum et al. 2009).

2.4.7 *Information*

The *Information* dimension represents the type, speed, and content of information elements used by individuals in the system. Information has many meanings as a concept (Floridi 2002) and is closely related to notions of communication, control, data, knowledge, meaning, pattern, and representation. This is seen in modern cultures where information exchange is facilitated by technological advancements that allow for swifter adoption of ideas, and hence more dynamic cultures.

2.5 Related Work on Cultural Modelling

Approaches to modelling culture from a multi-dimensional perspective are not new. Other key dimensions have been identified in organizational culture literature as seen in Ashkanasy et al. (2000). Hofstede (Chap. 25), for instance, promotes a four-dimensional and a six-dimensional model. The four-dimensional model targets culture as it relates to nations and governments, while the six-dimensional model targets organizations. Payne (Chap. 10), presents a three-dimensional model of

culture; Ashkanasy et al. (Chap. 8), promote a ten-dimensional model of culture; and Dickson (Chap. 28), presents a nine-dimensional model. These are seen in Table 2.1, alongside the framework presented in this chapter.

A detailed comparison between these models is left for future studies. However, the primary difference is that the seven-dimensional model has been designed with multi-agent systems simulations in mind and is a more general ontology. The approach targets a description of an organizational culture that can be built into properties of individual agents and encourages a holistic approach to modelling culture. In many ways, the approach of the seven-dimensional model for agents is generic and, arguably, subsumes the other multi-dimensional models. For instance, both Hofstede's "power distance" and Payne's "strength of consensus" dimensions could be included as factors within the social dimension.

This chapter focuses primarily on the bottom-up interactions of the cultural system and, as such, uses an agent-based modelling approach. The reader is referred to our previous work in Morris et al. (2011) and Hosseini and Ulieru (2011) for other related aspects of culture modelling involving agent-based interaction models, norm-governed models, learning and adaptation in cultures, and mathematical techniques, in addition to multi-dimensional descriptions of culture.

2.6 Modelling and Simulating Organizational Culture in a Multi-agent System

From our definition, culture represents a shared understanding of a set of beliefs that determines, among other things, accepted behaviour (Kroeber et al. 1963). The way in which culture emerges is based heavily on members of the organization. Particularly, the position taken in this chapter is that the influence of existing organizational members affects the culture of new members. While each member of the organization may have his or her own particular beliefs about a specific element, ultimately there is an overarching belief that becomes dominant in the culture. In this section, the mechanisms used to store cultural beliefs (i.e., the cultural belief set), calculate influence, and modify beliefs for each agent will be examined.

Literature to support these mechanisms is found in Ashkanasy et al. (2000). For example, in Ashkanasy et al. (2000, Chap. 3), the emergence of culture results from social actors engaging in processes called "events." Anyone participating in an organization does so by interpreting events and influencing the meanings that others give to them. Powerful organizational actors, such as managers, are able to create meaningfulness for other agents through formal or informal organizational rules (or norms). These develop and change through the actions of numerous actors as they establish, enact, enforce, misunderstand, resist, and/or break the rules (Ashkanasy et al. 2000, Chap. 6). Culture is determined precisely by the configuration of the rules and actors involved. Various influence models have also been discussed in the literature, and influence factors include role (e.g., superior, subordinate, and