

Chapter 2

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

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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

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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

Table 2.1 Multi-dimensional culture models found in literature and the proposed seven-dimensional model

Hofstede model for nations (1990)	Hofstede model for organizations (1990)	Payne model (1996)	GLOBE model for organizations (1999)	Ashkanasy organizational culture profile (2000)	Seven dimension model for agents (2010)
Power distance	Process-oriented	Strength of consensus	Power distance	Leadership	Physical
	vs.				
	Results-oriented				
Uncertainty avoidance	Job-oriented	Pervasiveness	Uncertainty avoidance	Structure	Structural
	vs.				
Individualism	Employee-oriented	Psychological intensity	Humane orientation	Innovation	Functional
vs.	Professional				
Collectivism	Parochial				
Masculinity	Open-system		Assertiveness	Job performance	Individual
vs.	vs.				
Femininity	Closed-system				
Long-term orientation	Tightly controlled		Gender egalitarianism	Planning	Social
vs.	vs.				
Short-term orientation	Loosely controlled		Future orientation	Communication	Normative
	Pragmatic				
	vs.				
	Normative				
			Performance orientation	Environment	Information
			Individualism	Humanistic workplace	
			vs.		
			Collectivism		
			Organizational collectivism	Development of the individual	
				Socialization on entry	

colleague), self, and leadership characteristics of the individual (Ashkanasy et al. 2000, Chaps. 6, 10). These have been captured already, along with other factors, using our seven-dimensional modelling approach.

2.6.1 Cultural Belief Set

The cultural belief set (CBS) contains beliefs that exist in the organization's cultural landscape. These may be beliefs about particular attitudes, values, goals, or practices. Each belief in the CBS can assume one of three values, based on deontic logic: prohibited, permitted, or obligated. As an example, a belief that "punctuality = prohibited" means that it is culturally unacceptable to be punctual; "punctuality = permitted" means that it is culturally neutral whether or not someone is punctual; and "punctuality = obligated" means that it is culturally required to be punctual.

Since the belief value in the CBS has been restricted to three possibilities, the current culture's stance on a particular cultural belief, x , in the CBS can be ascertained by determining which of the three possible values has the greatest consensus among the various members of the organization.

2.6.2 Influence Calculation

The influence of one agent over another agent is used as the mechanism for changing culture. It is based on the notion described previously that key individuals in the organization have a greater influence on its culture. This influence can be computed using factors from each of the seven dimensions. The factors in Table 2.2 have been incorporated into the influence calculation and are part of the influence factor set (IFS).

The equation used to calculate the influence of one agent over another is presented in Eq. 2.1. The IFS factors have been included, along with an impact ratio, α_j , for each factor. The latter allows the particular factor's influence to be customized for each agent.

$$\iota_1 = \sum_{j=1}^p (IFS_a(j) - IFS_b(j)) * \alpha_a(j), \quad (2.1)$$

where p is the number of items in the influence factor set (IFS) involving $agent_a$'s beliefs about $agent_b$ (i.e., items 1–7 in Table 2.3); j is an index to a row in the IFS table and α is the corresponding impact factor; IFS_a and IFS_b are the influence factor sets for $agent_a$ and $agent_b$, respectively.

Table 2.2 Factors incorporated into the influence calculation and influence factor set (IFS)

Cultural influence factors		
Structural	1	How does agent A relate structurally (within the context of an organization) to agent B? {supervisor, subordinate, colleague}
Physical	2	How close is agent A's workstation from agent B's workstation? {proximity_Threshold} (agent A has a greater chance of being influenced by agents within its proximity threshold)
Functional	3	How similar is agent A's role to agent B's role? [0–1]
	4	Do agent A and B share the same gender? {true, false} (agent A has a greater chance of being influenced by an agent with the same gender)
Individual	5	Are agent A's and B's personalities congruent? [0–1] (agent A has a greater chance of being influenced by an agent with a congruent personality)
	6	How does agent A's experience in the organization compare with agent B's experience? (agent A has a greater chance of being influenced by an agent with more experience)
	7	How does agent A's leadership ability compare with agent B's leadership ability? (agent A has a greater chance of being influenced by an agent with more leadership ability)
Normative	8	Is the particular belief from the CBS formally or informally specified? (an agent has a greater chance of quickly shifting its cultural belief if it relates to a norm that is formally specified)
Social	9	Does agent A seek peer validation from agent B? [0–1] (this may be due to several factors)
	10	Does agent A trust agent B? [0–1]
	11	Through what medium does agent B principally communicate to agent A? {face-to-face > Web 2.0 > phone > email}
Information	12	Does agent A experience the cultural feedback first-hand or second-hand from agent B? (this speaks to the strength of the confidence interval)
	13	If directly, does agent A receive feedback via verbal or non-verbal cues? (this speaks to the strength of the confidence interval; besides verbal cues may be misinterpreted)

Equation 2.2 represents a similar calculation, but for internal influences (e.g., preferences) of $agent_a$ that do not involve $agent_b$ directly.

$$\iota_2 = \sum_{j=p+1}^n IFS_a(j) * \alpha_a(j), \quad (2.2)$$

where $p + 1$ is the first item of the IFS that does not involve $agent_b$; n is the total number of items in the influence factor set (i.e., items 8–13 in Table 2.3); j is an index to a row in the *IFS* table and α is the corresponding impact factor.

The total influence calculation for $agent_a$ is seen in Eq. 2.3.

$$\iota_a = \iota_1 + \iota_2 \quad (2.3)$$

Table 2.3 Influence and impact factors used in the CBS (α values assigned in simulation)

Item no.	Influence factors	Impact ratios (α)
External influences		
1	Structural relation	Structural impact ratio
2	Workstation proximity	Distance impact ratio
3	Role similarity	Role impact ratio
4	Gender	Gender impact ratio
5	Personality similarity	Personality impact ratio
6	Experience similarity	Experience impact ratio
7	Leadership similarity	Leadership impact ratio
Internal influences		
8	Formally specified	Formality impact ratio
9	Seek validation	Validation impact ratio
10	Trust	Trust impact ratio
11	Communication medium	Communication impact ratio
12	First-hand feedback	First-hand impact ratio
13	Verbal feedback	Verbal impact ratio

2.6.3 Updating the Cultural Belief Set

In the simulation, agents share cultural beliefs with other agents whenever a cultural event takes place. These events occur whenever an agent tests a cultural belief in its CBS' . (CBS' is used to distinguish the agent's personal belief set from the organizational belief set, CBS .) These events take the form of a fact in the world, e.g., $agent_a.culturalbelief = value$. The current agent, $agent_a$, is enacting a specific belief in its CBS' . This agent will receive direct feedback—praise or chastisement—from the other agents in the organization. This feedback is in the form of $agent_b.culturalbelief = value$. If the value from $agent_b$ matches $agent_a$'s value, the behaviour or belief is being positively reinforced; otherwise, it is being negatively reinforced.

An agent's cultural beliefs are reconsidered everytime the agent experiences an event. The other agents also experience the event, but their feedback is received second-hand, or indirectly. Events that are experienced first-hand by the agent will have a greater impact on the value of a cultural belief than events that are experienced second-hand. This is accomplished via $IFS(12)$ in Table 2.3.

For each belief, x , in an agent's CBS' , a confidence value is associated with each of the three possible values—i.e., prohibited, permitted, or obliged. In order for the value of x to change, the confidence related to one of the other possible values must become the new maximum. These confidence values are based on the beliefs expressed by other agents, following a cultural event, combined with the influence of other agents based on previous calculations in Eqs. 2.1–2.3. For instance, dressing casually may start as a prohibited belief for $agent_a$, but as more and more interactions take place with different belief values, eventually the permitted or

obligated value may become the new maximum, meaning that $agent_a$'s belief value will change. Equations 2.4–2.6 show the confidence calculations associated with the three possible values of belief x inside $agent_a$'s CBS' .

$$\Phi_{prohibited}(x) = \sum_{i=1}^k \frac{\beta(x, i, prohibited) * \iota_i}{k}, \quad (2.4)$$

$$\Phi_{permitted}(x) = \sum_{i=1}^k \frac{\beta(x, i, permitted) * \iota_i}{k}, \quad (2.5)$$

$$\Phi_{obligated}(x) = \sum_{i=1}^k \frac{\beta(x, i, obligated) * \iota_i}{k}, \quad (2.6)$$

where x is the belief under consideration in the CBS' ; k is the number of agents in the system; ι_i is the influence of $agent_i$ on the current agent (in Eq. 2.3); β is the function below which produces a 1 if $agent_i$'s value for belief x matches the value currently under consideration, i.e., μ , which is one of the three possible values of x : prohibited, permitted, obligated.

$$\beta(x, i, \mu) = \begin{cases} 1 & \text{if } CBS'_i(x) = \mu \\ 0 & \text{otherwise} \end{cases} \quad (2.7)$$

After each cultural event, the agents recompute confidence for all three possible values of each belief in their CBS' . Ultimately, the belief value with the greatest confidence will be selected by the agent as cultural belief x . However, if an agent's confidence is below a certain threshold (unique to the agent), then the agent will feel free to “test” this cultural belief with counter-cultural behaviours, i.e., the agent may perform an action that is counter to the belief value in the CBS . Such “agents-of-change” (Ulieru and Verdon 2009), if combined with high influence, may eventually shift an organization's CBS into a new equilibrium.

2.7 Experiments

The previous section outlined the foundations used to develop our culture simulation, and in this section we test these notions in a simple, hypothetical organization (its roles and structure) using multi-agent techniques. We model a set of workers, having unique individual characteristics and roles. We have chosen to use the Brahms multi-agent development environment (Clancey et al. 1998) that builds on

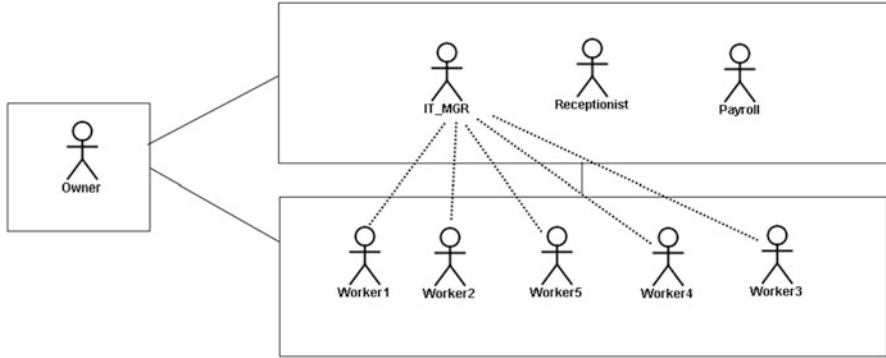


Fig. 2.1 A simple example of an organization consisting of nine agents. The most influential agents are the owner, IT manager, and payroll manager. Each agent is fully connected with all other agents. The *dotted lines* indicate supervisor-subordinate relationship between the IT manager and worker agents

the Beliefs-Desires-Intentions (BDI) paradigm (Rao and Georgeff 1995), with the concept of work practice, which attempts to capture what workers actually do in a typical day (as opposed to what workers should do).

2.7.1 Scenario

In our experiments, a small generic organization is considered, along with the following roles: an owner ($agent_1$), IT manager ($agent_2$), receptionist ($agent_3$), payroll manager ($agent_4$), and five generic worker agents reporting to the IT manager ($agents_{5-9}$), as seen in Fig. 2.1. The CBS is comprised of the following elements: (i) working after hours (overtime), (ii) appropriate business attire, and (iii) punctuality; and the culture of the organization can be determined at any given time based on the majority consensus of whether these beliefs are prohibited, permitted, or obligated. Each agent is instantiated with an initial set of beliefs pertaining to the CBS, as seen in Table 2.4, in addition to initial influence factors and impact ratios which were described previously. Agents in the organization are fully connected to each other in this scenario, having ‘subordinate-to’ and ‘colleague-of’ relationships based on role. Future experiments can explore different network configurations to see their effects on culture, but a fully-connected case is presented here as a first step.

In order to show emerging culture, we demonstrate how the belief set equilibrium of our basic organization is affected under three conditions: (i) the effect of adding the most influential agents at the beginning, (ii) the effect of adding the most influential agents in the middle, and (iii) the effect of adding the most influential agents at the end. The addition of an agent may shift the equilibrium of the

Table 2.4 Initial values for each agent’s CBS’

Agent	Overtime	Formal attire	Punctuality
<i>agent</i> ₁	Permitted	Prohibited	Obligated
<i>agent</i> ₂	Obligated	Prohibited	Obligated
<i>agent</i> ₃	Obligated	Prohibited	Permitted
<i>agent</i> ₄	Prohibited	Obligated	Permitted
<i>agent</i> ₅	Prohibited	Obligated	Obligated
<i>agent</i> ₆	Prohibited	Obligated	Permitted
<i>agent</i> ₇	Obligated	Obligated	Prohibited
<i>agent</i> ₈	Prohibited	Obligated	Permitted
<i>agent</i> ₉	Obligated	Prohibited	Obligated

organization’s culture, as each agent will have a different cultural influencing factor dependent on such things as role occupied, personality, and existing social connections within the organization.

2.7.2 Visualizing the Cultural Belief Set

By modelling each agent individually, each can have its own unique beliefs about culture. When multiple agents begin interacting, certain forces will cause some beliefs to be accepted by the community and become part of the culture (i.e., part of the social memory). Such a force may be a new manager, for example, who has authority over particular agents. Moreover, we believe that culture stabilizes as more agents join the organization, so it becomes resilient to change. However, we still maintain that if a major destabilizing force occurs (e.g., a key agent such as a manager in an organization is replaced), then a cultural shift may occur, resulting in a new equilibrium. To display culture, we use the notion of a *belief set equilibrium*, which represents changes in beliefs over all agents in the system.

This equilibrium is seen in the experiments below, represented as radar plots. The size of the plot indicates the number of agents in the system, or how mature the culture is. The shape of the plot indicates the orientation of the cultural system. Finally, the time-steps show the progression of the culture from a small organization of three agents to a larger group, and the variation between time-steps represents the cultural evolution in the system.

2.7.3 Experiment 1: Adding the Most Influential Agents at the Beginning

In this experiment, the organization begins with the three most influential agents: the owner and the two managers. These agents then have 1 simulated month to

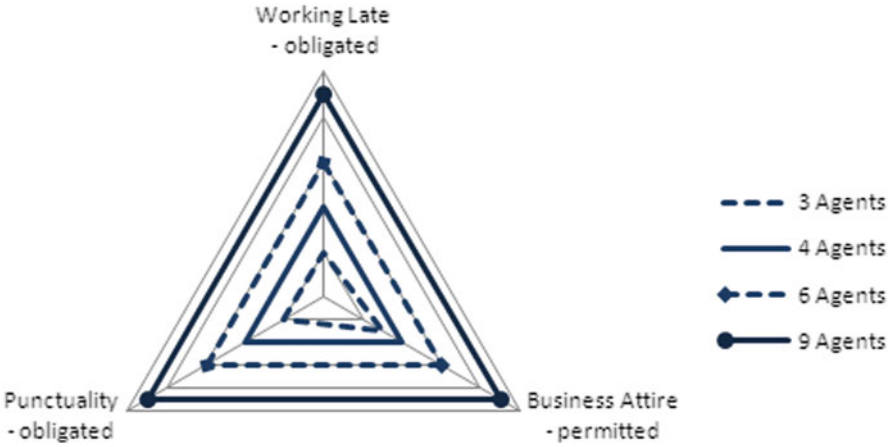


Fig. 2.2 Experiment 1: Adding most influential agents at the beginning. Cultural beliefs stabilize after the fourth agent is added

perform cultural interactions. During this time, for this experiment, two of the agents agree that employees must work after hours and be punctual, and all three agree that business attire is not that important. After the 1 month period, another agent is added to the organization. Once again, the agents have a month to perform cultural interactions before the next agent is added.

As can be seen in Fig. 2.2, once four agents are added to the organization, the cultural belief set stabilizes and other agents added to the system adopt the organization's culture. This is because the existing agents are sufficiently influential and eventually convince all other agents within the organization to conform to their culture.

2.7.4 Experiment 2: Adding the Most Influential Agents in the Middle

In this experiment, the organization's three most influential agents are added after three other agents perform cultural interactions for a month. As in the previous experiment, the additional agents are added subsequently after a 1-month simulated period. This continues until all nine agents have been added to the organization.

As can be seen in Fig. 2.3, complete stabilization of the culture does not occur until six agents have been added to the organization. This suggests that the influence of the most powerful agents impacted the initial culture of the organization, which existed during the first month when three initial agents were present. This likely occurred because none of the first three agents were sufficiently influential to convince the others to adopt their cultural position.

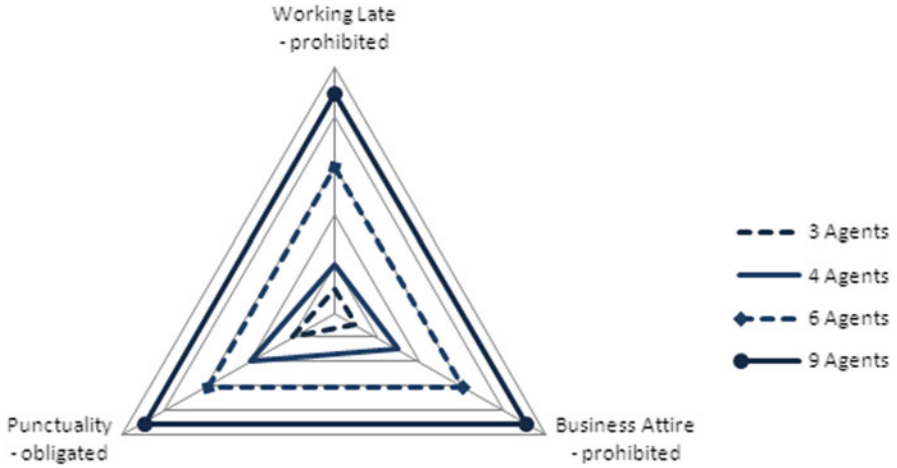


Fig. 2.3 Experiment 2: Adding most influential agents in the middle. Cultural beliefs stabilize after the sixth agent is added

2.7.5 Experiment 3: Adding the Most Influence Agents at the End

In this experiment, the organization's three most influential agents are added to the organization as the last three agents. Once again, they are added in monthly increments, following the initial three agents and the three subsequently added lesser influence agents. This particular experiment may simulate the case where some key management is replaced at some interval during the lifetime of the organization.

As can be seen in Fig. 2.4, complete stabilization of the culture occurs once six agents have been added to the organization. This suggests that even though the most influential agents are not added until the end, the first six agents are able to create enough "pull" together to compensate for the greater influence of these other three agents. Because these influential agents are added individually, neither one alone is able to overcome the cultural stability already existent within the organization.

2.8 Conclusion

Culture is not only an intangible social construct, but also an emergent property, and the primary theme of this chapter is that in order to understand, discuss, and measure culture it must be recognized as a complex, multi-dimensional, and multi-agent system. In this work, culture has been defined and considered holistically, from both a top-down and bottom-up perspective.

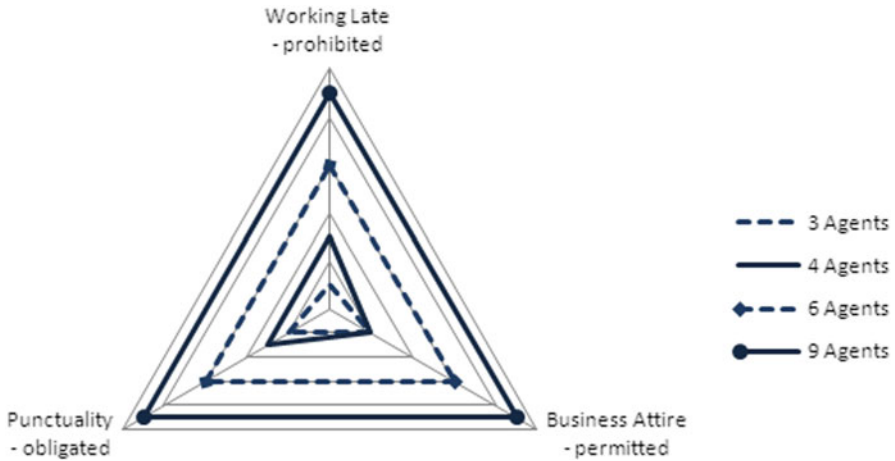


Fig. 2.4 Experiment 3: Adding most influential agents at the end. Cultural beliefs stabilize after the sixth agent is added

The multi-dimensional modelling work in this chapter adds to existing literature on culture's inherent multi-dimensionality, and seven new dimensions have been discussed. The multi-agent modelling and simulation of culture uses the seven-dimensional approach to understand how cultural belief-based equilibrium can emerge based on the relationships, communication, and influence idiosyncracies of individual agents in a complex organizational system.

The three initial simulation experiments show how different configurations of the same agent organization can result in different cultures, depending on when highly-influential agents-of-change are added to the system. Moreover, agent-oriented culture modelling has been demonstrated, and the results have shown how beliefs stabilize for a simple example, as a first step towards modelling more complicated cultures and diverse organizations.

Future work will target this direction and investigate how the addition or removal of groups of agents impacts culture, as in common organizational mergers and acquisitions, as well as testing different social-network configurations.

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