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# A DIMENSIONAL MODEL FOR CULTURAL BEHAVIOR IN VIRTUAL AGENTS

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□ *Intercultural training is becoming more important than ever before. As a result, there is a stronger need for developing more advanced educational methods. Virtual environments can provide an innovative approach in this area. Users can safely explore complicated intercultural situations by interacting with virtual agents that display human cultural behavior. However, current environments that address cultural aspects focus on explicit aspects such as gestures, spoken language, or norms. Implicit cultural manifestations, such as values, have been greatly disregarded and yet they are a fundamental aspect. This article addresses the integration of such implicit manifestations in an agent architecture, through a dimensional model based on anthropological studies. Using the implemented architecture, two different agent cultures were created. Users were asked to visualize and describe both cultures performing a short emergent story. Results confirmed that users perceived the two cultures with significant differences that were in congruence with the model used.*

## INTRODUCTION

Today, the world is becoming a much smaller place, and people from quite different cultures have now the chance to connect, interact, collaborate, and live with other cultures. As such, intercultural awareness is becoming more important than ever before. From a business perspective, companies are growing globally, and, as such, business in countries that have very different cultures is now commonplace. But this globalization is not easily achieved, and a cultural misunderstanding may result in a loss of an important deal. Therefore, companies are starting to provide

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intercultural training for their employees (Landis et al. 2003). Further, from a social perspective, groups of people that have a distinct culture from the majority (usually called a subculture) are becoming more common. Lack of understanding about these subcultures can often lead to the creation of stereotypes that generate prejudice and discrimination.

This greater need for intercultural training has motivated the development of more demanding and complex educational methods. As reported in (Landis et al. 2003), current active methods such as real-life role-plays or simulation games, for example, Barnga (Thiagarajan and Steinwachs 1990), are specially indicated for trainees to modify their attitudes, adopt new values, and change their perspective on culture. Yet these methods have significant disadvantages; for example, players can be too shy to participate, and a large number of human participants are often required.

Facing this scenario, virtual environments, where users interact with virtual agents, can be a promising alternative as an active method for intercultural training. They can combine the strengths of real-life role-plays and simulation games while solving some of their related issues. In a virtual environment, similar to a real-life role-play, a user may experience the role of someone else while exploring a computer-generated virtual world. There is no dependency on the number of other human participants, because the virtual environment can be populated with embodied agents that behave in a human-like manner. Also, the user gets to apply his or her knowledge directly, deciding which actions to take in the virtual world, given the situation. Yet the user can feel safe to face complicated social and emotional situations, because his or her actions will not have any consequences outside the virtual world.

Despite these advantages, the development of virtual environments for intercultural training is still in the beginning stages. Namely, current applications that address cultural aspects in their agents' behavior are mainly focused on explicit cultural differences such as gestures (Rehm et al. 2007; Johnson et al. 2004), spoken language (Johnson et al. 2004), specific norms (Solomon et al. 2008; Bogdanovych et al. 2009), and rituals (Mascarenhas et al. 2009). However, according to Hofstede (2001), implicit manifestations such as values (e.g., believing that people with higher social status should be treated in a privileged manner) also play a major role in characterizing human cultures. Moreover, the representation of these less obvious cultural differences are necessary to have in a tool designed for intercultural training (Hofstede et al. 2002). As such, the following problem is addressed in this article:

> How can we build an agent architecture that allows the creation of different cultural groups of agents, capable of exhibiting distinguishable

differences in their implicit patterns of behavior, similar to those found in real human cultures?

With this problem in mind, we address the integration of implicit cultural manifestations in an agent architecture, through a dimensional model that directly influences the way agents choose goals and appraise events in the environment. The dimensional model is directly based on two of the cultural dimensions, individualism vs. collectivism and power distance, proposed in Hofstede (2001).

The structure of this article as follows. In the next section we present some background on culture and describe in detail Hofstede's dimensional model. In Section 3 we discuss related work in the area of culture specific agents to situate our approach. In Section 4 we present the conceptual approach we used, and its implementation into an agent architecture is described in Section 5. We then present a case study used to perform an evaluation where users observed two cultural groups with different dimensional parametrizations. Finally, after analyzing and discussing the obtained results, we draw conclusions and present some future work.



## BACKGROUND

Culture is a vast concept that is not easily defined. In 1952 a list containing 164 possible definitions of culture was compiled by Alfred Kroeber and Clyde Kluckhonn. Still, no consensus has yet been reached.

The notion of culture adopted here is the one proposed by Geert Hofstede. The foundation for his theory is a large empirical study conducted in more than 70 countries. According to him, culture is "the collective programming of the mind that distinguishes the members of one group or category of people from another" (Hofstede 2001, p. 9). These "mental programs" refer to patterns of thinking, feeling, and potential acting that are shared and learned by members of the same culture. These patterns can manifest themselves at an explicit or implicit level (Table 1). The difference is that explicit manifestations are more easily perceived as cultural by an average person. In other words, it is easier, for instance, to recognize that a different culture uses a different gesture for greeting than it is to recognize that people are more individualistic in that culture.

Other than the cultural manifestations presented above, Hofstede proposes five dimensions on which cultures vary (Hofstede 2001). Different from the previous manifestations, which can be very specific to a certain culture or subculture (e.g., the Japanese tea ceremony), these dimensions are universal. They are directly based on the culture's values and indicate general behavioral tendencies shared by the members of the culture. These tendencies should be not considered deterministic, because other factors

**TABLE 1** Explicit and Implicit Manifestations of Culture

| Explicit | Implicit |
|---|---|
| Rituals: essential social activities carried out in a predetermined fashion | Values: represent cultural preconceptions about what is desirable and undesirable |
| Heroes: persons, alive, dead, or even imaginary that serve as role models | |
| Symbols: words, gestures, pictures, or objects that members of a given culture have assigned a special particular meaning | |



such as the individual's personality also play an important role on human behavior. Hofstede's five dimensions are described as follows:

1. **Power Distance Index (PDI):** The degree to which less powerful members of the group expect and accept that power is distributed unequally. In small PDI cultures (e.g., Austria), people tend to regard others as equals despite their formal status. In high PDI cultures (e.g., Malaysia), powerful people have more privileges and like to wear symbols that reflect their status.

2. **Individualism (IDV):** Versus its opposite, collectivism, indicates the extent to which individuals see themselves integrated into groups. In collectivistic cultures (e.g., Guatemala), everyone looks out for one another in exchange for unquestioning loyalty. On the other hand, in individualistic cultures (e.g., United States), people stress the importance of personal achievements and individual rights. Everyone is expected to be responsible only for themselves and their immediate family.

3. **Masculinity (MAS):** Very masculine cultures (e.g., Japan) favor assertiveness, ambition, efficiency, competition, and materialism. Also, differences between gender roles are accentuated. On the other hand, in very feminine cultures (e.g., Sweden), relationships and quality of life are more important. Both sexes should have equal rights and responsibilities.

4. **Uncertainty Avoidance Index (UAI):** This dimension indicates to what extent people prefer structured over unstructured situations. In low UAI cultures (e.g., Singapore), people have as few rules as possible, and unfamiliar risks and ambiguous situations cause no discomfort. In an opposite manner, in high UAI cultures (e.g., Portugal), people tend to have strict laws and rules and also various safety measures to avoid situations that are novel, unknown, or different from usual.

5. **Long-Term Orientation (LTO):** Indicates to what extent the future has more importance than the past or present. Short-term oriented

cultures (e.g., Nigeria) value the respect for tradition, quick results, fulfilling social obligations, and reciprocation of gifts. On the other hand, in long-term oriented cultures (e.g., China) people give more importance to the future than to the past and present.

The main advantage of this model is the fact that it gives a clear and detailed notion of universal differences between cultures. As such, we believe the model serves the purpose of our work by indicating how we should characterize general cultural aspects of behavior in artificial agents.



## RELATED WORK

Axelrod developed one of the first agent-based models of culture (Axelrod 1954). However, it was mostly concerned with simulating the dissemination of culture. Only recently have researchers started to address agent architectures that include cultural factors in virtual agents' behavior. Still, a substantial part of the work done so far addresses only cultural communication aspects. For instance, CUBE-G (Rehm et al. 2007) is a system where embodied conversational agents adjust their expressive nonverbal behavior to the user's culture. To achieve this, Hofstede's (2001) dimensions are used to portray cultural differences regarding four different variables of expressive nonverbal behavior: (1) overall activation (number of gestures in a specific time), (2) spatial extent (how much space a gestures uses), (3) speed (temporal extent of movements), and (4) power (the strength of gestures). During the conversation with a virtual agent, the cultural background of a user is inferred by sensing his or her nonverbal behavior using a Nintendo's Wii remote controller. The motivation for this work comes from a study (Lee and Nass 1998) that shows users tend to prefer to interact with a virtual agent that has a similar cultural background. Overall, the system provides a good insight on how to correlate the cultural dimensions to specific expressive behavior, although it focuses exclusively on this type of behavior.

Another project that focuses on communication aspects is the Tactical Language Training System (TLTS) (Johnson et al. 2004). In this application, users interact with autonomous characters from a foreign culture to train in the culture's spoken language and gestures. The goal is to teach communicative skills in languages that are less commonly taught in the United States, such as Arabic, Chinese, or Russian. Learning such languages with traditional courses can be very time-consuming, due to their unfamiliar writing systems and cultural norms.

In TLTS, the architecture that drives the behavior of the characters is called Thespian (Si et al. 2006), which was built on top of PsychSim (Pynadath and Marsella 2005), an architecture for social behavior. Thespian embeds cultural behavior in the characters' conduct by using

social relationships such as trust and liking and then by authoring special social variables to represent temporary obligations between agents. Obligations are created when an agent performs a certain action on another agent. To satisfy the obligation the target agent must choose a proper action in response. Examples of such obligations are greeting and greeting back, thanking and saying you are welcome, offering and accepting/rejecting, and so on. The notion of obligation is somewhat similar to the concept of a ritual in Hofstede (2001). The main difference is that obligations are limited to two actions.

A more recent work on cultural behavior that focuses on cultural norms is the culturally affected behavior (CAB) model (Solomon et al. 2008). The model is based on two social theories: (1) theory of mind and (2) schema theory. The first is defined in Nichols and Stich (2003) as the human ability of attributing mental states such as intentions, beliefs, and values, not only to oneself but to others as well. The latter postulates that a culture can be represented as a shared organization of schemas (D'Andrade 1992). The way CAB allows the representation of cultural norms is by using graphs named sociocultural networks. In these networks, specific actions are linked to one or more cultural norms with a specified intrinsic utility (the importance of the norm in the culture). Each link has a value that indicates if the action contributes or detracts from the associated norm. For example, a norm can be *respectful-of-modesty* to which the action *show-picture-of-wife* is linked with a negative value, meaning that it is a disrespectful action regarding the norm.

In Bogdanovych et al. (2009), a formal model of culture for virtual agents is proposed. The goal of the work is to preserve the knowledge associated with a certain culture using agents in a 3D virtual world so one can learn about a culture in an interactive manner. One interesting aspect is that the cultural knowledge is considered to be directly connected with the environment and the manufactured objects of that environment. Additionally, cultural norms of behavior are characterized through the notion of *institutions*, based on Esteva (2003). In general terms a cultural institution involves (1) a set of roles (e.g., *fisherman*, *visitor*, *fisherman's wife*), (2) restrictions among these roles, (3) a common language (ontology), (4) acceptable interaction protocols (the activities of each role), (5) a role flow policy that determines how agents can modify their roles, and (6) relations of social influence among roles.

A re-creation of the Uruk culture (an ancient city located in present-day Iraq) was used as a case study for the model implemented. The prototype simulates the daily life of four virtual agents (the members of two families of fishermen). Each agent acts according to its role, formalized in the institution. For instance, the routine of the *WaterSupplier* role consists of waking up on the roof, collecting water from the well, doing house work, and climbing back on the roof to sleep there.

Another important type of cultural manifestation, namely rituals, was addressed in Mascarenhas et al. (2009), where a computational model of rituals was defined and integrated into a virtual agent architecture. Rituals were considered as a social activity where a set of actions with symbolic value are carried out in a predetermined fashion. The model was inspired by plan recipes used in traditional BDI architectures with a fundamental difference: traditional plans are based on technical activities (the focus is in the result), whereas rituals are based on ritual activities (the focus is in the sequence of steps). Like an *institution* discussed in the previous work, a ritual has a set of roles associated with it. Each role has one or more steps that must be performed following any specified ordering constraints.

In summary, all these systems provide good insight on how to model explicit cultural behavior that is related to particular communication aspects, norms, actions, or tasks. However, none of the systems addresses implicit manifestations of culture. Our dimensional model tries to represent this type of cultural behavior such as an agent deciding between acting for his or her own sake or acting to maintain the welfare of the group. Both approaches may complement each other and may eventually be merged into a more complete model.



## CULTURAL DIMENSIONS IN AGENTS

In his studies with different cultures, Hofstede was able to extract five cultural dimensions (with values in a scale of roughly 0 to 100) that represented differences between cultures. Distinct cultures are classified with different values, making it reasonable to expect that two cultures with opposing values in one of the dimensions will be perceived differently by viewers. So it seems that if one can model cultural dimensions and use them to affect behavior, one can create agents with distinguishable cultural behavior. Yet because dimensions are considered an implicit manifestation, users may have difficulties perceiving the agents' associated behavioral patterns as being of a cultural nature.

Note that the construal of cultural dimension is very abstract and simply indicates general behavioral tendencies shared by the members of the culture. The question that must be answered then is how can a specific value for a cultural dimension affect the agents' behavior? To answer this question, we look again to Hofstede's description of cultural dimensions. He states that cultural dimensions are directly based on the culture's values, which represent cultural preconceptions about what is desirable/undesirable. This means that elements of the same culture share patterns used to evaluate the desirability of options or events and that cultures with different dimension scores tend to evaluate the same options and events differently. According to the concept of rationality, agents choose options or goals to maximize their expected utility. Thus, putting

together these two perspectives and making the utility of goals, and thus decision making, depend on the cultural dimensions creates the desired link between culture and behavior.

The way that culture affects decision making and behavior corresponds to what Hofstede identified as the "mental programs," which refer to patterns of thinking and potential action. In addition to these patterns, he also identified patterns of feeling. In the same way that members of a given culture share common patterns of how they think, they should also share patterns of how they feel and react to certain events. This is also in accordance with the definition of values. Appraisal theories of emotion see emotions as a result of an appraisal process where an event is evaluated. If these cultural preconceptions help determine what is desirable and undesirable, they will have a strong impact on the appraisal process and thus on the emotions felt and expressed by the agents. As such, the influence of culture on emotional responses is also considered in the proposed model.

There is, however, an important simplification. We decided to encompass only two of the five dimensions (the ones that seemed to be more easily recognizable in a short-term interaction): (1) individualism vs. collectivism and (2) power distance. As such, the other dimensions are left as future work.



## Influence of Culture in Goal Utility

Generally, a goal utility is defined as a function that receives a goal and returns a numeric value that indicates how useful that goal is for the agent (based on its current beliefs). In a dynamic environment beliefs are always changing, which means it is very likely that a utility of a certain goal increases or decreases over time. For example, the goal of eating food has a high utility when the agent believes that it is hungry, even higher utility if the agent believes it is starving, and almost zero utility after the agent has eaten a satisfying amount of food. Rational agents continuously calculate the utility of every achievable goal and then select to focus on achieving the goal with the highest utility at the particular moment.

### *Impact of the Individualism Dimension*

How can culture affect goal utility? According to Hofstede (2001, p. 225), in an individualistic culture "people are expected to be only responsible for themselves and their immediate family." Also, close friendships are very important. Differently, in a collectivistic culture "everyone looks out for one another in exchange for unquestioning loyalty," (Hofstede 2001, p. 225). As such, it seems clear that our cultural agents should evaluate a goal's utility using two different perspectives: (1) the

impact the goal has to themselves and (2) the impact the goal has to others (which requires the ability to form mental models of others). Individualistic agents are much more concerned with the first perspective, because the second is only important if the agent has a strong social relation (symbolizing a close bond) with any of the other agents. Oppositely, collectivistic agents are equally concerned with both perspectives and treat every other agent of the culture in the same manner (regardless of existent social bonds).

To capture these notions, we proposed Eq. (1) for calculating a goal's utility. This equation takes as parameters the individualism score (IDV), the impact the goal has on the character's self ($I_s(g)$), the impact the goal has on others ($I_o(g)$), and a positive relationship factor (PREL),[1] which considers interpersonal social attractions between the targets of the goal and the agent:

$$\text{Utility}(g) = I_s(g) + I_o(g)\left(\frac{100 - \text{IDV}}{100} + \frac{\text{IDV}}{100} \times \text{PREL}(g)\right) \quad (1)$$

To explain the rationale behind this particular equation, the situation depicted in Figure 1 is used. In this example agent A is considering the goal of giving some food to agent B versus the goal of giving food to agent C. A has plenty of food, so losing just a little bit has a small negative impact,[2] such as $I_s(g) = -1$. However, B is hungry and cannot afford to buy food, so receiving some food would have a considerable positive impact, like $I_o(g) = 5$. On the other hand, C is also hungry but wealthy, so the impact of his receiving some food is lower, for example $I_o(g) = 4$. Moreover, A has a negative interpersonal attraction toward B, thus $\text{PREL}(g) = 0$. On the other hand, A has a positive interpersonal attraction toward C, which makes $\text{PREL}(g)$ return a positive multiplier depending on the intensity of the relation (in this particular scenario, we'll assume that it returns 0.5).

Using the previous situation, three different cultural scenarios are examined: (1) an extreme collectivistic culture, (2) an extreme individualistic culture, and (3) a neutral culture. In the first scenario IDV is equal to zero and so Eq. (1) is reduced to

$$\text{Utility}(g) = I_s(g) + I_o(g)$$

In this scenario both $I_s(g)$ and $I_o(g)$ are weighted equally, which means an agent considers his own well-being to have the same importance as the well-being of others, regardless of the existent relationships. As such, regarding the example depicted, the utility of giving B food is higher ($\text{Utility}(g) = 4$) than giving it to C ($\text{Utility}(g) = 3$).

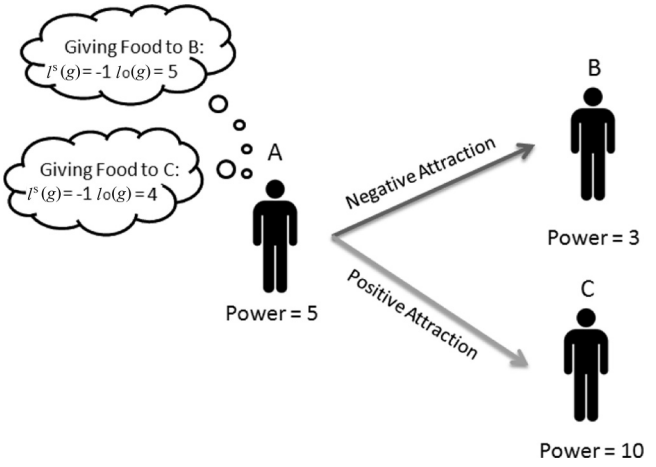


**FIGURE 1** Giving food example.



For an extreme individualistic culture (IDV = 100), Eq. (1) changes to

$$\text{Utility}(g) = I_s(g) + I_o(g) \times \text{PREL}(g)$$

In this scenario the others' well-being depends only on the existence of a positive relationship. Because in the previous situation A disliked B, $\text{PREL}(g) = 0$. Thus, A now will never create an intention to give B food, because the goal has a utility of $-1$. But for C, because A has a positive relation with him, $\text{PREL}(g)$ returns a positive multiplier (e.g., 0.5). Thus, the utility of giving C food is now equal to 2.

In the third scenario, for a neutral culture (one that is neither inclined to individualism or collectivism), the equation changes to

$$\text{Utility}(g) = I_s(g) + I_o(g) \times 0.5 + I_o(g) \times \text{PREL}(g) \times 0.5$$

In this culture the utility for giving B food is equal to 1.5. It is not negative but is less than the utility of giving it to C, which is equal to 2. This means that, generally, characters of a neutral culture care for all other agents but give preference to their friends.

### *Impact of Power Distance Dimension*

According to Hofstede (2001), in low power distance cultures people tend to regard others as equals despite their formal status. Oppositely, in high power distance cultures powerful people are expected to be privileged. As such, agents that belong to a high power culture should favor goals that positively affect others who have a higher status. To achieve this result, we proposed to augment Eq. (1) with an additional fraction at

the end, based on the power distance score (PDI), and a power distance factor (DIST($g$)),[3] which considers the differences of power between the targets of the goal and the character:

$$\text{Utility}(g) = I_s(g) + I_o(g)\left(\frac{100 - \text{IDV}}{100} + \frac{\text{IDV}}{100} \times \text{PREL}(g) + \frac{\text{PDI}}{100} \times \text{DIST}(g)\right) \quad (2)$$

Let's consider again the goal of character A (power = 5) to give food to character B (power = 3) and the goal of character A to give food to character C (power = 10). Before, in the extreme collectivistic scenario (IDV = 0), it was concluded that A would prefer to give the food to B (Utility($g$) = 4) than to give it to C (Utility($g$) = 3).

How does the situation change with the addition of the power distance dimension? Like before, three different scenarios are considered: (1) an extreme low power distance culture; (2) an extreme high power distance culture, and (3) a neutral culture. In the first scenario PDI is equal to zero, which makes the DIST($g$) factor irrelevant; thus the previous situation remains unchanged. In the second scenario PDI is equal to 100. Because B has lower power than A, DIST($g$) is equal to zero and so the goal of giving it food remains with an utility of 4. Now, C has a power that is two times higher than the power of A, thus DIST($g$) returns a value greater than zero (e.g., DIST($g$) = 0.5). Thus, the goal of giving food to C has now a utility of 5, and so A prefers to give C the food instead of giving it to B. Finally, in the neutral scenario (PDI = 50), the DIST($g$) factor is divided in half. This reduces the utility of giving C food to 4. Thus, A will not have any preference in choosing to which agent it should give food, because both goals have the same utility in a neutral power distance and extreme collectivistic culture.

### Influence of Culture in Emotional Appraisal

The idea that emotions are elicited by evaluations (appraisals) of events or situations was first introduced by Magda Arnold in Arnold and Gasson (1954). Since then, many different appraisal theories that attempt to describe the structure and/or the process of appraisal have been proposed. A detailed description of several theories can be found in Roseman and Smith (2001). Even though the theories disagree on several aspects, they are all based on the idea that emotions result from a subjective evaluation of events. This explains why two different people can show dramatic differences in their emotional response to the same event.

One particular appraisal theory is the OCC theory of emotions (Ortony et al. 1988), which is the theory used by most current architectures for synthesizing emotions in virtual agents. OCC defines the concept of

emotion as a valenced (good or bad) reaction to an event, which is triggered by a subjective evaluation according to one's goals, standards and beliefs. In total, the OCC emotion model specifies 22 emotion types (e.g., joy, anger, distress, reproach, shame, etc.). The assessment of the relationship between events and emotion types is done according to a set of appraisal variables. For example, the *Desirability* variable assesses how much a given event was desirable for the agent responsible.

Of particular interest to our work is the *Praiseworthiness* variable, because it represents how much a given event was in line with the agent's cultural standards. Events that have a positive praiseworthiness potentially make the agent "feel" pride and the others admiration. On the other hand, a negative praiseworthiness leads the agent to feel shame if it was responsible for the event or reproach toward the agent responsible.

Furthermore, in Mesquita and Frijda (1992, p. 198), "cross-cultural differences as well as similarities have been identified in each phase of the emotional process." For example, although evidence supports that facial expressions of emotions are universal across human cultures (Ekman 1982), there are also dramatic differences regarding regulation processes. For instance, the expression of shame is valued in strongly hierarchical cultures (e.g., Japan), whereas it is often regarded as a negative event in Western cultures.

Yet how do invidualistic cultures differ from collectivistic ones in terms of emotions? In Markus and Kitayama (1991), it is argued that in individualistic cultures the individual "appears as focused on his or her independence and self-actualization," whereas in a collectivistic culture the individual is "focused predominantly on his or her relationship with in-group members or with the in-group as a whole." Consequently, individualists appraise events in "terms of their individual achievements and properties," whereas collectivists appraise events in "terms of group the person belongs to or as affecting the interpersonal relationships." In other words, collectivistic cultures try to avoid conflicts that would disrupt the harmony and welfare of the group.

Therefore, to represent the notions previously presented into the OCC model, we proposed the following Eq. (3) for calculating the praiseworthiness of an event:

$$\text{Praiseworthiness}(e) = \begin{cases} 0, & \text{if } I_{\text{a}}(e) > I_{\text{o}}(e) \geq 0 \\ (I_{\text{o}}(e) - I_{\text{a}}(e)) \times \dfrac{100 - \text{IDV}}{100}, & \text{if otherwise} \end{cases} \tag{3}$$

The equation proposed is based on the impact the event has on the agent who caused it ($I_{\text{a}}(e)$), the sum of impacts the event has on the other agents ($I_{\text{o}}(e)$), and the individualism score (IDV). In general terms, the

first branch of the equation refers to events that did not harm others ($I_o(e) \geq 0$) but had a more beneficial effect for the agent who caused them ($I_a(e) > I_o(e)$). As such, no matter how collectivistic a culture is, an agent will not be ashamed if, for example, it has just eaten an apple (an event that had a positive effect on himself but a neutral effect on others). As for the second branch, it provides the following results: (1) the more collectivistic a culture is (i.e., the lower the IDV), the more an event that is undesirable for others ($I_o(e) < 0$) but is beneficial for the responsible agent ($I_a(e) > 0$) will be blameworthy (e.g., stealing something); and also (2) the more collectivistic a culture is, the more an event that is good for others ($I_o(e) > 0$) but is bad for the responsible agent ($I_a(e) < 0$) will be highly praiseworthy (e.g., giving food). In other words, collectivistic agents find a spirit of self-sacrifice for the well-being of the group highly admirable and find selfish acts highly reproachable.

To give an example, consider the following situation: Agent B has directly asked agent A for some food and A denies it. This has a positive impact on A considering he keeps the food for future use (e.g., $I_a(e) = 1$). However, it has a negative impact on B who is very hungry (e.g., $I_o(e) = -3$). Let's consider that agent A and agent B are from a culture that has an IDV of 27 (the value found for the Portuguese culture). Applying the equation, agent A's decision has a praiseworthiness value of $-3$ approximately. This means that A will potentially feel ashamed, whereas B would feel reproach for A. Instead, if A decides to give B food, it has a negative impact on A (e.g., $I_a(e) = -2$) but a positive effect on B (e.g., $I_o(e) = 3$). The praiseworthiness value of this decision is 3.6. As such, A will likely feel pride, whereas B will feel admiration for A. Finally, if we reexamine both decisions, if the agents belong to a culture with an IDV of 91 (the value of the U.S. culture), both decisions have a very low praiseworthiness. Namely, the praiseworthiness of the decision of giving B food is equal to 0.4, whereas the praiseworthiness of keeping it is $-0.3$.

## INTEGRATION INTO AN AGENT ARCHITECTURE

For the implementation of our cultural model for intelligent agents, we extended an emotional agent architecture, named FAtiMA-PSI (Dias and Paiva 2005; Lim et al. 2008), which follows the OCC model of emotions (Ortony et al. 1988). The extended architecture is shown in Figure 2.

As Figure 2 shows, when an event is perceived it passes through a *symbol translator* that translates the meaning of the event according to the culture's symbols, using a simple association mechanism. For instance, a waving hand may be considered a greeting in one culture and insulting in another one. The event is then used to update the agent's *knowledge base* (KB) and *autobiographic memory* (AM). These are the main memory components. Whereas the first one is responsible for storing semantic

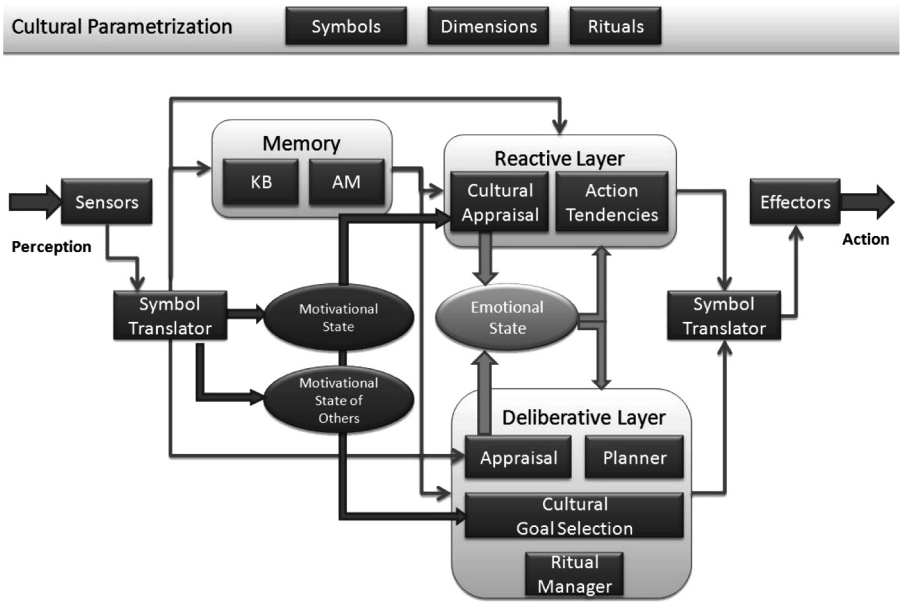


**FIGURE 2** Cultural Agent Architecture.

knowledge such as properties about the world and relations, the second one stores information concerning past events and the agent's personal experience.

At the same time the memory components are updated, the event is used to modify the agent's *motivational state*. Agents have different motivational needs that must be continuously satisfied. These needs are grounded on a psychological model of human action regulation called PSI Dorner (2003). For instance, if an agent finishes an eating action, its need for energy goes down. To know if other agents have their needs satisfied or not, the agent also builds and updates a *motivational state of others* according to events perceived. This information is used later in the *cultural goal selection* and *cultural appraisal* processes.

After updating the motivational states, the event is finally appraised. There are two main appraisal processes: The *deliberative appraisal* handles emotions related to the achievement of goals (e.g., satisfaction, disappointment) and the *cultural reactive appraisal* associates a set of appraisal values to the event perceived and then generates the corresponding emotions. In particular, the *praiseworthiness* variable is determined by using the proposed Eq. (3), where $I_a(e)$ is associated with the effect the event had on the motivational state of the agent responsible for causing the event and $I_o(e)$ is matched to the effect the event had on the motivational state of the other agents affected by the event. The

resulting emotional state is then used to trigger *action tendencies* (reactive actions).

In the deliberative layer the event perceived will also activate predefined goals, and the agent will have to select between competing alternative goals. Here the *cultural goal selection* process calculates the expected cultural utility for each active goal using Eq. (2), where $I_s(g)$ is associated with the expected impact the goal will have on the agent's motivational state and $I_o(g)$ to the expected impact the goal will have on the goal's target (determined using the representation of that agent's motivational state). The goal with the highest expected cultural utility will be selected as the agent's current intention, and the *planner* component will develop and execute a plan to achieve the goal.

The architecture also has a *ritual manager* for dealing with the activation and execution of cultural rituals. This component is described in Mascarenhas et al. (2009) in greater detail. Finally, for more information about the previous elements of the architecture, see Dias (2005) and Lim et al. (2008).



## CASE STUDY

The cultural architecture developed was used to drive the behaviors of an autonomous agent's culture in a serious game called ORIENT: Overcoming Refugee Integration with Empathic Novel Technology (Aylett et al. 2009). In ORIENT, players (assuming the role of space travelers) must interact with *Sprytes*, an unfamiliar fictional foreign culture whose planet is about to be destroyed by a large meteor. The game is an agent-based educational role-play that tries to promote intercultural empathy, and it was developed in the context of an EU-funded project called eCIRCUS. After conducting two pilot studies, users did found the Sprytes to be a very different culture from their own, and most users were interested in the storyline.

Additionally, we used the architecture in a simpler scenario, which was designed to measure the architecture's power in portraying distinct cultures with virtual agents. This scenario consisted of a common real-life situation, a dinner party (Figure 3). The overall plot is simple: The characters arrive at the party location, greet each other, socialize for a while, and then sit together at a dinner table and start to eat.

Noticeably, all the characters have the same appearance and are dressed in the same peculiar outfit (just with different colors). The main reason for designing the characters in this manner was so users could not associate the characters' appearances to any particular known culture, because that would very likely lead the users to create cultural expectations that would not be related to our cultural model. However, despite the fact

**FIGURE 3** Characters at the dinner table.



that the characters all look alike, they have some individual differences. Figure 4 shows the set of goals available to the characters as well as some of the characters' individual properties.

In total, there are five characters. Two of them have a low social status (character 1 and character 2), another two have a medium social status (character 3 and character 4), and the last one has a high status (character 5, the elder of the group). All characters have the same available goals, but their activation directly depends on the character's properties and on the calculated utility of the goal. For example, the goal *Give-Medicine* can only be selected by character 1 because it's the only one that satisfies the goal's preconditions (having medicine).[4] Yet the character will only try

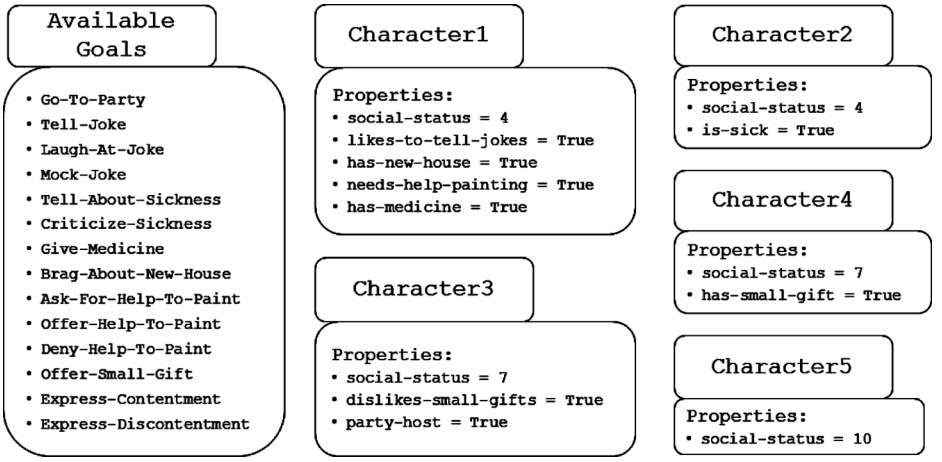


**FIGURE 4** Goals and character properties.

to achieve it if it has a high utility for him. To exemplify the characters' behavior, consider the following very simple situation. After the characters greet each other, character 2, who is sick, reports about his sickness to the other characters. Then, if the culture is highly individualistic, character 1, who has medicine but is not a friend of character 2, will criticize him for complaining. Conversely, if the culture is highly collectivistic, character 1 will promptly offer his medicine to help.[5]

## EVALUATION

Using the previous dinner party scenario, we performed an evaluation to determine the impact that a simple change in a dimensional parameter would have on users' characterizations of the agents' behaviors. As such, two cultures were created, one where IDV was equal to 100 (extreme individualism) and the other where IDV was equal to 0 (extreme collectivism). All other specifiable elements such as goals, actions, symbols, social relations, or personality profiles were exactly the same in the two groups. We wanted to see if users could in fact recognize one group as more individualistic and the other as more collectivistic, just by changing the corresponding dimension in the model. We chose to use the individualism dimension to differentiate the two agent cultures, because the power distance dimension was already explored in Mascarenhas et al. (2009), where the same architecture (but focusing on rituals) was used to determine if users could perceive differences between a high power distance culture and a low power one.

### Methodology

Using the two different cultures created with the architecture, two videos were obtained using the dinner party situation described previously. These videos were then used in an online questionnaire. The questionnaire asked users what values and adjectives were more fitting to describe the behavior of each cultural group. It starts by asking participants to watch the video of the individualistic culture and characterize the characters seen, and then repeat the characterization for the second video with the collectivistic culture. Because repeated measures were used, participants were randomly assigned to a visualization order. Roughly half of them saw the collectivistic culture after the individualistic one and vice versa.

The initial questions concerned cultural values and were based on Hofstede's study. Each question concerned a statement that is associated either with individualism or with collectivism (Table 2). Users were not aware of the association but had to decide if the statement was appropriate to describe the characters in each video or not (using a seven-point Likert scale).

**TABLE 2** Results for the Statements Related to Individualism vs. Collectivism

| Value statement (culture associated) | Culture | Avg. | StD. | Differences between cultures |
|---|---|---|---|---|
| The eldest male should be the head of the household *(High Power Distance)* | Col. | 1.40 | 1.58 | $\|\Delta\text{Avg}\| = 0.11$ |
| | Ind. | 1.29 | 1.52 | $p = 0.435$ |
| Power and wealth are bad *(Low Power Distance)* | Col. | −0.71 | 1.37 | $\|\Delta\text{Avg}\| = 0.31$ |
| | Ind. | −0.40 | 1.55 | $p = 0.058$ |
| | | | | $r = 0.21$ |
| They are concerned with everyone's well-being *(Collectivism)* | Col. | 1.62 | 1.56 | $\|\Delta\text{Avg}\| = l$ |
| | Ind. | 0.62 | 2.16 | $p = 0.003$ |
| | | | | $r = 0.33$ |
| Personal achievements are very important *(Individualism)* | Col. | 0.74 | 1.43 | $\|\Delta\text{Avg}\| = 0.43$ |
| | Ind. | 1.17 | 1.15 | $p = 0.006$ |
| | | | | $r = 0.30$ |
| Direct confrontations should be avoided *(Collectivism)* | Col. | 0.50 | 1.64 | $\|\Delta\text{Avg}\| = 0.5$ |
| | Ind. | 0.00 | 1.81 | $p = 0.033$ |
| | | | | $r = 0.23$ |
| It is important for leaders to make all the decisions *(High Power Distance)* | Col. | 0.24 | 1.41 | $\|\Delta\text{Avg}\| = 0.21$ |
| | Ind. | 0.45 | 1.35 | $p = 0.303$ |
| It is right to openly disagree with superiors *(Low Power Distance)* | Col. | −0.10 | 1.36 | $\|\Delta\text{Avg}\| = 0.09$ |
| | Ind. | −0.19 | 1.40 | $p = 0.600$ |
| They like to trust and cooperate with other people *(Collectivism)* | Col. | 2.05 | 1.08 | $\|\Delta\text{Avg}\| = 1.43$ |
| | Ind. | 0.62 | 2.22 | $p = 0.00$ |
| | | | | $r = 0.38$ |
| It is important for them to be independent *(Individualism)* | Col. | 0.07 | 1.31 | $\|\Delta\text{Avg}\| = 0.48$ |
| | Ind. | 0.55 | 1.42 | $p = 0.015$ |
| | | | | $r = 0.27$ |



Furthermore, we measured the differences in the behavior of the characters by asking participants to choose a number between two opposite adjectives in a scale from −3 to 3 (Table 3), according to the adjective they thought to best describe the characters.

Finally, the questionnaire concludes with two additional questions that try to assess if any differences between the videos presented were perceived, and if so, whether participants understood those differences as being caused by the culture of the characters, or by their personalities, or by neither one of these factors.

## Results

We had a total of 42 participants (36 Portuguese, 5 German, and 1 British), aged between 18 and 34 years old, of which 76% were

male. Concerning the group of questions about values the Wilcoxon test was applied to see if there were significant differences in the users' classification. For every statement related to individualism or collectivism (Table 2) the results were statistically significant ($p < 0.05$). Users found the individualistic/collectivistic values to be more appropriate for the individualistic/collectivistic culture respectively. The highest effect ($r = 0.38$) was observed in the statement "They like to trust and cooperate with other people." This suggests that users could recognize appropriate differences related to cultural values in the two different cultures created with our model.

For the adjective's classification the Wilcoxon test was used once more. The results are shown in Table 3. Except for the *equal/biased* and *warm/cool*,

**TABLE 3** Second Experiment – Results for the User's Adjective Classification

| Adjective | Culture | Avg. | StD. | Differences between cultures |
|---|---|---|---|---|
| Approachable/distant | Col. | −1.21 | 2.28 | $\|\Delta Avg\| = 0.81$ |
| | Ind. | −0.40 | 2.14 | $p = 0.036$ |
| | | | | $r = 0.23$ |
| Equal/biased | Col. | 0.00 | 1.93 | $\|\Delta Avg\| = 0.07$ |
| | Ind. | 0.07 | 1.87 | $p = 0.788$ |
| Independent/sharing | Col. | 1.57 | 1.33 | $\|\Delta Avg\| = 1.07$ |
| | Ind. | 0.50 | 2.20 | $p = 0.001$ |
| | | | | $r = 0.37$ |
| Equalitarian/hierarchical | Col. | 1.55 | 1.61 | $\|\Delta Avg\| = 0.65$ |
| | Ind. | 0.90 | 1.92 | $p = 0.009$ |
| | | | | $r = 0.29$ |
| Polite/impolite | Col. | −1.71 | 1.85 | $\|\Delta Avg\| = 1.09$ |
| | Ind. | −0.62 | 1.97 | $p = 0.005$ |
| | | | | $r = 0.30$ |
| Pleasant/unpleasant | Col. | −1.83 | 1.45 | $\|\Delta Avg\| = 1.19$ |
| | Ind. | −0.64 | 1.90 | $p = 0.000$ |
| | | | | $r = 0.40$ |
| Individualistic/collectivistic | Col. | 1.50 | 1.35 | $\|\Delta Avg\| = 2.1$ |
| | Ind. | −0.60 | 1.96 | $p = 0.002$ |
| | | | | $r = 0.33$ |
| Unfriendly/friendly | Col. | 2.12 | 1.19 | $\|\Delta Avg\| = 1.26$ |
| | Ind. | 0.86 | 1.83 | $p = 0.000$ |
| | | | | $r = 0.41$ |
| Relaxed/tense | Col. | −1.38 | 1.59 | $\|\Delta Avg\| = 0.5$ |
| | Ind. | −0.88 | 1.76 | $p = 0.042$ |
| | | | | $r = 0.22$ |
| Compassionate/indifferent | Col. | −1.36 | 1.54 | $\|\Delta Avg\| = 0.96$ |
| | Ind. | −0.40 | 1.95 | $p = 0.002$ |
| | | | | $r = 0.33$ |
| Serious/cheerful | Col. | 1.00 | 1.58 | $\|\Delta Avg\| = 0.6$ |
| | Ind. | 0.40 | 1.95 | $p = 0.04$ |
| | | | | $r = 0.22$ |
| Warm/cool | Col. | −0.81 | 1.77 | $\|\Delta Avg\| = 0.6$ |
| | Ind. | −0.21 | 1.93 | $p = 0.066$ |

every pair of adjectives yields significant results. Among them are the adjectives *individualistic/collectivistic* (which has the largest difference in averages) and *independent/sharing*. This constitutes a very good result, because it demonstrates that the user's interpretation of the characters' behavior matches the parametrization of the dimensions component.

Moreover, there was a significant effect for adjectives that are more related to the power distance dimension. For example, users found the collectivistic culture to be more hierarchical than the individualistic culture. This is an interesting result that suggests that the behaviors caused by one dimension can alter the user's perception of behaviors more directly related to another dimension.

In the last two questions to assess directly if users perceived the videos as being different, only one did not find any differences. This corresponds to only 3% of the participants. From the remaining 41 participants (which answered they had perceived differences), 63% associated the differences with personality, 30% with culture, and only 7% answered neither. We performed a a chi-square test to determine if the result was not obtained by chance. The chi-square value obtained was 5.158 and was significant ($p = 0.023$). These results are the opposite to these found in Mascarenhas et al. (2009), where a similar experiment was performed but using distinct rituals to differentiate the cultures instead of the dimensions. When asked the same question in that experiment, 67% associated the differences with culture, 30% with personality, and 3% answered neither. This difference in results can be explained by the fact that, as pointed out earlier, behavioral tendencies associated with cultural dimensions are implicit cultural manifestations, contrasting with rituals and symbols that are explicit manifestations (Hofstede 2001).



## CONCLUSIONS

The research in culture-specific agents is quite novel, and the existing work has mainly focused on explicit cultural manifestations (gestures, spoken language, norms, and rituals). Nevertheless, Hofstede identified an implicit type of manifestation that plays a major role in characterizing human cultures: values, which represent cultural preconceptions of what is desirable and undesirable and are responsible for general behavioral tendencies shared by the members of the culture.

With this in mind, we aimed at creating an agent model to allow the creation of different cultural groups of agents, based on implicit manifestations of culture. Thus, we started with the hypothesis that if we could model cultural dimensions and use them to affect behavior, we could create agents with distinguishable cultural behavior.

To do so, we modeled two dimensions (individualism vs. collectivism and power distance) and used them to influence the processes of decision

making (selecting between alternative goals) and emotional appraisal. Because these processes have a strong impact on the agent's behavior, we were able to create the desired link between culture and behavior. The main idea for achieving this was to make characters more or less concerned with the needs and social statuses of others, according to the dimensional parametrization established.

The cultural architecture was then implemented and used to create two different cultures, one extremely individualistic and the other extremely collectivistic. An evaluation was performed to determine the effect the dimensions implemented had on the user's characterization of the created cultures. The results show that the different dimensional parametrization used was strong enough to cause users to perceive significant differences in the two cultures. Users classified the cultures as individualistic or collectivistic in congruence with the parametrization used. This is a very encouraging result as it shows that our model is able to create cultures with perceivable differences, just by changing a simple dimensional parameter. Furthermore, the results also showed that although users perceived differences between the cultures, they attributed those differences to personality and not to culture. This is in accordance with what we expected, because Hofstede already pointed out that although implicit manifestations are important, they are not easily attributed to culture by an average person.

As future work, we would like to perform additional evaluations of the model. For instance, we would like to repeat the same experiment but with users from highly individualistic culture (because must users were from a collectivistic one). Moreover, it is important to study the effects of combining explicit with implicit cultural manifestations (e.g., rituals with values) across the dimensions, to see if users would still characterize the cultures as significantly different yet ascribe such differences to cultural factors instead of personality. Moreover, the notion of subcultures (association to ethnic, religious, or other social groups) was left unexplored in the model but could be additionally included. Furthermore, there are several other relations between culture and emotions (e.g., how should one act when experiencing a certain feeling), that were not addressed but are also important in characterizing cultural behavior. Moreover, it would be interesting to develop a scenario where agents from different cultures had to interact with each other, giving rise to intercultural conflicts between them. Finally, we want to explore additional ways to use the dimensions implemented and include the other dimensions as well.

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## NOTES

1. PREL is normalized to a scale of 0 (no positive relationships) to 1 (maximum positive relationships).
2. The exact equations for $I_s(g)$ and $I_o(g)$ are domain dependent. However, for illustration purposes, consider their range to be from $-10$ to 10.
3. Similar to the positive relationship factor (PREL($g$)), DIST($g$) is also normalized to a scale of 0 (power equal or lower than self) to 1 (power is higher than self).
4. The goals are all described and authored in a STRIPS-like manner, having logic preconditions.
5. An illustrative video of the case study can be found online: http://www.informaworld.com/uaai.