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Structuring the Cultural Domain with an Upper Ontology of Culture

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ABSTRACT

The study of culture is important for many disciplines such as psychology, sociology, anthropology, archaeology, museology, communication, management and business. This research presents many potential opportunities for Information Technology specialists to develop culturally-aware technology, but it also raises the risk of inconsistent approaches to the cultural domain. In this chapter, the authors present the fundamental concepts of the Upper Ontology of Culture (UOC), a formal conceptualization of the cultural domain they developed by identifying the common backbone of culture-related disciplines and activities. As a neutral, theory-driven, and interdisciplinary conceptualization, the UOC provides guidelines for the development of culturally-aware applications, for the consistent computerization of cultural data and their interoperability, as well as for the development of culture-driven automatic reasoning processes.

INTRODUCTION

The study of culture is important for many disciplines such as psychology, sociology, anthropology, archaeology, museology, communication, management and business to cite but a few. This research presents many potential opportunities for Information Technology (IT) specialists to develop culturally-aware technology.

However the various coexisting and competing discipline-specific approaches and methods that have been developed, the genuine fuzziness of folk language that people use to discuss cultural matters and the ill-defined nature of cultural questioning lead us to the statement that cultural awareness is particularly difficult to address consistently in IT.

As mentioned by Lane and his colleagues, "*ill-defined domains, in contrast to those that are well defined, are characterized by problems that tend to lack consistent, unambiguous, and generalizable solutions*" (Lane et al., 2007). Indeed, culture is an easy-to-use concept in everyday discussions. But it becomes much more difficult to deal with when the time comes to give it a proper and consensual definition, to determine its constituents or to describe its specifics: in other words to consider it in a scientific manner (Blanchard & Mizoguchi, 2008).

Even when this is the case, cultural notions and terminologies sometimes differ from one discipline to another. The research focus of disciplines may also vary. For instance, some disciplines such as

anthropology may be interested in discussing cultural artefacts, whereas others such as psychology may not be. Moreover, a huge amount of data is annually produced by research that could nurture the development of culturally-aware systems. But the computerization of such cultural data as well as the interoperability and centralization of the resulting collections are currently limited. Finally, mastering the various research initiatives on culture is a difficult and highly time-consuming task, and the process of knowledge acquisition may frequently be limited by commercial realities and constraints such as deadlines. This could potentially result in ill-designed systems that would extensively rely on the ethnocentric view of their development team, implying cultural misconceptions and stereotypes. This may thus affect the credibility of the resulting application, potentially increasing users' misconceptions about a targeted culture, or reducing the efficiency of human-computer interactions.

Using formal ontology engineering techniques, the Upper Ontology of Culture (UOC) project aims to develop a generic conceptualization of the cultural domain, neutral and interdisciplinary, by identifying the cultural backbone common to culture-related disciplines and activities. Such theory-driven conceptualization has many interests for the development of research on artificial cultural awareness:

1. To allow development teams to consider cultures in a scientifically-sound and cross-disciplinary way, i.e. to propose appropriate guidelines on what IT development teams should focus on when addressing a specific cultural issue,
2. To propose ways of appropriately computerizing cultural aspects of a given problem by suggesting templates for theory-driven data structures and data management processes,
3. To promote interoperability by enforcing the consistency of cultural data modelling between systems, thus facilitating reuse of computerized cultural data,
4. To promote cultural automatic reasoning, thus allowing systems to take culturally-informed decisions that may impact on their internal processing as well as on human-computer interaction.

This chapter is organized as follows. The first section is dedicated to the presentation of previous research linking culture and information technology. We start by discussing the different potential meanings of the notion of *cultural awareness*. Thereafter we explore the nature and potential sources of cultural knowledge, the necessary component that all culturally-aware systems have in common. The second section is dedicated to the presentation of the domain of ontology engineering. Basic notions and principles widely endorsed in this domain are described as well as specific technologies we are using in our project i.e. the HOZO ontology editor and the YAMATO Standard Upper Ontology. The UOC is discussed in the third section. After listing its main objectives and presenting some techno-cultural challenges it will help to address, we report our ontological analysis of three culture-related domains (context, cognition and affect) whose conceptualizations are required to adequately model core cultural concepts presented afterwards. Finally we introduce future developments of the UOC.

CULTURE AND INFORMATION TECHNOLOGY: EARLY DEVELOPMENTS

The meaning of "Cultural Awareness" in Technological Contexts

Cultural awareness has recently begun to be addressed in information technology. To our understanding, a "*culturally-aware system*" refers to any system where culture-related information has had some impact on its design, runtime or internal processes, structures, and/or objectives. This may have many interpretations and can lead to several different approaches that we will now discuss.

Enculturated design

Culture has been considered at the design level in order to develop systems that fit the particular requirements and specifics of a cultural group. For instance, a basic internationalization process such as the linguistic adaptation of the Graphic User Interface (GUI) helps to reach different kinds of users. But more technological cultural specializations of GUIs may also be useful to strengthen a system's usability and enhance its endorsement by users in a given cultural context (Clemmensen, 2010).

On the other hand, some studies specifically focus on understanding GUI particularities that are the result of the designer's cultural background. Marcus and his colleagues (Marcus & Gould, 2000; Marcus & Alexander, 2007) have analyzed cultural variability of design according to Hofstede's system of national dimensions (Hofstede, 2001; Hofstede, 2009; see also next section on *Cultural Knowledge in Information Systems*). They propose relations between these dimensions and country-dominant design choices that could help to develop culturally-aware design recommendations. Even if the method of analysis of Marcus and his colleagues can be criticized, the interest of their approach lies in the opportunity to apply potential recommendations to all countries and regions for which Hofstede's values have been obtained (Hofstede, 2009), and thus to help designers make informed design choices in order to reach a specific population in an optimal manner.

Runtime Cultural Adaptation

More and more systems are implementing real-time adaptations that take into account the specific characteristics of their users (Sleeman & Brown, 1982; Brusilovsky, 2001; Houben et al., 2009). Runtime adaptive methods are generally based on analyzing users' interactions with the system in order to inform internal decision processes. More and more human factors are being considered for such purposes, including cognitive, bio-physiological and affective aspects of users (Picard, 1997; Blanchard et al., 2007; Blanchard et al., 2009c; Arroyo et al., 2009).

Research on runtime considerations of users' cultural characteristics has just recently emerged. Its mechanism lies in extracting cultural information about the user (Reinecke & Bernstein, 2009; Blanchard, 2009; Reinecke et al., 2010) to nurture adaptive processes that already make use of some cultural knowledge. The aim of such research is similar to artificially reproducing strategies adopted by culturally-intelligent people when interacting with foreigners (Earley & Mosakowski, 2004). This process can be divided into two parts:

- *Understanding:* the system translates a user's interactions with regards to his/her cultural characteristics and develops hypotheses about the user (Blanchard, 2009; Reinecke & Bernstein, 2009).
- *Adaptation*: the system uses previous hypotheses to select proper actions to undertake in order to optimize positive as well as limit negative interactions with the user (Johnson et al., 2005; Miller et al., 2008; Miller et al., 2010).

Among other considerations, methods for culturally adapting displayed content have been proposed (Blanchard, 2009). For instance, pictures of Champagne bottles would be appropriate to illustrate a wedding party concept for French people, but is likely to be inappropriate for people from Muslim countries, where religious norms proscribe alcohol, and whose traditional wedding ritual is quite different. Iconic faces, sometimes interpreted in a different manner from one cultural group to another, could also be adapted in real-time (Koda et al., 2009). Other studies also focus on enculturating Embodied Communication Agents (ECAs), especially their non-verbal abilities (Rehm et al., 2009; Rehm, 2010). Indeed, making realistic ECAs requires taking into account the well-known cultural variability of body language.

Finally, it is to be noticed that not only can the visible part of systems illustrate cultural adaptation, internal decision-making processes could also reproduce cognitive (Kashima, 2000; Nisbett & Norenzayan, 2002; Oishi, 2004), affective (Ekman, 1972; Mesquita et al., 1997; Mesquita, 2001; Elfenbeim & Ambady, 2003), or motivational (Chirkov et al., 2003; Elliot & Bempechat, 2002; Lim, 2004; Salili et al., 2001) cultural variations that may influence Human-Computer Interaction, leading for instance to a *culture-personality based affective model* (Nazir et al., 2009).

Cultural Data Management

Software tools may be specifically developed for culture-related sciences and activities (such as anthropology, archaeology, sociology, geopolitics, or even international business & management). In such systems, cultural awareness refers to the proper computerization of cultural data and efficient usage that is made of them.

Cultural data centralization formerly required books, or paper listings. As the information era dawned, this centralization has naturally moved to the Internet, taking the form of databases that group cultural knowledge of, for instance, a discipline (TMP, 2009; NADP, 2009; HRAF, 2009) or a museum (Le Louvre, 2009; British Museum, 2009). Many other kinds of online knowledge

repositories (such as wikis, newspapers websites or weblogs) could also be seen as less explicit sources from which information about a cultural group can be extracted.

The quality of cultural data computerization can be enhanced by using proper semantic web techniques (Aroyo et al., 2007). This results in new functionalities and opportunities to manipulate cultural collections in an "intelligent manner", to facilitate their use for research purpose, or to make them more accessible to the general audience (Hyvönen, 2009; Stock & Zancanaro, 2010).

Other artificial intelligence approaches have been proposed to retrieve, organize, and understand non-homogenous cultural knowledge by cross-analyzing several sources of information. For instance, the OASYS system (Cesarano et al., 2006) illustrates the opinion intensity of a group of people by analyzing its web production (blogs, forums, newspapers) related to targeted topics, which may then inform and tailor geopolitical decisions.

Intercultural Education

In the history of mankind, it has never been so easy for an individual to interact with foreigners or to discover distant cultures through virtual or real life opportunities. Hence there is a growing need for intercultural education, and developing systems that teach intercultural skills is a very dynamic field of research. UNESCO (2007) has identified several objectives for intercultural education:

1. To respect "*the cultural identity of the learner through the provision of culturally appropriate and responsive quality education for all*",
2. To provide "*every learner with the cultural knowledge, attitudes and skills necessary to achieve active and full participation in society*",
3. To provide "*all learners with cultural knowledge, attitudes and skills that enable them to contribute to respect, understanding and solidarity among individuals, ethnic, social, cultural and religious groups and nations*".

These objectives imply that systems for intercultural education should integrate culturally-relevant pedagogical practices not only because it is respectful of learners, but also because it may frequently be highly efficient. Indeed research has shown that local educational practices frequently increase performance more than internationally-endorsed practices. For instance, Biggs's analysis of Commonwealth-spread versus Hong-Kong pedagogical strategies showed a better efficiency of the latter on Hong-Kong students (Biggs, 2001).

These systems also need to have a good overall understanding of both the learner's culture and the targeted culture. This is extremely difficult because the cultural domain is known to be ill-defined (Lane et al., 2007) and cultures are entities that are too complex to be fully modelled (Blanchard & Mizoguchi, 2008). Determining the amount of information that is necessary to develop a sufficient and neutral model of a given culture, and how such information is to be efficiently transmitted to a learner, are complex tasks that have to be adequately considered in order to provide effective intercultural education. Furthermore, pedagogical designers are enculturated human beings and, as such, may be subject to ethnocentric views about knowledge in a particular domain (Blanchard & Mizoguchi, 2008). This has to be regulated in order to avoid the dissemination of misconceptions and stereotypes.

Nowadays, military funding has supported major culturally-aware educational systems that focus on cultural issues that soldiers may encounter. Examples of such systems include the *Adaptive Thinking and Learning System* (Raybourn et al., 2005), the *Tactical Language and Culture Training System* (Johnson, 2007), the *Virtual Environment Cultural Training for Operational Readiness system* (Deaton et al., 2005), and *BiLAT* (Lane et al., 2007). More civilian approaches also exist such as *Second China* (Henderson et al., 2008) and the work of Ogan and her colleagues (Ogan et al., 2008). Ogan and Lane (2010) provide a comprehensive review of these systems.

Intercultural Collaboration

IT is also used to enhance intercultural communication. Allowing an individual to understand behaviors and perspective of foreigners, or providing him or her with advice on how to efficiently communicate with foreigners are tasks that may be achieved by software assistants in online environments or through the use of personal devices (see for instance CultureGPS, 2009).

Intercultural education and intercultural communication are closely linked. Indeed the development of intercultural communication skills is the specific objective of some of the systems that have been

cited in the previous sections (Johnson, 2007; Lane et al., 2007). However, whereas educational systems focus on learners' internalization of transmitted knowledge, the use of cultural communication assistants may not necessary focus on long term learning. Some professionals may require culturally-intelligent suggestions only in a very specific context. Hence developing the ability of such assistants to clearly identify communication issues the user may face in a specific cultural context would allow them to provide contextually-appropriate recommendations For instance, consider a business executive that has to travel to many different countries in a short period of time, He could consult an assistant with his mobile phone before each of his meetings in order to express culturally-specific greetings, and to receive advice on how to behave in front of his business partners.

Cultural Knowledge in Information Systems

Whatever the domain of application is, cultural awareness implies the ability to target one or more group(s) of people and manipulate appropriate cultural knowledge. Depending on the discipline, different approaches exist to study the cultural domain. In this section, we briefly introduce the main sources of cultural knowledge to which information systems could refer.

Information systems have a long history of basic **internationalization**, and this currently consists of two main approaches: (a) asking limited information such as the current localization and language when setting up operating systems and loading the appropriate configuration, or (b) referring to the IP address to infer the localization, this being what major international websites do to customize their front page to show more locally-relevant information (see for instance differences between French, French-Canadian and English-Canadian front-pages of the video-sharing website "*Dailymotion*" [1], or try a similar request on various national versions of "*Google"*).

Additional information can also be inferred from such country-based categorization by using frameworks known as **systems of national values** that summarize country/region characteristics in a limited number of dimensions. Values related to such dimensions are supposed to express major orientations of a cultural group. Among all proposed models, *Hofstede's framework* (Hofstede, 2001) has had the most impact within the last 25 years (Kirkman et al., 2006). It characterizes more than 70 cultures through the following five dimensions (Hofstede, 2009): Power Distance (PDI, *"the extent to which the less powerful members of organizations and institutions (like the family) accept and expect that power is distributed unequally"*), Individualism (IDV: *"the one side versus its opposite, collectivism, that is the degree to which individuals are integrated into groups"*, Masculinity (MAS: "*the distribution of roles between the genders*"), Uncertainty Avoidance (UAI: "*a society's tolerance for uncertainty and ambiguity*"), and Long Term Orientation (LTO: a more recently added dimension referring to a general interest for "*virtue regardless of truth*").

Even if Hofstede's framework is the most frequently cited system of values, it is not supported by all scholars and has frequently been criticized. For instance, McSweeney (2002) pointed out that such a general overview of national tendencies can't really be applied at the individual level. Other systems of values, such as *Schwartz' s Value Inventory* (Schwartz, 1992) or the recent *GLOBE* study (House et al., 2004) have indeed tried to address this specific issue by proposing dimensions for both group and individual level analysis. However, as stated by Earley (2006) and Smith (2006), there is no perfect system of values, and each of the proposed frameworks has positive and negative qualities. But overall, this paradigm allows easy cross-cultural comparisons and understanding of characteristics of a national group. This is probably one of the reasons why systems of values have inspired several IT studies (Marcus & Gould, 2000; Marcus & Alexander, 2007; Savard et al., 2008; Reinecke & Bernstein, 2009; Blanchard, 2009).

The "system of national values" paradigm itself raises several criticisms, which include an oversimplification of national characteristics or an inefficient consideration of individual variations within cultural groups (McSweeney, 2002). Furthermore, all existing systems of values have been primarily designed in business contexts and do not necessarily apply well in other domains (Blanchard et al., 2009b; Stewart & Chakraborty, 2010). Finally, systems of values mainly consider cultures at their country level whereas other **cultural layers** such as religious, organizational, social class, or

[1] Using the IP address, local version is displayed by default when accessing www.dailymotion.com : French version: www.dailymotion.com/fr; French-canadian version : www.dailymotion.com/ca-fr; English-canadian version: www.dailymotion.com/ca-en;

ethnicity membership to cite but a few, may provide relevant information for cultural awareness in information technology (Reinecke et al, 2010 ; Rehm, 2010).

Many studies have investigated the different possible cultural layers and,several approaches have been proposed for this purpose, each fostering in turn new research initiatives and developments. For instance, as stated by Cooper and Denner (1998), at least seven theoretical orientations exist that try to link culture to psychology research. They focus either on "*core cultural ideas*", on context and ecological systems, on castes in stratified societies, on intergroup relations, or on social capital. A similar variety of approaches can be observed within other culture-related disciplines. It should also be noted that the cultural focus may vary from a discipline to another. For instance, tangible cultural production is of primary interest in some disciplines such as archaeology. But it is almost completely ignored in others such as psychology.

Several scholars have also investigated universal versus cultural characteristics of human beings. Notable initiatives include:

- A list of *basic universal emotions*, which consists of anger, disgust, fear, happiness, sadness, surprise, has been proposed by Ekman (1972) and has greatly inspired the development of affective computing (Picard, 1997). However, not all researchers agree on this concept of universal emotions (see Mesquita et al., 1997 for a more complete discussion about this question).
- The *Self Determination Theory* (Ryan & Deci, 2000) depicts human motivation as universally regulated by basic psychological needs (autonomy, competence, and relatedness) whose fulfilment strategies would vary from a culture to another (Chirkov et al., 2003).
- The *Politeness Theory* (Brown & Levinson, 1987) proposes to categorize communication acts in two categories: positive faces and negative faces. This theory has recently inspired an abundance of culturally aware systems (Johnson et al., 2005, Wang & Johnson, 2008; Miller et al., 2008; Miller et al., 2010).

Various methodologies for collecting data have been proposed, including **participant observation** (see DeWalt et al., 1998) where the observer tries to become part of the society (s)he is analyzing. By making researcher presence transparent to studied individuals, the objective of participant observation is to reduce side effects and increase the quality/relevance of collected data.

Finally, it is also to be mentioned that some institutions develop their own summaries of information about a culture for their employees. For instance, in 2006, the *US Army Training and Doctrine Command* has issued such a document "*to provide soldiers with a basic overview of Arab culture*" (ACA, 2009). However such surveys do not necessarily include references, which makes verification of their statements problematic. Depending on the credibility of the author institution, the use of such data repositories may be questionable in culturally-aware systems for the sake of data reliability.

Overall, most of the vast amount of cultural information obtained in previously-cited cultural studies is rarely used in IT projects. There are many potential explanations for this: the lack of comprehensive comparisons between the various existing initiatives, the lack of centralized sources of information, the lack of computerized data, or even the lack of comprehensive and easily computerizable cultural frameworks. All of this leads to a limited awareness of IT designers about the variety of approaches in cultural studies.

Indeed, acquiring a general understanding of the cultural domain is a particularly intense and time-consuming task for an IT development team that is not always compatible with business constraints. It is however a necessary process for a team in order to ensure that design and development choices are in-line with the objectives of a culture-related project. A generic conceptualization of the cultural domain, neutral and interdisciplinary, would thus be of great interest to IT teams: by extracting the common backbone of cultural disciplines, it should allow better transfer of information from one approach to another as well as new comparison opportunities. Formalisms for interoperability could be extracted from this conceptualization, and would constitute the core of systems that could computerize, centralize, compare, share, and manipulate many kinds of cultural data.

Formal ontology engineering focuses on such objectives. Hence our project aims to apply an ontological analysis to the cultural domain. The ontology we wish to obtain is not to be considered as a cultural theory but rather as a set of formal and neutral definitions of concepts that may be needed by culturally-aware systems in order to address different kinds of cultural issues. Furthermore, by

remaining at a high level of conceptualization, the particular perception of a cultural issue by a specific school of thinking could latter be extended from the work presented in this chapter.

In the next section, we introduce the principles behind the domain of ontology engineering.

ONTOLOGY ENGINEERING

Fundamentals of Ontology Engineering

Ontology

Ontology engineering is currently a hot topic in computer science research. According to the IEEE Standard Upper Ontology Working Group (SUOWG), an **ontology**:

"is similar to a dictionary or glossary, but with greater detail and structure that enables computers to process its content. An ontology consists of a set of concepts, axioms, and relationships that describe a domain of interest." (SUOWG, 2009)

Several applications have been proposed to develop ontologies, the most famous one being *Protégé*[2]. Our project is developed with *HOZO*[3], an ontology editor from Osaka University. HOZO, even if less popular than Protégé, has notable functionalities that are of particular interest for our project. Figure 1 presents the two main representation styles of a fictional ontology in HOZO. We will use it to (a) present additional ontology engineering concepts, (b) to explain the main characteristics of HOZO, and (c) to familiarize readers with the way of understanding screenshots used in this chapter.

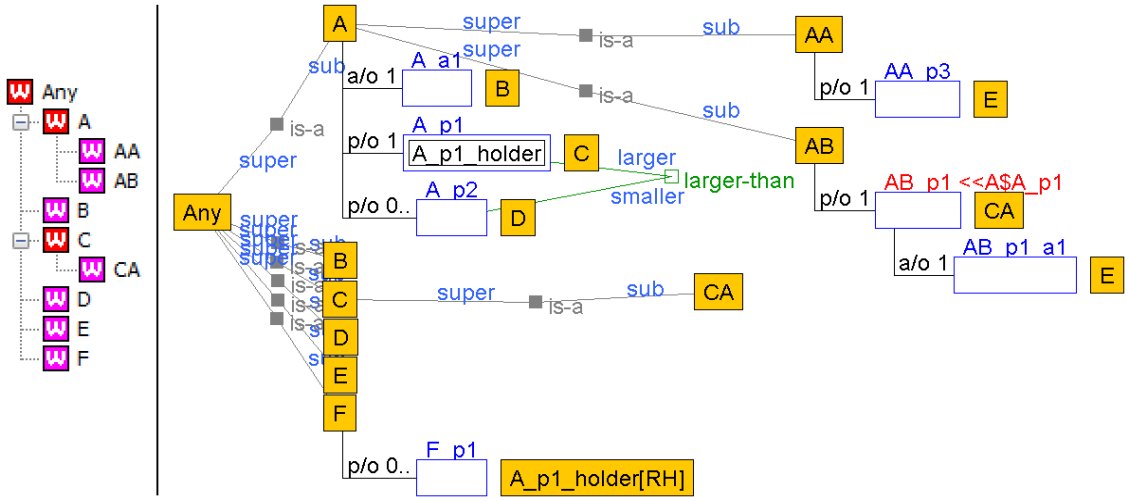

Figure 1. Representations of an ontology in HOZO

Two tree views are available in HOZO in order to elicit and manipulate concepts of an ontology. The one on the left part of Figure 1 is a summary of the information that is presented in the section on the right. Defined concepts appear as rectangle nodes and are organized through a structure of *is-a* relation links, which is a classic way of representing the relation between a concept (**parent**) and its specializations (its **offspring** i.e. children, grand children and so on) in ontology engineering. Hence in figure 1, *AA* and *AB* are specializations of *A*, and *CA* is a specialization of *C*, all concepts being specializations of *Any*, the root concept.

The right section of Figure 1 contains much more information that we will now explain.

[2] http://protege.stanford.edu/
[3] http://www.hozo.jp/

Elicitation of the Internal Structure of a Concept

HOZO uses the internal structure of a concept (its essential features) in order to define its identity rather than solely relying on a label (*A* for instance); this approach is known to promote a common understanding of the concept. Instantiations of structural elements of a concept have to be of a specific kind (or type), which is known as **class-constraint** in ontology engineering: in Figure 1, *B*, *C* and *D* are class-constraints of structural elements of concept *A*. Two kinds of relation links are used to describe a concept's internal structure, and **cardinality** information complements such links:

- **Attribute-of** links (depicted as *a/o*) are used to define essential attributes of a concept. Hence a type-*B* attribute is a necessary element of the identity of *A*. For instance, each *organ* can be assigned a *function*-type attribute (with a potentially multiple cardinality).
- **Part-of** links (depicted as *p/o*) are used to describe essential parts of a concept. *A* should thus be read as having one *C*-type and potentially several *D*-type essential parts. For instance, a *head*-type element could be determined as an essential part of a *human body* (with a 1-cardinality).

Role Assignation to Structural Elements

While acting as class-constraints, type-*B* attribute, as well as types-*C* and *D* parts of concept *A* are also assigned specific **roles**. Those are *A_a1*, *A_p1*, and *A_p2* respectively. HOZO's primary distinguishing characteristic is probably its alignment to an ontological theory of roles (see Mizoguchi et al., 2007). To summarize, should we want to discuss the concept of "*faculty*", we could determine that, among other things, parts of it are "*human being"*-types with a "*teacher*" role (in charge of teaching), and one is a "*human being*"-type with a "*dean*" role (the head of the faculty). Hence in HOZO, "*human being*" would be the class constraint of 2 *p/o* of "*faculty*". For one of these *p/o*, the cardinality would be "*1..*" (i.e. min cardinality set to 1, max not defined), and its role would be "*teacher*"; for the other one, the cardinality would be "*1*" and its role would be "*dean*".

Role classes are original concepts on their own, and as such, their internal structure can also be elicited. This is the case for the *CA*-type part of concept *AB*: its role is *AB_p1* and, as such, it has one defined *E*-type attribute (whose role is *AB_p1_a1*). For instance, using the previous "*teacher*" example, it could thus be mentioned that all "*human beings"* in a "*teacher"* role have a "*specialty"*-type attribute, whose role is "*taught discipline"*.

The ontology developer may also want to clearly specify a label for a particular element of an internal structure of a class-constraint in order to facilitate its unambiguous reuse in other sections of the ontology. Such a thing is known as **role-holder** in HOZO. In Figure 1, *A_p1_holder* is the label given to a *C*-type concept when its role is *A_p1*in the context of an *A*-type concept. *A_p1_holder*-type concepts are parts of an *F*-type's structure, and role-holder specificity is identified with *[RH]* at the end of the label. Following the same "*faculty*" example that we introduced before, "*faculty professor*" could be the label given to a "*human being*" with a "*teacher*" role in the context of a "*faculty*". This could allow disambiguating the identity of a *teacher* in *faculty* from the one from a teacher in *secondary school* environments.

To summarize, the ontological definition of the *A*-labelled concept (its identity) refers to an entity composed of one *C*-type part, whose role is *A_p1* and is labelled as *A_p1*_holder in such situation, and potentially several *D*-type parts, whose roles are *A_p2*. Furthermore a *B*-type attribute, whose role is *A_a1*, also needs to be specified.

Specialization of a Concept

As said earlier, *AA* and *AB* are elicited as specializations of *A* in Figure 1, which means they are full *A*-type concepts with some specific characteristics. In HOZO however, internal structure that has been specified for a concept (the parent) is not necessarily expressed in its specializations (the children or offspring). Only additional information on the internal structure will be expressed such as a new *E*-type part for the *AA* specialization of *A* (whose role-name *AA_p3* expresses that this *E*-type part is the 3rd property of *AA, C*-type and *D*-type parts being the two other ones). Another way to disambiguate a child from its parent is to specify one of its internal part or attribute. For instance, in order to be an *AB*, an *A*-type concept will need its *C*-type part to be a *CA*-type element (*CA* being already a specialization of *C*).

Class-concept versus instance

The ontological definition of an element refers to the definition of a **class-concept** (role, class-constraint, as well as role-holder concepts can all be seen as different kinds of class-concepts). A class-concept can be seen as the objective specification of a notion, and as such, it needs to be instantiated in order to become real. This is similar to defining what a *faculty professor* is (i.e. a human being with a teacher role in a faculty), and saying that there is a faculty professor known as John Smith: "*faculty professor*" is a class-concept whereas *John Smith* is an **instance** of the "*faculty professor*" class-concept.

Being an instance of a class-concept means that if an element of the internal structure of the class-concept (its identity) is not fulfilled, or were to be destroyed, the related instance could no longer exist. For instance, if John Smith were to be fired, his "*teacher*" role would no longer exist, thus the current instance of John Smith as a faculty professor would disappear (even if the instance of John Smith as a human being would normally survive).

Relation-class definition

As seen in Figure 1, several kinds of between-concepts relations are available in HOZO representations of ontology (is-a, part-of, attribute-of, role-of, role-holder-of). However, an infinity of relations could help in understanding the interactions between concepts. Such relations are concepts on their own (**relation concept**) and HOZO allows a developer to describe any such thing in a dedicated frame similar to the right side of Figure 1 (this means that the internal structure of a relation concept can also be elicited). Due to space constraints, we can't present this frame in this chapter. After being elicited, new kinds of relations can be used in the main view of HOZO. For instance, in Figure 1, *A_p1* and *A_p2* are linked with a "*larger-than*"-type relation

Lightweight versus Formal (Heavyweight) Ontologies

There are several more or less rigorous ways of dealing with ontology engineering. Mizoguchi (2003) and others classify ontologies as lightweight or heavyweight. According to Mizoguchi:

- **Lightweight ontology** *"includes ontologies for web search engines like Yahoo ontology which consists of a topic hierarchy with little consideration of rigorous definition of a concept, principle of concept organization, distinction between word and concept, etc. The main purpose of such a hierarchy is to power up the search engine and hence it is very use-dependent."*
- **Formal (heavyweight) ontology** *"includes ontologies developed with much attention paid to rigorous meaning of each concept, organizing principles developed in philosophy, semantically rigorous relations between concepts, etc. Instance models are usually built based on those ontologies to model a target world, which requires careful conceptualization of the world to guarantee of the consistency and fidelity of the model."*

Developing formal ontologies, while much more difficult, presents several advantages compared to lightweight ontology development (Smith, 2003), and is grounded on an unbiased (i.e. domain and application-independent) approach in the conceptualization of reality, with pure objectivity as the targeted horizon on any formal ontology engineer.

By focusing on the elicitation of the internal structure of concepts, HOZO supports the development of heavyweight ontologies. However the quality of the final product always depends on developers' skills and their commitment to their project.

Upper Ontology

An **upper ontology** or **top-level ontology** is a specific kind of formal ontology. According to the SUOWG, an upper ontology:

"*is limited to concepts that are meta, generic, abstract and philosophical, and therefore are general enough to address (at a high level) a broad range of domain areas. Concepts specific to given domains will not be included; however, this standard will provide a structure and a set of general concepts upon which domain ontologies (e.g. medical, financial, engineering, etc.) could be constructed." (SUOWG, 2009).*

Several Standard Upper Ontologies (SUO) have been proposed such as BFO[4], DOLCE[5], SUMO[6], GFO[7] or YAMATO[8]. OpenCyc[9] is another SUO candidate, but its development is less compliant with philosophical achievement than the five previously cited. SUOs try to define top level categories of concepts in order to address any aspects of the world, whether they are concrete or abstract. SUOs are designed to be the foundations of more specific ontologies that could then be used in real applications. Recently, there have been initiatives to explore how conceptualizations of main SUOs match each others (Mizoguchi, 2009b).

In our attempt to conceptualize the cultural domain, we face a major challenge: each culture-related discipline has specific "traditions" for dealing with this domain. Since one of our primary objectives is to allow interoperability of research initiatives from different disciplines and culture-related domains, the ontology we are developing has to remain at a high level of conceptualization and aims "*to serve as common neutral backbone, which would be supplemented by the work of ontologists working in more specialized domains*" (Smith, 2003). It can thus be qualified as an upper ontology even if the conceptual categories we are addressing are a step below those of SUOs. Hence our own work has been grounded on concepts defined in YAMATO and could thus be considered as a cultural extension of this SUO. In the next section, we briefly introduce the main principles of YAMATO.

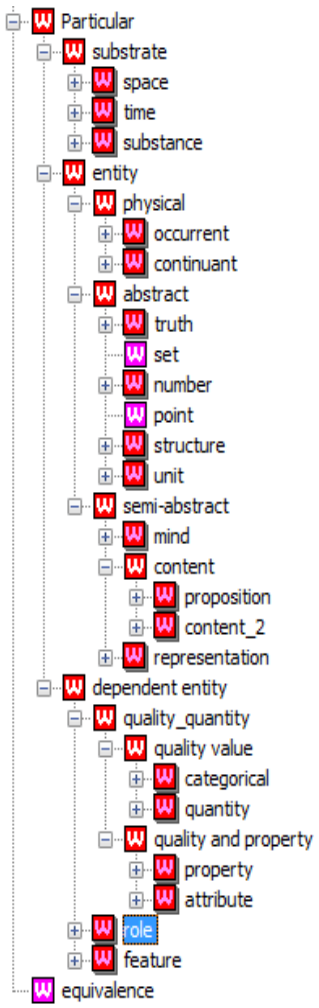

Figure 2. Major concepts of YAMATO

YAMATO: Yet Another More Advanced Top Ontology

YAMATO was first released in 2009 (YAMATO, 2009), and is described in detail in (Mizoguchi, 2009a). Figure 2 presents the main concepts of YAMATO.

Entity

Entity is the root concept for any concept that is related to an element of the real world, and is defined as *"something which exists independently of others"***.** Three families of entities are identified in YAMATO**,** the first two of them (Physical and Abstract) being commonly discussed in the ontology literature**.**

- **Physical** entities are things "*that need both 3D space and time to exist*". It has two sub-categories: **continuant**, covering entities that are mainly considered along with the 3D space (such as **artifact** or **agent**), and **occurrent**, covering entities that are mainly considered along with the time dimension and whose children are **event** and **stative,** the latter including both **process** and **state**.
- **Abstract** entities are "*things that need neither 3D space nor time to exist*". **Truth**, **number or unit** are examples of abstract entity concepts.
- **Semi-abstract** entities are specific to YAMATO and defined as entities that "*need only time to exist*". **Content** must be distinguished from its **representation**, the latter being defined as "*anything which has content as its essentials rather than itself…"*. A **proposition,** such as **information** or **thought,** is an example of a content entity, whereas **computer program**, **painting** or **text** are classic examples of representation entities.

4 http://www.ifomis.org/bfo
5 http://www.loa-cnr.it/DOLCE.html
6 http://www.ontologyportal.org/
7 http://www.onto-med.de/ontologies/gfo/
8 http://www.ei.sanken.osaka-u.ac.jp/hozo/onto_library/upperOnto.htm
9 http://cyc.com/cyc/opencyc/overview

Substrate

Substrate is defined as "*what entities need to exist in the real world*". Not surprisingly, two of its three offspring branches refer to **space** and **time**, used to distinguish the three families of entities. **Substance** is the parent concept of the third branch (for instance, previously mentioned artefact entities not only will have to be defined in time and space, but also according to the substances from which they are made).

Quality_Quantity

Distinctions between quality-related concepts are currently the subject of intense discussions between ontology specialists, and are not adapted for the non-specialist audience of this handbook. Readers interested in learning about YAMATO's quality approach are invited to consult (Mizoguchi, 2009a).

To summarize, a quality cannot exist alone: it is "*a certain dependent property possessed by an entity*". A quality keeps its identity even if its **quality_value** has changed, the latter being either **quantitative** (like a length) or **categorical** (like a colour). **Attribute** and **property** are two ways of expressing quality in YAMATO: attribute refers to a genuine quality type such as "*length"* or *"weight",* whereas property refers to a quality taking a certain value, for instance "*150 cm long*".

THE UPPER ONTOLOGY OF CULTURE PROJECT

Objectives and Potential Techno-Cultural Challenges of the UOC

As mentioned in the introduction, the UOC aims at proposing a neutral, theory-driven, conceptualization of the cultural domain, and as such it addresses several objectives related to the development of culturally-aware technology:

1. To allow IT development teams to deal with cultural considerations in a scientifically-sound and cross-disciplinary way, i.e. to propose appropriate guidelines on what development teams should focus on when addressing a specific cultural issue,
2. To suggest ways of appropriately computerizing cultural aspects of a given problem by suggesting templates for theory-driven data structures and data management processes,
3. To promote interoperability by enforcing the consistency of cultural data modelling between systems, thus facilitating reuse of computerized cultural data,
4. To promote cultural automatic reasoning, thus allowing systems to take culturally-informed decisions that may impact on their internal processing as well as on human-computer interaction.

Hence, the UOC may help to tackle several techno-cultural challenges such as:

- Developing realistic 3D representations of past and contemporary cultural environments (Pavlidis et al., 2007) as well as common artefacts such as clothes or tools, and potentially using them adequately for an educational purpose (see Ogan & Lane, 2010).
- Developing realistic (groups of) embodied Enculturated Communication Agents (ECA: Rehm, 2010; Endrass et al., 2010). This implies embedding specific cultural knowledge (Henrich & Boyd, 2002; Pyysiäinen, 2002; Scharifian, 2003; Dawkins, 2006) into cognitive agents (Johnson et al., 2005; Miller et al., 2010; Rehm et al., 2009; Blanchard, et al., 2009a), specifying a spectrum of common interaction and communication behaviors with compatriots, foreigners, as well as with their environment (Rehm, 2010; Endrass et al., 2010), detailing physical characteristics, and so on. This lies in the not-so-new computational anthropology initiative of developing artificial cultures by computational means (Gessler, 1994; Gessler, 2002). Concerns about the heterogeneous nature of a cultural group could also be addressed. Indeed cultural group members vary in their endorsement of their culture (Scharifian, 2003), and sub-cultures also exist.
- Developing culturally-aware adaptive techniques to take into account cultural characteristics of users of an application (Blanchard, 2009). This implies determining the cultural profile of such users, which is not a trivial task on its own (Reinecke et al., 2010). This information then

has to be adequately embedded in adaptive processes in order to enhance the efficiency of the system, the interest users may develop in (re)using it, as well as to avoid the use of references that may conflict with user-endorsed cultural norms.

- Translating into a common format data gathered from different sources such as museum collections, anthropological databases (HRAF, 2009), empirical data, or cross-cultural studies (Schwartz, 1992; Hofstede, 2001; House et al., 2004), This would facilitate their use in different contexts. Indeed, such data could be used at different technical development steps (3D representation, behavioral and cognitive modelling of ECAs, adaptive processes, embedding information within the environment). Furthermore, the UOC could help to develop formalized techniques for enhancing the traceability of cultural data (how it was obtained/collected/discovered/manipulated) in order to improve the quality and credibility of information that culturally-aware systems can rely on..
- Developing culturally-aware systems in a reproducible manner in order to make the development of similar applications for other countries easier, or to later extend possibilities of a system with additional cultural functions and information.

Some of the cultural challenges we mentioned above are already addressed by various research teams. The main difficulty lies in having a coherent approach when considering several of them together. This is the very purpose of the UOC development: to come up with a general and neutral framework of the cultural domain in order to address any kind of cultural issue in a neutral and theory-grounded manner. Interests of the UOC are however not restricted to the examples mentioned above, and many other culturally-aware systems should benefit from the development of such cross-disciplinary cultural conceptualization.

Ontological Conceptualizations of Culture-Related Domains

The conceptualization of some additional domains is required in order to adequately model core cultural concepts of our upper ontology of culture. Thus, in this section, we discuss the conceptualization of three culture-related domains. They have to be considered as full parts of the UOC.

Firstly, a model of the *cognitive domain* is required because cultural experiences are strongly mind-related (Nisbett & Norenzayan, 2002). Having a model of the *affective domain* is also important, cultural and affective experiences being strongly intertwined (Mesquita et al., 1997). Finally cultural experiences have to be understood as being context-sensitive in order to correctly address them. The UOC conceptualization of *context* is the subject of the first part of this section.

Conceptualization of Centered Context

It is necessary to consider cultural elements and experiences within their context or situation. Context-awareness is already a hot topic in Human-Computer Interactions (Dourish, 2001; Greenberg, 2001). Rohlfing and her colleagues (Rohlfing et al., 2003) propose that a situation can be defined as "*the spatio temporal ordering of agents alongside physically-constraints or characteristics*" and a context as "*a general construct that depends on various factors and is defined on at least two different levels*", a global level (such as a socio-cultural context) and a local level (such as a meeting context). In their approach, "*a situation is thus embedded in a certain context*". Even if several aspects of their work are very inspiring, we think that, strictly speaking, disambiguating context and situation refers more to a terminological issue than to a conceptual one since these terms are used interchangeably most of the time.

A frequent use of context/situation is also linked with a memory-recall process (for instance if you are asked to imagine yourself in a medical or meeting context). This is a different concept that we will describe along with our conceptualization of the cognitive domain. In this section the notion we want to discuss is referred to with the term **centered context.**

Centered Context is grounded on the idea that "*contexts have an infinite dimension hence they cannot be described completely*" (Dichev et al., 2007). Dourish (2001) especially advocates the interest of not only considering spatio-temporal dimensions but also other dimensions such as the social one or the cultural one. Hence, we see a context as multidimensional and infinite and, as such,

its complete description can not be achieved. Rather, the description of specific dimensions should be favoured according to its expected use,. A centered context is thus seen as a limited context, whose focus is on the description of specific, more or less complex, dimensions (for instance the spatial one, the social one, the cultural one, and so on). Figure 3 presents our conceptualization of centered context.

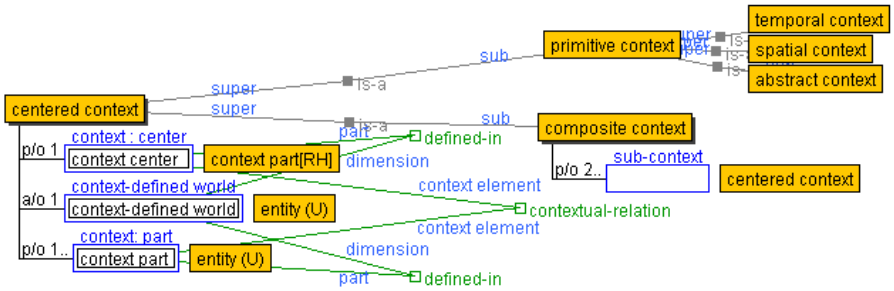

Figure 3. UOC conceptualization of centered context with HOZO

Centered context is defined in a given **world** such as the spatial world, the social world, the political world, the cultural world, and so on ("world" here refers to a specific referential frame). It consists of a subset (its **parts**) of all the elements that may be defined in this world. All these parts surround a specific part of the context (its **center**) and are related to the latter according to **contextual relations**.

Contextual relations are essential to the description of a centered context and are world-specific: for instance, spatial relations (next-to, near-to, on-the-right-of…) can't be used for describing social worlds. In this case, social relations are required (son-of, friend-of, boss-of…).

There is no structural differences between micro and macro levels (sometimes called local and global levels). However, a macro/micro distinction may emerge in some specific worlds according to the kinds of parts that are considered, and to relations that are defined for the sake of linking such parts. In a spatial world, *country areas* are obviously macro parts whereas *rooms of a house* may be considered as micro ones to some extent. A relation *has-border-with* linking two countries may thus be seen as a macro relation, whereas *next-to* linking two rooms would be considered as a micro one. Indeed it appears that micro/macro distinctions are relatively subjective in nature.

Centered contexts can be more or less complex. In **primitive contexts**, only one dimension is discussed that is either **spatial** (with relations such as next-to, near-to, on-the-right-of…), **temporal** (with relations such as *prior-to*, *after*) or **abstract** (the social context introduced above is a kind of abstract context). However, most of the time, primitive contexts are too limited for providing sufficient context awareness.

Composite contexts are thus defined as associations of several (primitive or composite) centered contexts (i.e. **sub-contexts**). Hence they relate to several worlds. For instance, should we wish to define the geopolitical context of an element, we have at least to consider elements/relations defined in the geographical world and in the political world, but also some that are specific to the geopolitical world. A composite context is thus more complex than just the sum of its sub-contexts. Furthermore, the complete description of a composite context may be difficult to achieve (this is the case for a cultural context) because the exact list of sub-contexts is hard to determine. People eliciting such contexts may then choose to describe a limited list of specific sub-contexts according to their needs.

Finally, meaningful interpretations are sometimes associated with contexts. This can be achieved by assigning a role-concept (and a role-holder label) to a centered context. Indeed a composite context can be labelled as a "*meeting context*" and have additional structural parts explaining socio-cultural meanings and implications. Expressing qualities of a context may be another interesting usage of the ontological role paradigm: a "*dangerous context*" is a regular context that has "dangerous" as a qualitative attribute (this may then require to define other necessary conditions).

Conceptualization of the Cognitive Domain

As mentioned earlier, the cultural domain cannot be modelled adequately without considering its cognitive dimension (Nisbett & Norenzayan, 2002). In this section we describe the cognitive conceptualization we adopted in the UOC.

Firstly, **mental processor** refers to any structure in charge of processing/treating cognitive information. Figure 4 presents the *is-a* tree of mental processor.

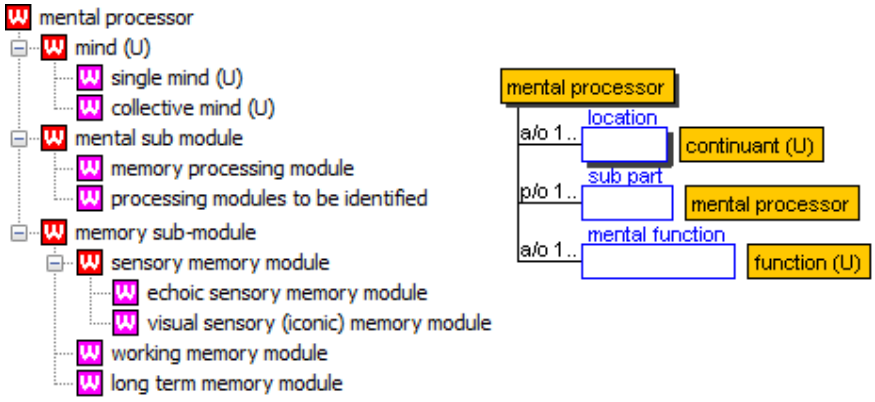

Figure 4. UOC is-a tree and conceptualization of mental processor

In the UOC (as in YAMATO), top mental processors are **single mind** (located in the brain of a singleton agent such as a human being) and **collective mind** (located in the brain of a complex agent i.e. a group of several agents such as a cultural group). Jerry Fodor's seminal idea that mind is composed of separate specialized modules in charge of specific cognitive functions (Fodor, 1983) brings us to the identification of **Sub-modules of top mental processors**. They are mental processors on their own.

Until now, our conceptualization of the cognitive domain in the frame of artificial cultural awareness development has mainly focused on the **memory processor** in charge of memory management functions. We refer to the Atkinson-Schiffrin Model (ASM) that identifies the following three kinds of **memory sub-modules** (Atkinson & Schiffrin, 1968):

1. **Sensory memory module** for sensory information retained after the end of the sensory experience. To our current state of understanding, this module doesn't seem to be particularly related to cultural issues. It is however mentioned to demonstrate the consistency of our conceptualization with previous work.
2. **Long term memory module** for long term information storage.
3. **Working memory module** (also known as short term memory) where information is retrieved from the long term memory in order to be processed. It is frequently described as a limited buffer.

Further refinements in memory conceptualization have been proposed. For instance, Baddeley and Hitch (1974; see also Baddeley, 2000) distinguish several kinds of working memory modules. The ASM conceptualization of memory can however be seen as the common ancestry of memory representations in many modern cognitive architectures of the mind such as SOAR (Laird et al., 1987), ACT-R (Anderson et al., 2004), EPIC (Meyer & Kieras, 1997), or the recent CLARION (Sun, 2006) and, as such, it is an ideal "neutral backbone" for our conceptualization (see the previous section on ontology engineering). This would not restrict further specification of our mental processors in order to adequately represent modules of more modern cognitive architectures.

As mentioned earlier, memory sub-modules process cognitive information. Such information is indeed referred to as **cognitive information** when stored in the long term memory module. However, when being cognitively processed within a working-memory module, it is then referred to it as a **thought** (here one can see an analogy with computer science concepts of *instructions* and *tasks* respectively)**.** Figure 5 presents concepts related to cognitive information.

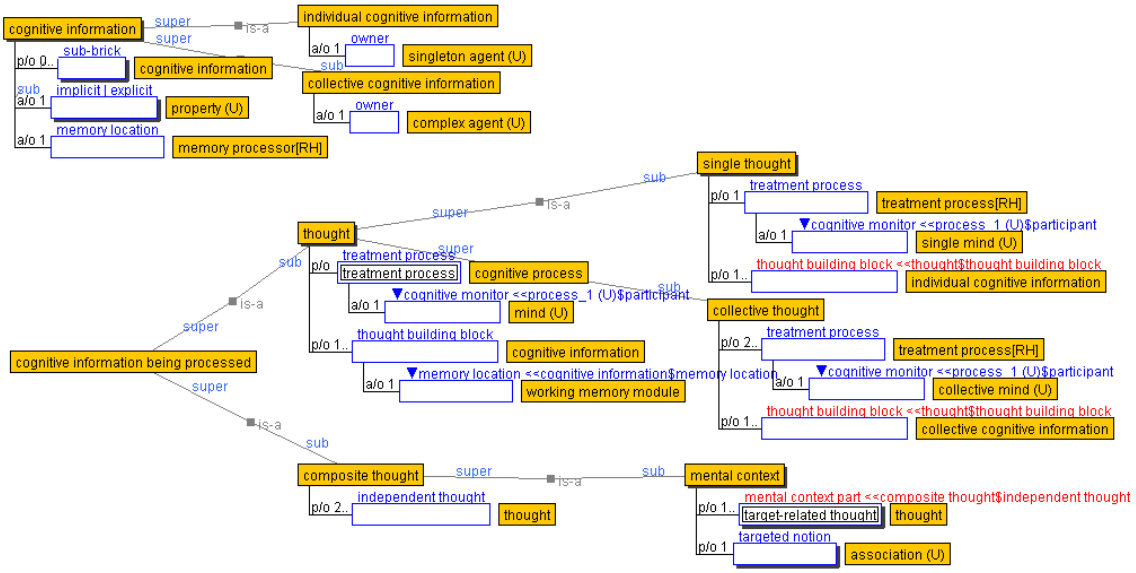

Figure 5. UOC conceptualization of cognitive information with HOZO

When cognitive information is owned by a singleton agent, it is labelled as **individual cognitive information**, and when it is owned by a complex agent, it is then labelled as **collective cognitive information**. Cognitive information always has a **memory locator** that depends on the way the related top mental processor is structured. For instance, the memory locator of a collective mind may refer to a collection of memory modules distributed among several singleton agents.

Anderson (1976) described two kinds of cognitive information, declarative cognitive information to represent facts, and procedural cognitive information to represent procedures or skills. Nowadays explicit memory is frequently used as a synonym of declarative memory whereas procedural memory is said to be a specific kind of implicit memory (along with other kinds of cognitive information such as simple classic conditioning i.e. reflex for instance. See BRAIN, 2009). In UOC, since the structure of cognitive information remains the subject of intense debate, we chose to conceptualize this point as an **implicit or explicit property** for cognitive information. Other cognitive information types such as episodic and semantic cognitive information (Tulving, 1972), could also be defined as specializations of cognitive information .

Shared cognition is a dynamic research trend that studies mental information emerging from collective minds (Tumer & Wolpert, 2004; Panzarazas & Jennings, 2006). In the UOC it is labelled as **collective cognitive information** and could be used to represent culture-specific information such as *shared interpretations of elements*, *stereotypes* or *myths*.

A thought is composed of one or more cognitive information elements that are being processed all together through a **treating process** (for instance if you see a rose and think that "*this rose is beautiful*", it means that you understand the concepts of *rose* and *beauty*, and dynamically make an association between them). Similarly to cognitive information, **single thought** is distinguished from **collective thought,** with several cognitive processes jointly treating collective cognitive information in the latter case**.**

Several independently-processed thoughts can also be linked together. The result is labelled as a **composite thought**. For instance, **mental contexts** that we have introduced in the context section are composite thoughts: if you are asked to think about a hospital context, you may think about several thoughts that are rather independent from each other such as: "*there are physicians in a hospital*", "*a hospital is a clean building*", and "a *medical context potentially implies injections of drugs*". It is to be mentioned that mental contexts strongly refer to personal experience and, as such, are culturally-sensitive. For instance, a Japanese person would probably consider "*wearing a medical mask*" as part of his/her hospital context because it is mandatory as soon as you enter Japanese hospitals. This is however not the case in many other countries.

Conceptualization of the Affective Domain

Affective and cultural domains are strongly intertwined (Mesquita, 2001; Elfenbeim & Ambady, 2003; Scollon et al., 2004; Mauss et al., 2008; Scherer & Brosch, 2009). Affective phenomena frequently arise from cultural situations. Reciprocally, culture frequently influences affective experiences. Research has "*convincingly demonstrated that there are cultural differences in the ecology of emotions*" (Mesquita et al., 1997). Hence, the necessity of a conceptualization of the affective domain in the UOC is obvious.

Addressing the affective domain in a scientific and consensual manner however remains complex for several reasons (Blanchard et al., 2009). For instance, affect-laden words are frequently used interchangeably (Ketal, 1975; Owens & Maxmen, 1979; Linnenbrick, 2006; Scherer, 2005), and do not always convey the full spectrum of an affective experience, which may lead to overgeneralization (Schwarz & Skurnik, 2003). To address this issue, psychologist Klaus Scherer produced a framework of the affect domain that adopts an approach similar to ontology engineering in many respects (Scherer, 2005).

Scherer clearly discriminated six different affective processes from each other according to several design features (*event focus*, *appraisal driven*, *response synchronization*, *rapidity of change*, *behavioral impact*, *intensity*, *duration).* They are all described as multi-component processes that involve various physiological, cognitive, and behavioral subsystems (Scherer, 2005). Their descriptions are presented in Table 1.

Table 1. Scherer's classes of affective processes (extracted from Scherer, 2005)

Affective Process	**Definition**
Emotions	- "*An episode of interrelated, synchronized changes in the states of all or most of the five organismic subsystems in response to the evaluation of an external or internal stimulus event as relevant to major concerns of the organism*". - Emotion can be distinguished from feeling, an emotion being *"the total multimodal component process*", whereas a feeling is *"a single component* [of any affective process] *denoting the subjective experience process"*. - Disambiguation between aesthetic emotions *("produced by the appreciation of the intrinsic qualities of the beauty of nature, or the qualities of a work of art or an artistic performance")* and utilitarian emotions *("facilitating our adaptation to events that have important consequences on well-being").*
Moods	- "*Diffuse affect states, characterized by a relative enduring predominance of certain types of subjective feelings that affect the experience and behavior of a person*"; - "*Often emerge without apparent causes*"; - "*Generally of low intensity*"
Preferences	- "*Relatively stable evaluative judgments in the sense of liking or disliking a stimulus, or preferring it or not over other objects or stimuli*"
Attitudes	- "*Relatively enduring beliefs and predispositions towards specific objects"* - *"Can be labelled with terms such as hating, valuing or desiring*"
Affect dispositions	- "*Tendency of a person to experience certain moods more frequently or to be prone to react with certain types of emotions*"
Interpersonal Stance	- "*Affective style that spontaneously develop, or is strategically employed in the interaction with the person or a group of persons*" - "*Examples: being polite, distant, cold, warm, supportive, contemptuous*" - "*Often triggered by events (encounter of a person), but less shaped by spontaneous appraisal than by affect dispositions, interpersonal attitudes, and most importantly strategic intentions*".

The UOC conceptualization of the affective domain, presented in Figure 6, is strongly inspired by Scherer's meta-analysis.

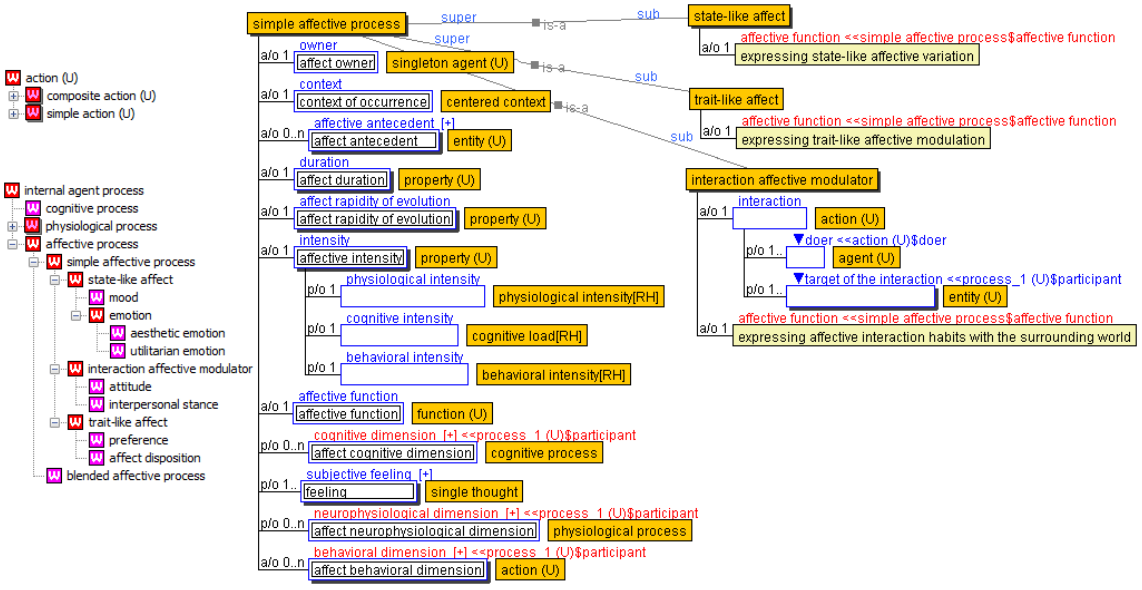

Figure 6. UOC is-a tree and conceptualization of affect-related concepts with HOZO

Like cognitive and physiological processes, an **affective process** is a kind of **internal process**. As stated by Scherer, multiple cognitive processes comprise the **cognitive dimension** of an affective process and multiple physiological processes comprise the **neurophysiological dimension**. Since an agent's behavior is labelled as **action** in YAMATO, then, similarly, multiple **actions** (i.e. behavioral processes) compose the **behavioral dimension** resulting of the occurrence of an affective process.

An affective process is also identified according to several attributes. It is **owned** by a singleton agent and has a **context of occurrence**. It may result from an **affective antecedent** and is characterized by its **duration**, its **rapidity of evolution**, and its **intensity**. Intensity is composed of a **physiological intensity** (i.e. the intensity of biological reactions), a cognitive intensity frequently labelled as **cognitive load** (i.e. the impact of the affective process on the working memory module), and a **behavioral intensity** (i.e. the intensity of resulting behaviors). In (Scherer, 2005), the importance and potential values of each of those attributes in the definition of each affective processes are clearly stated.

In the UOC, we endorsed the list of affective processes defined in Scherer's framework (see Table 1). However major structural distinctions exist between (1) **mood** and **emotion** that are labelled as **state-like affects** and "*reflect a response to the changing environment that is based on the situation and is less stable over time"* (Linnenbrick, 2003), (2) **preference** and **affect disposition** that are labelled as **trait-like affects** and **"***reflect a general way of responding to the world, which varies by person, but are relatively stable"* (Linnenbrick, 2003), and (3) **interpersonal stances** and **attitudes** that are labelled as **interaction affective modulators** because they regulate interaction of their owner with the environment.

Finally, a **blended affective process** describes an affective experience, whose components (i.e. affective processes) are intertwined and cannot be considered individually.

Ontological conceptualization of culture and its implication at individual and group levels

In this section, we finally discuss core cultural concepts within the UOC. Many different studies from various research fields have inspired this conceptualization. This includes, but is not limited to, research in philosophy (Pyysiäinen, 2002; SEP, 2009), in psychology (Bronfenbrenner, 1989; Cooper & Denner, 1998; Ekman, 1972; Elfenbeim & Ambady, 2003; Kashima, 2000; Mesquita et al., 1997; Oishi, 2004; Schwarz, 1992), in business & management (Earley & Mosakowski, 2004; Hofstede, 2001; House et al., 2004), in anthropology (Dawkins, 2006; Henrich & Boyd, 2002, HRAF, 2009), in cognitive sciences (Nisbett & Norenzayan, 2002; Scharifian, 2003), archeology (NADB, 2009, TMP,

2009), and even in computer science (Gessler, 1994; Gessler, 2002; Gilbert & Troitzsch, 2005; Tumer & Wolpert, 2004).

Merging all those sources led us to propose ontological answers to the questions pertaining to (1) the identity of culture, as well as to cultural implications at (2) individual and (3) group levels. We think those three aspects cannot be discussed individually, and must be considered together. Hence, Figure 7 presents the conceptualization of **culture** within the UOC, as well as the **enculturated agent** and the **enculturated complex agent** concepts describing how culture is to be integrated at individual and group levels respectively.

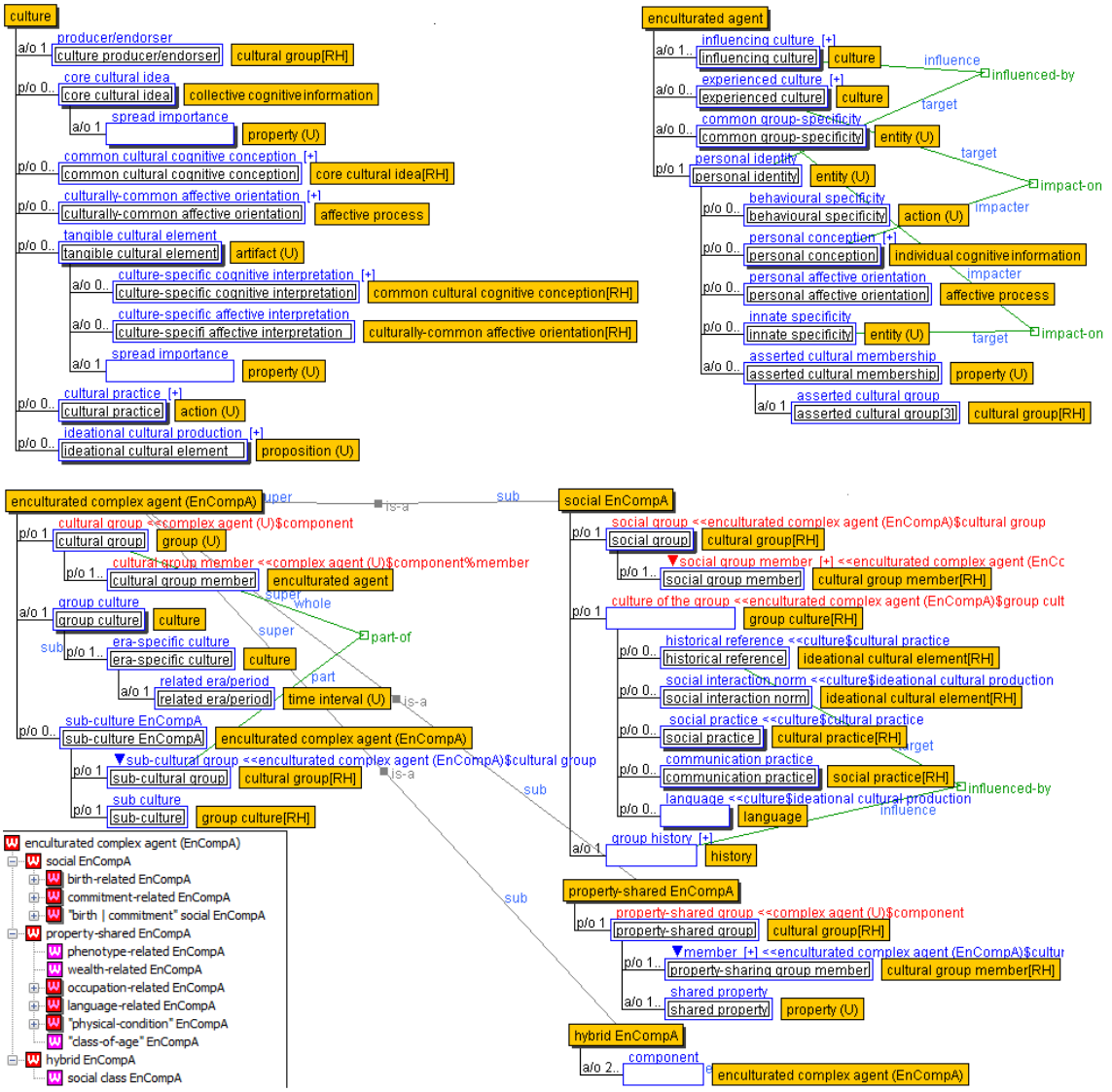

Figure 7. UOC conceptualization of culture, enculturated agent, and enculturated complex agent with HOZO

Culture, **enculturated agent**, and **enculturated complex agents** (EnCompA) are subject to interdependent definitions in the UOC. A culture is seen as an accumulation of elements produced or integrated (endorsed) by a cultural group i.e. a coherent population of singleton agents that are thus said to be enculturated. A culture cannot exist without the cultural group that created it and, reciprocally, a group cannot be said to be cultural if it does not possess its culture. Hence an EnCompA is defined as the association of cultural group and its related culture.

Cultural Elements

Cultural elements are either the direct production of a cultural group, or elements that this cultural group has borrowed, integrated, and potentially adapted from another cultural group through group-level interactions such as conquests for instance. Cultural elements have to be considered at group level and are not necessarily homogeneously known/accepted/endorsed by members of their related cultural group. However, an elements still needs to be endorsed by a significant portion of a cultural group in order to be considered as a genuine part of its culture . The endorsement diffusion of an element within its related cultural group is expressed with the **spread importance** property.

Different kinds of cultural elements exist:

- **Core cultural ideas** refer to collective cognitive information that may emerge from the collective mind of the EnCompA. Hence they represent information shared by members of the related cultural group such as myths, stereotypes, beliefs, common cultural interpretations, and so on.
- **Tangible cultural elements** refer to artefacts that have been created/adopted, or are commonly used by cultural group members (for instance tools, pieces of furniture, but also food).
- **Cultural practices** refer to simple behaviors (body language) or more complex ones (for instance rituals) that are well spread and endorsed within the cultural group membership.
- **Ideational cultural elements** refer to original propositions or refinements that have been consciously constructed within a cultural group. For instance, "the republic" is a concept that emerged from Greek thinkers and was endorsed by their society. Later it was adopted and modified by many other cultural groups. Science discoveries, laws and formal norms are other examples of ideational cultural elements.

Potential **cognitive** and **affective interpretations** of a cultural element within its related group are very important for describing the identity of this element (in Figure 7, they are only shown for tangible cultural elements, but other kinds of elements are also subject to similar interpretations). A cultural element can indeed be linked with specific cognitive interpretations within a cultural group. For instance, people familiar with the French culture are likely to easily associate "*General de Gaulle*", a French major historical figure, with a well-known radio message known as "*Appel du 18 Juin*" and/or with ideas pertaining to the *French doctrine of international independency*. A cultural element can also be commonly related to affective reactions. For instances, after an international conflict, a controversial person may be seen as a hero within one cultural group, and as a war criminal within another one, thus stimulating antagonist affective reactions. Body language acts are also known to be cognitively (meaningfully) and affectively interpreted differently from one cultural group to another.

Personal Identity and Cultures

The identity of an enculturated agent depends on complex interactions between his/her personal identity and potentially several different cultural influences. In the UOC, the personal identity of an enculturated agent refers both to **innate characteristics** (such as his/her phenotype i.e. his/her observable characteristics), and to acquired/developed characteristics, the latter including his/her **affective orientations**, his/her **behavioral characteristics,** and his/her **personal cognitive conceptions.** Such conceptions can notably be related to the subjective perception of an agent regarding his/her memberships to different cultural groups (**asserted memberships**). Still, they do not necessarily model correctly the cultural influences that impact on the agent.

Acquired/developed characteristics of the personal identity of an agent can result from personal experiences, They can also be the result of cultural pressures. Indeed, cultures can affect an agent in two different manners:

- A culture is defined as an **influencing culture** when its related cultural elements are commonly and, to a certain extent, unconsciously endorsed by the agent. They become genuine parts of his/her personal identity.
- A culture is defined as an **experienced culture** when the agent had a certain access to it. thus leading to the generation of cultural understandings and interpretations. Those understandings/interpretations may be influenced by pre-existing personal conceptions. They are then integrated (acquired elements) but still remain clearly identified as "foreign elements" Furthermore, their use may sometimes be incorrect if their interpretation is false.

As mentioned previously, cultural elements are not diffused homogeneously within a cultural group. Hence a culture is said to affect an agent as soon as a sufficient number of cultural elements is known or internalized by the agent.

Distinctions between Classes of Enculturated Complex Agents

As said earlier, the identity of an EnCompA mainly refers to a culture and to its related cultural group. In some cases, sub-EnCompA can also be described by identifying a **sub cultural group** of enculturated agents who share a specific culture (**sub culture**) that other members of the main EnCompA do not know/endorse. For instance, a youth sub-culture can be identified in many countries. Members of a sub-culture can endorse additional cultural elements. They can replace cultural elements from the dominant culture by other ones.

Furthermore, cultural development being a never-ending process, it is sometimes possible and useful to consider the status of a culture at a certain period of the history. This is labelled as **era-specific culture** in the UOC. Several sub-cultures of a main culture can co-exist, but that is not possible in the case of era-specific cultures since they are defined sequentially. Sometimes a formal name can be attributed to an era-specific culture. For instance, Edo culture, and Meiji culture are Japanese era. Overall, any date-to-date specification can be enough to specify an era. For instance current US youth sub-culture is different than US youth sub-culture during the 1985-1995 period.

Culture, sub-culture and era are notions that are frequently country-specific. However, cultures can be attached to many other kinds of groups, thus forming an EnCompA. Hence in the UOC, various kinds of EnCompA are proposed. We now present the first levels of criteria for the disambiguation of EnCompA.

In **social EnCompA**, the group cohesion results from social interactions between group members. There are different way of becoming a member of a social EnCompA: (a) only by birth (one can be considered an Apache - **ethnic nation**, to be distinguished from appearance/phenotype-based grouping - only if at least one of his/her parents is already an Apache), (b) only by commitment (one can be part of a **business organization** only if he/she decides he/she wants to, or if someone forces him/her to be), or (c) by both (one can be a German – **civic nation** - because he/she has a German parent or because he/she obtained citizenship by legal means). The social nature of such EnCompA may imply specific socio-cultural elements such as **social practices**, (**communication practices** being particular ones), and **interactions norms** to inform the use of social practices. As mentioned previously, there exists many potential social EnCompA subtypes such as *ethnic nation*, *civic nation*, *tribe*, *belief-based EnCompA*, *business company*, *academic EnCompA*, and *military EnCompA*. Furthermore, in the Internet age, social services can be provided through communication tools (such as chat and forums for instance) to various communities that would otherwise be composed of socially-isolated learners, thus revealing a new social dimension.

In **property-sharing EnCompA**, group cohesion depends on a common non-social property shared by group members. Many different non-social properties are commonly adopted to discriminate EnCompA and some are frequently used in academic research : shared phenotype (*Black, Caucasian, Asian*…), wealth level (*rich, poor, middle class*), work or leisure occupations (soccer *fans, farmers, scientists*…), language (*English speaking people, Arabic speaking people*…), physical condition (*deaf people, blind people*) to cite but a few. To support the study/use of property-shared groups as cultural groups, it is suggested that people sharing a specific property are likely to better understand each others because they are familiar with similar information, living conditions, or shared experiences. Sometimes it is however questionable whether such categorizations are realistic, and actually reflect a cohesive cultural group.

Risks of oversimplification are huge when defining an EnCompA with only one property, whether it be social or not. Associations of property are possible and well suited in many cases: they are labelled as **hybrid EnCompA**. Indeed using only a phenotype attribute such as *Black* to design an EnCompA is very fuzzy since it may reflect very different realities among its members. However, the association of the Black phenotype attribute with the US civic nation allows to describe a US minority, and to discuss social variations. EnCompA can thus be defined with many degrees of specialization (*Irish Catholic American, Asian-American middle class, Canadian citizen of Indian ancestry and living in Toronto, French-speaking Belgians*, and so on). Such accumulation of properties is a common practice in human and social sciences. However not all associations are possible in any

circumstances: in France for instance, phenotype-based comparisons are proscribed by law whereas they are of common use in the USA.

The definition of cultural groups is a highly sensitive and ethical question. It is thus to be noticed that the conceptualization of EnCompA proposed in the UOC focuses on including all potential approaches for the definition of cultural groups. It does not make claims about their veracity, relevance, and/or acceptance. They are indeed subject to variations from one school of thinking to another, from one cultural group to another.

FUTURE TRENDS

Refinements of some aspects of the UOC are necessary to further explain important aspects of the cultural domain. More precisely, we are currently focusing on improving UOC concepts referring to *communication*, as well as to *history*, two domains that have just been briefly considered in the version presented in this chapter.

Communication

As social animals, human beings are provided with communication skills. However the level of communication complexity and the variety of communication forms have risen to a much greater extent in mankind compared to other species. Indeed, there are many cultural concepts in the communication domain such as formalized languages, writing systems, body-based communication (sometimes referred to as body language), meaningful ceremonials and symbolisms, oral traditions to cite but a few.

In the UOC, the communication domain is currently addressed in a limited manner with communication practices defined as cultural elements produced by a social EnCompA. However the ability to process communication-related concepts is of major importance for many culturally-aware systems. Developing cultural communication skills is indeed the principal objective of several culturally-aware projects (see Ogan & Lane, 2010). Initiatives on intangible cultural heritage (UNESCO, 2009) also consider several communication elements, and a better UOC conceptualization of communication-related concepts could help to instigate the development of further applications tailored for ensuring their study, their wide dissemination throughout the population, and more importantly the preservation of some of them that are highly at risk of vanishing (SOROSORO, 2009).

Among other sources, we are currently considering Claude Shannon's theory of communication, and more particularly the general communication system he has proposed (Shannon, 1948), research in anthropology (Bonvillain, 2008), in the specific field of oral traditions (Foley, 1998), and dedicated to the study of writing systems (Coulmas, 1996) in order to determine basic communication-related concepts to be integrated in the UOC. Some of the communication-related objectives that we want to address in the UOC include, but are not limited to, expressing the structure of the various kinds of communication acts, messages, languages, symbol systems, writing systems, and non-verbal communication, as well as determining relations between communication and the culture-related domains already defined in the UOC (i.e. context, affect, and cognition). .

History

History is a very difficult domain to conceptualize in a neutral and consensual way. Our preliminary analysis of History is mainly inspired by the interesting summary of research made by Daniel Little (Little, 2007).

Little describes the human historical process as "*a temporally ordered sequence of events and processes involving human doings, within which there are interconnections of causality, structure, and action, within which there is the play of accident, contingency, and outside forces*" (Little, 2007). He also explains how to nurture this process: through "*facts in the present—ruins, inscriptions, documents, oral histories, parish records, and the writings of previous generations of historians—to support inferences about circumstances and people in the past*" (Little, 2007). Concepts will have to be determined to describe archaeological, anthropological, and historical procedures of analysis.

Whether historical objectivity can be obtained is a long-lasting question because, as for a culture, the historical process is too broad to be fully modelled:

"To single out the history of something specific […] is unavoidably to select, from the full complexity of events and actions, a limited set of related historical features that will be traced through a process of development. And this in turn raises the point that "history" depends partly on "what occurred" and partly on "what we are interested in." (Little, 2007)

Furthermore, the notion itself of "*objective history*" is limited to simple historical facts, whereas considering higher order historical events will necessarily imply interpretation, thus provoking (conscious or unconscious) subjectivity and raising the risk of controversies:

"The past occurred in precisely the way that it did—agents acted, droughts occurred, armies were defeated, new technologies were invented. These occurrences left traces of varying degrees of information richness; and these traces give us a rational basis for arriving at beliefs about the occurrences of the past. So we can offer a non-controversial interpretation of the "objectivity of the past." However, this objectivity of events and occurrences does not extend very far upward as we consider more abstract historical events: the creation of the Greek city-state, the invention of Enlightenment rationality, the Taiping Rebellion. In each of these instances the noun's referent is an interpretive construction by historical actors and historians, and one that may be undone by future historians."(Little, 2007)

While ensuring the objectivity of a culturally-aware system is far beyond the scope of the UOC and will remain a prerogative of its development team, the UOC still has to provide all the necessary conceptual tools to coherently computerize notions such as non-definitive claims, hesitations, incompleteness of knowledge or competing/controversial interpretations of historical traces and events.

CONCLUSION

In this chapter, we have presented results of a thorough formal ontology analysis that we have applied to the cultural domain. The fundamental concepts of our Upper Ontology of Culture (UOC) have been obtained by identifying the common backbone of culture-related disciplines and activities, and are of interest for the development of a variety of culturally-aware technologies and applications.

As a neutral and interdisciplinary conceptualization, the UOC proposes (a) theory-grounded guidelines on what IT development teams should focus on when addressing a specific cultural issue, (b) ways of appropriately computerizing cultural aspects of a given problem by suggesting templates for theory-driven data structures and data management processes, (c) ways of promoting interoperability by enforcing the consistency of cultural data modelling between systems, thus facilitating their reuse, and (d) hints for developing automatic reasoning processes that should allow systems to take culturally-informed decisions.

Developing the UOC is a long journey, and refinements and extensions are already in process. The UOC has to be understood as a meta-approach to the cultural domain (discipline and application-independent), which means that adaptations of our conceptualization will be necessary when integrating UOC conceptualization to the design and runtime processes of information systems.

Finally, a successful ontology requires a certain level of endorsement from a community. Thus, the evolution of our project will imply discussions, corrections, and agreements with other scholars, as well as the successful development of UOC-grounded applications.

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REFERENCES

ACA. (2009). *Arab Cultural Awareness: 58 factsheets*. Retrieved September 28, 2009, from http://www.fas.org/irp/agency/army/arabculture.pdf

Arroyo, I., Cooper, D., Burleson, W., Woolf, B. P., Muldner, K., & Christopherson, R. (2009). Emotion Sensors Go To School. In *14th International Conference on Artificial Intelligence in Education*, Brighton, 17-24.

Aroyo, L., Hyvönen, E., & Van Ossenbruggen, J. (2007). *Proceedings of the first international workshop on cultural heritage on the semantic web*. Retrieved September 21, 2009, from http://www.cs.vu.nl/~laroyo/CH-SW/ISWC-wp9-proceedings.pdf.

Anderson, J. R. (1976). *Language, memory, and thought*. Mahwah, NJ: Lawrence Erlbaum Associates.

Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., & Qin, Y. (2004). An integrated theory of the mind. *Psychological Review*, *111*, 1036-1060.

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of Learning and Motivation.* London: Academic Press.

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Science, 4*, 417-423.

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (pp. 47-89). New York: Academic Press.

Biggs, J. B. (2001). Teaching across cultures. In F. Salili, C. Chiu, & Y. Hong (Eds.), *Student motivation: the culture and context of learning* (pp. 293-308). New York: Kluwer Academic/ Plenum Publisher.

Blanchard, E. G. (2009). Adaptation-oriented culturally-aware tutoring systems: When adaptive instructional technologies meet intercultural education. In H. Song & T. Kidd (Eds.), *Handbook of Research on Human Performance and Instructional Technology*. Hershey, PA: Information Science Reference.

Blanchard, E. G., Chalfoun, P., & Frasson, C. (2007). Towards advanced learner modeling: Discussions on quasi real-time adaptation with physiological data. In *7th International Conference on Advanced Learning Technologies* (pp. 809-813).

Blanchard, E. G., & Mizoguchi, R. (2008). Designing culturally-aware tutoring systems: Towards an upper ontology of culture. *1st Workshop on Culturally-Aware Tutoring Systems (CATS2008).* In conjunction with International Conference on Intelligent Tutoring Systems (ITS2008), Montréal, Canada.

Blanchard, E. G., Mizoguchi, R., & Lajoie, S. P. (2009a). Addressing the interplay of culture and affect in HCI: An ontological approach. In *13th International Conference on Human-Computer Interaction (HCII-3-2009)* (pp. 575-584). Berlin: Springer.

Blanchard, E. G., Roy, M., Lajoie, S. P., & Frasson, C. (2009b). An evaluation of sociocultural data for predicting attitudinal tendencies. In *14th international conference on Artificial Intelligence in Education (AIED2009).* Brighton, UK (pp. 399-406).

Blanchard, E. G., Volfson, B., Hong, Y.-J., & Lajoie, S. P. (2009c). Affective Artificial Intelligence in Education: From detection to adaptation. In *14th international conference on Artificial Intelligence in Education (AIED2009)*. Brighton, UK (pp. 81-88).

Bonvillain, N. (2008). *Language, culture, and communication: The meaning of messages* (5th Ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

BRAIN. (2009). *The Brain from Top to Bottom - Different Types of Long Term Memory*. Canadian Institute of Neuroscience, Mental Health, and Addiction. Retrieved October 20, 2009, from http://thebrain.mcgill.ca/flash/a/a_07/a_07_p/a_07_p_tra/a_07_p_tra.html#3

Bronfenbrenner, U. (1989). Ecological systems theory. In R. Vasta (Ed.), *Annals of child development* (Vol. 6, pp. 187-251). Greenwich, CT: JAI.

British Museum. (2009). *Database of the British Museum.* Retrieved September 19, 2009, from http://www.britishmuseum.org/research/search_the_collection_database.aspx

Brown, P., & Levinson, S. (1987). *Politeness: some universals in language usage*. Cambridge, UK: Cambridge University Press.

Brusilovsky, P. (2001). Adaptive hypermedia. *User Modeling and User Adapted Interaction, 11*(1/2), 87-110.

Cesarano, C., Dorr, B., Picariello, A., Reforgiato, D., Sagoff, A., & Subrahmanian, V. S. (2006) OASYS: An Opinion Analysis System. In *AAAI-2006 Spring Symposium on Computational Approach to Analyzing Weblogs*, March 2006.

Chirkov, V. I., Ryan, R. M., Kim, Y., & Kaplan, U. (2003). Differentiating autonomy from individualism and independence: A self-determination theory perspective on internalization of cultural orientations and well-being. *Journal of Personality and Social Psychology, 84*, 97-110.

Clemmensen, T. (2010). A framework for thinking about the maturity of cultural usability. In E. G. Blanchard & D. Allard (Eds.), *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models*. Hershey, PA: IGI Global.

Cooper, C. R., & Denner, J. (1998). Theories linking culture and psychology: Universal and community-specific processes. *Annual Review of Psychology, 49*, 559-584.

Coulmas, F. (1996) *The Blackwell encyclopedia of writing systems*. Oxford, UK: Blackwell.

CultureGPS. (2009). *Culture GPS*. Retrieved September 30, 2009, from http://www.culturegps.com/About.html

Dawkins, R. (2006*). The Selfish Gene*. Oxford, UK: Oxford University Press.

Deaton, J., Barba, C., Santarelli,, T., Rosenzweig, L., Souders, V., McCollum, C., Seip, J., Kerr, B., & Singer, M. (2005). Virtual environment cultural training for operational readiness (VECTOR). *Virtual Reality, 8*(3), 156-167.

DeWalt, K. M., DeWalt, B. R., & Wayland, C. B. (1998). Participant observation. In H. R. Bernard (Ed.), *Handbook of Methods in Cultural Anthropology* (pp. 259-299). Walnut Creek, CA: AltaMira Press.

Dichev, C., Dicheva, D., & Fischer, J. (2007). Identity: How to name it, how to find it. In *16th International World Wide Web Conference (WWW2007)*, Banff, Canada.

Dourish, P. (2001). Seeking a foundation for context-aware computing, *Human-Computer Interaction*, *16*(2), 229-241.

Earley, C. P. (2006). Leading cultural research in the future: A matter of paradigms and taste. *Journal of International Business Studies, 37*, 922-931.

Earley, C. P., & Mosakowski, E. (2004). *Cultural Intelligence.* Harvard Business Review, 139-146.

Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska Symposium on Motivation* (Vol. 19, pp. 207-282). Lincoln, NE: University of Nebraska Press.

Elliot, J., & Bempechat, J. (2002). *Learning in culture and context: Approaching the complexities of achievement motivation in student learning*. San Francisco: Jossey-Bass.

Elfenbein, H. A., & Ambady, N. (2003). Universals and cultural differences in recognizing emotions. *Current Directions in Psychological Science, 12*, 159-164.

Endrass, B., Rehm, M., & André, E (2010). Towards culturally-aware virtual agent systems. In E.G. Blanchard & D. Allard (Eds.), *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models*. Hershey, PA: IGI Global.

Fodor, J. (1983). *Modularity of mind: An essay on faculty psychology*. Cambridge, MA: MIT Press.

Foley, J. M. (1998). *Teaching Oral Traditions*. New York: Modern Language Association.

Gessler, N. (1994). Artificial Culture. In R. Brook & P. Maes (Eds.), *Proceedings of the Fourth International Workshop on the Synthesis and Simulation of Living Systems* (pp. 430-435). Cambridge, MA: MIT Press. Retrieved October 10, 2009, from http://www.duke.edu/web/isis/gessler/cv-pubs/94articult.htm

Gessler, N. (2002). Computer models of cultural evolution. In D. B. Fogel & G. B. Fogel (Eds.), *Proceedings of the Center for the Study of Evolution and the Origin of Life*. Sudbury, MA: Jones and Bartlett Publishers. Retrieved October 10, 2009, from http://www.viewingspace.com/genetics_culture/pages_genetics_culture/gc_w07/gessler_text.htm

Gilbert, N., & Troitzsch, K. G. (2005). *Simulation for the social scientist* (2nd Ed.). Milton Keynes, UK: Open University Press.

Greenberg, S. (2001). Context as a dynamic construct. *Human Computer Interaction*, *16*(2), 257-268.

Henderson, J., Fishwick, P., Fresh, E., Futterknecht, R. & Hamilton, B.D. (2008). Immersive Learning Simulation Environment for Chinese Culture, *Proceedings of Interservice/Industry Training, Simulation, and Education Conference* (I/ITSEC), paper 8334.

Henrich, J., & Boyd, R. (2002). On modeling cognition and culture: Why culture evolution does not require replication of representations. *Journal of Cognition and Culture, 2*(2), 87-112.

Hofstede, G. (2001). *Culture's consequences: Comparing values, behaviors, institutions, and organizations across nations* (2nd Ed.). London: Sage.

Hofstede, G. (2009). *Scores of Hofstede's Cultural Dimensions*. Retrieved September 20, 2009, from http://www.geert-hofstede.com/hofstede_dimensions.php.

Houben, G.-J., McCalla, G., Pianesi, F., & Zancanaro, M. (2009). *17th international conference on user modeling, adaptation, and personalization.* Berlin: Springer.

House, R. J, Hanges, P. J., Javidan, M., Dorfman, P., & Gupta, V. (2004). *Culture, leadership and organizations: The GLOBE study of 62 societies*. Thousands Oaks, CA: Sage.

HRAF. (2009). *Human Relation Area Files*. Retrieved from http://www.yale.edu/hraf/

Hyvönen, E. (2009). Semantic Portals for Cultural Heritage. In S. Staab & R. Studer (Eds.), *Handbook on Ontologies* (2nd Ed.). Berlin: Springer-Verlag.

Johnson, W. L. (2007). Serious use of a serious game for language learning. In *13th International Conference on Artificial Intelligence in Education, Marina Del Rey* (pp. 67-74).

Johnson, W. L., Mayer, R. E., André, E., & Rehm, M. (2005). Cross-cultural evaluation of politeness in tactics for pedagogical agents. In *12th International Conference on Artificial Intelligence in Education,* Amsterdam (pp. 298-305).

Kashima, Y. (2000). Conceptions of culture and person for psychology. *Journal of Cross-cultural Psychology*, *31*(1), 14-32.

Ketal, R. (1975). Affect, mood, emotion and feeling: Semantic considerations. *American Journal of Psychatry, 132*, 1215-1217.

Kirkman, B. L., Lowe, K. B., & Gibson, C. B. (2006). A quarter century of culture's consequences: a review of empirical research incorporating Hofstede's cultural values framework. *Journal of International Business Studies, 37*, 285-320.

Koda, T., Ishida, T., Rehm, M., & André, E. (2009). Avatar culture: cross-cultural evaluations of avatar facial expressions. *International Journal of AI and Society, 24*(3), 237-250.

Laird, J. E., Newell, A., & Rosenbloom, P. S. (1987). SOAR: An architecture for general intelligence. *Artificial Intelligence*, *33*, 1-64.

Lane, H. C., Gore, M. G., Gomboc, D., Karnavat, A., & Rosenberg, M. (2007). Intelligent tutoring for interpersonal and intercultural skills. In *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC 2007)*, Orlando, FL.

Le Louvre. (2009). *ATLAS Database of The Louvre.* Retrieved September 19, 2009, from http://cartelfr.louvre.fr/cartelfr/visite?srv=crt_frm_rs&langue=fr&initCritere=true

Lim, D. H. (2004). Cross-cultural differences in online learning motivation. *Educational Media International, 41*(2), 163-175.

Linnenbrick, E. A. (2006). Emotion research in education: Theoretical and methodological perspective on the integration of affect, motivation and cognition. *Educational Psychology, 19,* 307-314.

Little, D. (2007). Philosophy of history. *Stanford Encyclopedia of Philosophy*. Retrieved October 18, 2009, from http://plato.stanford.edu/entries/history/

Marcus, A., & Gould, E. W. (2000). Crosscurrents: cultural dimensions and global Web user-interface design. *Interactions*, *7*(4), 32-46.

Marcus, A., & Alexander, C. (2007). User validation of cultural dimensions of a website design. In *12th International Conference on Human-Computer Interaction (HCII2007)* (pp. 160-167).

Mauss, I. B., Bunge, S. A., & Gross, J. J. (2008). Culture and automatic emotion regulation. In S. Ismer, S. Jung, S. Kronast, C. van Scheve, & M. Vanderkerckhove (Eds.), *Regulating emotions: Culture, social necessity and biological inheritance* (pp. 39-60). London: Blackwell Publishing.

McSweeney, B. (2002). Hofstede's model of national cultural differences and their consequences: a triumph of faith – a failure of analysis. *Journal of Human Relations*, *55*(1), 89-118.

Mesquita, B. (2001). Emotions in collectivist and individualist contexts. *Journal of Personality and Social Psychology*, *80*(1), 68-74.

Mesquita, B., Frijda, N. H., & Scherer, K. R. (1997). Culture and emotion. *Handbook of Cross-Cultural Psychology Vol. 2: Basic processes and Developmental Psychology* (255-297). Boston: Allyn & Bacon.

Meyer, D. E., & Kieras, D. E. (1997). A computational theory of executive cognitive processes and multiple-task performance. Part 1. Basic mechanism. *Psychological Review*, *104*, 2-65.

Miller, C., Wu, P., & Funk, H. (2008). A computational approach to etiquette: Operationalizing Brown and Levinson's politeness model. *IEEE Intelligent Systems, 23*(4), 28-35.

Miller, C., Ott, T., Wu, P., & Vakili, V. (2010). Politeness and etiquette modeling: Beyond perception to behaviour. In E. G. Blanchard & D. Allard (Eds.), *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models*. Hershey, PA: IGI Global.

Mizoguchi, R. (2003). Tutorial on ontological engineering - part 1: Introduction to ontological engineering. *New Generation Computing, 21*(4), 365-384.

Mizoguchi, R. (2009a). *Yet Another More Advanced Top Ontology: YAMATO, 2nd revised version*. Retrieved October 7, 2009, from http://www.ei.sanken.osaka-u.ac.jp/hozo/onto_library/YAMATO.pdf

Mizoguchi, R. (2009b). *Reconciliation between BFO and DOLCE leads to YATO*. Paper presented at the 2009 Signals, Symptoms and Findings Workshop (SSSW09). Retrieved September 14, 2009, from http://bimib.disco.unimib.it/images/3/37/SSFW09_Mizoguchi_YATO.ppt

Mizoguchi, R, Sunagawa, E., Kozaki, K., & Kitamura, Y. (2007). A Model of roles within an ontology development tool: HOZO. *Journal of Applied Ontology, 2*(2), 159-179.

NADB. (2009). *National Archeology DataBase.* Retrieved September 19, 2009, from http://www.nps.gov/history/archeology/TOOLS/nadb.htm

Nisbett, R. E., & Norenzayan, A. (2002). Culture and cognition. In D. Medin & H. Pashler (Eds.), *Stevens' Handbook of Experimental Psychology, Third Ed., Volume Two: Memory and Cognitive Processes*. New York: John Wiley & Sons.

Nazir, A., Enz, S., Lim, M. Y., Aylett, R., & Cawsey, A. (2009). Culture-personality based affective model. *International Journal of AI and Society, 24*(3), 281-293.

Ogan, A., Jones, C., & Aleven, V. (2008). Pause, predict, and ponder: Use of narrative video to improve cultural discussion and learning. In *Proceedings of Computer-Human Interaction* (pp. 155-162).

Ogan, A., & Lane, H. C. (2010). Virtual learning environments for culture and intercultural competences. In E. G. Blanchard & D. Allard (Eds.), *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models*. Hershey, PA: IGI Global.

Oishi, S. (2004). Personality in culture: A neo allportian view. *Journal of Research in Personality, 38*, 68-74.

Owens, H., & Maxmen, J. S. (1979). Mood and affect: A semantic confusion. *American Journal of Psychatry, 136*, 97-99.

Panzarasa, P., & Jennings, N. R. (2006). Collective cognition and emergent in multi-agent systems. In R. Sun (Ed.), *Cognition and Multi-Agent Interaction: From Cognitive Modelling to Social Simulation* (pp. 401-408). Cambridge, UK: Cambridge University Press.

Pavlidis, G., Koutsoudis, A., Arnaoutoglou, F., Tsiouka, V., & Chamzas, C. (2007). Methods for 3D digitization of cultural heritage. *Journal of Cultural Heritage, 8*, 93-98.

Picard, R. (1997). *Affective Computing*. Cambridge, MA: The MIT Press.

Pyysiäinen, I. (2002). Ontology of culture and the study of human behavior. *Journal of Cognition and Culture, 2*(3), 167-182.

Raybourn, E.M., Deagle, E., Mendini, K., & Heneghan, J. (2005). Adaptive thinking & leadership simulation game training for special forces officers. In *Proceedings, Interservice/ Industry Training, Simulation and Education Conference Proceedings* (Paper 2370).

Rehm, M. (2010). Developing enculturated agents - Pitfalls and strategies. In E. G. Blanchard & D. Allard (Eds.), *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models*. Hershey, PA: IGI Global.

Rehm, M., Nakano, Y., André, E., Nishida, T., Bee, N., Endrass, B., Wissner, M., Akhter Lipi, A., & Huang, H.-H. (2009). From observation to simulation: generating culture-specific behavior for interactive systems. *International Journal of AI and Society, 24*(3), 267-280.

Reinecke, K., & Bernstein, A. (2009). Tell me where you've lived, and I'll tell you what you like: Adapting interfaces to cultural preferences. *17th international conference on user modeling, adaptation, and personalization* (LNCS 5535, pp. 185-196). Berlin: Springer.

Reinecke, K., Schenkel, S., & Bernstein, A. (2010). Modeling a user's culture. In E. G. Blanchard & D. Allard (Eds.), *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models*. Hershey, PA: IGI Global.

Rohlfing, K. J., Rehm, M., & Goecke, K. U. (2003). Situatedness: The interplay between context(s) and situation. *Journal of Cognition and Culture*, 3(2), 132-157.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*, 68-78.

Salili, F., Chiu, C., & Hong, Y. (2001). *Student motivation: The culture and context of learning*. New York: Plenum Press.

Savard, I., Bourdeau, J., & Paquette, G. (2008). Cultural variables in the building of pedagogical scenarios. In *1st Workshop on Culturally-Aware Tutoring Systems (CATS2008).* In conjunction with International Conference on Intelligent Tutoring Systems (ITS2008), Montréal, Canada.

Scharifian, F. (2003). On cultural conceptualizations. *Journal of Cognition and Culture, 3*(3), 187-207.

Scherer, K. R. (2005). What are emotions? And how they can be defined. *Social Science Information, 44*(4), 695-729.

Scherer, K. R., & Brosch, T. (2009). Culture-specific appraisal biases contribute to emotion dispositions. *European Journal of Personality*, 23, 265-288.

Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. In M. P. Zana (Ed.), *Advances in Experimental Social Psychology* (pp. 1-65). New York: Academic Press.

Schwarz, N., & Skurnik, I. (2003). Feeling and Thinking: Implications for problem solving. In J. E. Davidson & R. J. Sternberg (Eds.), *The psychology of problem solving* (pp. 263-290). Cambridge, UK: Cambridge University Press.

Scollon, C. N., Diener, E., Oishi, S., & Biswas-Diener, R. (2004). Emotions across cultures and methods. *Journal of Cross-Cultural Psychology*, *35*(3), 304-326.

SEP. (2009). *Stanford Encyclopedia of Philosophy*. Retrieved from http://plato.stanford.edu/

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical Journal,* 27, 379–423. Retrieved October 17, 2008, from http://plan9.bell-labs.com/cm/ms/what/shannonday/shannon1948.pdf

Sleeman, D. H., & Brown, J. S. (1982). *Intelligent Tutoring Systems.* New York: Academic Press.

Smith, B. (2003). Ontology. In L. Floridi (Ed.), *Blackwell guide to the philosophy of computing and information (*pp. 155-166), Oxford: Blackwell.

Smith, P.B. (2006). When elephants fight, the grass gets trampled: the GLOBE and Hofstede projects. *Journal of International Business Studies, 37*, 915-921.

SOROSORO. (2009). *SOROSORO program for the preservation of endangered languages*. Retrieved October 17, 2008, from http://www.sorosoro.org/en/

Stewart, O. T., & Chakraborty, J. (2010). Culturally Determined Preferences: Automatic Speech Recognition (ASR) Systems versus Live Help. In E.G. Blanchard & D. Allard (Eds.), *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models*. Hershey, PA: IGI Global.

Stock, O., & Zancanaro, M. (2010). Personalized active cultural heritage: The PEACH experience. In E. G. Blanchard & D. Allard (Eds.), *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models*. Hershey, PA: IGI Global.

Sun, R. (2006). The CLARION cognitive architecture: Extending cognitive modeling to social simulation. In R. Sun (Ed.), *Cognition and Multi-Agent Interaction*. New York: Cambridge University Press.

SUOWG. (2009). *IEEE Standard Upper Ontology Working Group*. Retrieved from http://suo.ieee.org

TMP. (2009). *Theban Mapping Project.* Retrieved September 19, 2009, from http://www.thebanmappingproject.com/

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory* (pp. 381-403). New York: Academic Press.

Tumer, K., & Wolpert, D. H. (2004). A survey of collective intelligence. In K. Tumer & D. H. Wolpert (Eds.), *Collectives and the Design of Complex Systems* (pp. 1-42). Berlin: Springer.

UNESCO. (2007). *UNESCO Guidelines on Intercultural Education*. Retrieved September 25, 2009, from http://unesdoc.unesco.org/images/0014/001478/147878e.pdf

UNESCO. (2009). *UNESCO Website on Intangible Cultural Heritage*. Retrieved October 17, 2009, from http://www.unesco.org/culture/ich/index.php?lg=EN&pg=home

Wang, N., & Johnson, W. L. (2008). The politeness effect in an intelligent foreign language tutoring system. In *9th International Conference on Intelligent Tutoring Systems (ITS2008)* (LNCS 5091, pp. 270-280). Berlin: Springer.

YAMATO. (2009). *Yet Another More Advanced Top Ontology - Browsable ontology*. Retrieved October 7, 2009, from http://133.1.32.226/OntologyViewer/view.jsp?id=onto4

KEY-TERMS AND DEFINITIONS

Culture. In this chapter, a culture is seen as an accumulation of elements that have been produced, or integrated and possibly adapted by a cultural group.

Cultural Group. In this chapter, a cultural group is seen as a coherent population of individual agents that share a common culture.

Cultural element. In this chapter, cultural elements are either the direct production of a cultural group, or elements that it has borrowed, integrated and potentially adapted from another cultural group through group-level interactions such as conquests for instance. Cultural elements are to be considered at a group level and are not necessarily homogeneously known/accepted/endorsed by members of the cultural group. Four kinds of cultural elements are defined in this chapter: core cultural ideas, tangible cultural elements, cultural practices, and ideational cultural elements.

Culturally-aware system. A culturally-aware system refers to any system in which culture-related information had/has some impact on its design, runtime or internal processes, structures, and objectives. Cultural awareness may have many interpretations and can lead to several different approaches.

Ontology. "*An ontology is similar to a dictionary or glossary, but with greater detail and structure that enables computers to process its content. An ontology consists of a set of concepts, axioms, and relationships that describe a domain of interest*" (SUOWG, 2009). An ontology can also be read by humans, who do not necessarily need computer expertise in order to interpret its meaning.

Upper ontology. "*An upper ontology is limited to concepts that are meta, generic, abstract and philosophical, and therefore are general enough to address (at a high level) a broad range of domain areas. Concepts specific to given domains will not be included; however, this standard will provide a structure and a set of general concepts upon which domain ontologies (e.g. medical, financial, engineering, etc.) could be constructed*" (SUOWG2009). Smith (2003) further mentions that an upper ontology aims at serving "*as a common neutral backbone, which would be supplemented by the work of ontologists working in more specialized domains*"

Lightweight ontology. According to Mizoguchi (2003), lightweight ontology "*includes ontologies for web search engines like Yahoo ontology which consists of a topic hierarchy with little consideration of rigorous definition of a concept, principle of concept organization, distinction between word and concept, etc. The main purpose of such a hierarchy is to power up the search engine and hence it is very use-dependent.*"

Formal (heavyweight) ontology. According to Mizoguchi (2003), formal (heavyweight) ontology "*includes ontologies developed with much attention paid to rigorous meaning of each concept, organizing principles developed in philosophy, semantically rigorous relations between concepts, etc. Instance models are usually built based on those ontologies to model a target world, which requires careful conceptualization of the world to guarantee of the consistency and fidelity of the model*."