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SPICE

Social cohesion, Participation, and Inclusion through Cultural Engagement

D6.5 Final Ontology Network Specification

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12	CELI	MAIZE SRL	Italy
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Executive summary

The deliverable presents the final version of the SPICE Ontology Network (SON), whose main objective is to provide the ontological backbone for the representation of citizen curation activities.

The SPICE Ontology Network (SON) is the main outcome of the task T6.3 (Ontology network for citizen curation) of the WP6 work package.

In WP6, we design and implement the formal semantics for an integrated socio-technical system for citizen curation. WP6, jointly with WP4, aims at devising a technical research infrastructure to integrate multiple knowledge graphs and ontologies, a linked data social media layer, interface components, annotation software, recommendation systems, data mining tools, and models/methods devised by the SPICE work packages.

SON is an integration driver: it creates an interoperable space, where applications can interact with a shared semantics. SON enables software components to organise, exchange, query, interpret and reason over data collected or generated during the citizen curation activities.

SON empowers applications with knowledge level reasoning to support citizen curation activities. This enables, for example, the discovery and extension of latent sensemaking, and the automated inference of implicit (non-trivial) implications from the data shaped according to the SON or aligned to it.

This deliverable complements the Deliverable D6.2 "Initial Ontology Network Specification" with the major updates to the SON occurred during the period M13-M24. In summary this report includes the description of: 1) two ontologies for representing User Profile and Communities (devised based on the results of the Work Package 3); 2) an ontology formalizing the Curry's theory on moral values; 3) an ontology, called Value Core, developed to generalize the various ontologies formalizing theories on Moral Values (i.e. Curry, Haidt, Schwartz); 4) an ontology called "Atlas of Emotions" aims at integrating the multiple theories on emotions (i.e. Ekman, Pluchick, Ortony-Clore-Collins and Shaver); 5) an ontology dealing with symbolic meaning; 6) an ontology for supporting thematic reasoning; 7) an ontology for supporting formal comparison of non-formal theories.

Finally, this document provides an overview of how the ontologies of the SPICE ontology network are adopted in the case studies.

Document History

Version	Release date	Summary of changes	Author(s) -Institution
V0.1	12/04/2022	First draft released	Luigi Asprino (UniBo), Stefano De Giorgis (UniBo), Aldo Gangemi (CNR), Bruno Sartini (UniBo), Manuel Striani (UniTo)
V0.2	19/4/2022	Review	Belen Díaz (UCM), Nele Kadastik (AAU)
V0.3	22/4/2022	Revision	Luigi Asprino (UniBo), Stefano De Giorgis (UniBo), Aldo Gangemi (CNR)
V1.0	29/4/2022	Final version	Luigi Asprino (UniBo), Aldo Gangemi (CNR)

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1 Introduction

This deliverable presents the final version of the SPICE Ontology Network (SON), whose main objective is to provide the ontological backbone for the representation of citizen curation. As discussed in D2.1 (Initial methods for interpretation), *citizen curation* can be defined as "citizens applying curatorial methods to archival materials available in memory institutions in order to develop their own interpretations, share their own perspective and appreciate the perspectives of others". Moreover, SON enables software components to organise, exchange, query, interpret and reason over data collected or generated during the citizen curation activities. This document gives an overview of the final version of the ontology network, its underlying principles, and its modular component ontologies. The description provided here is complemented by the documentation available online at[1]. Consider that ontologies are living artifacts, and they might evolve during the third year of the project, based on emerging requirements, and fine-tuning of data integration or applications.

1.1 Work Package 6 Objectives

The SPICE Ontology Network (SON) is the main outcome of the task T6.3 (Ontology network for citizen curation) of the WP6 work package.

In WP6, we design and implement the formal semantics for an integrated socio-technical system for citizen curation. WP6, jointly with WP4, aims at devising a technical research infrastructure to integrate multiple knowledge graphs and ontologies, a linked data social media layer, interface components, annotation software, recommendation systems, data mining tools, and models/methods devised by the SPICE work packages.

SON is an integration driver: it creates an interoperable space, where applications can interact with a shared semantics. SON enables software components to organise, exchange, query, interpret and reason over data collected or generated during the citizen curation activities.

SON empowers applications with knowledge level reasoning to support citizen curation activities. This enables, for example, the discovery and extension of latent sensemaking, and the automated inference of implicit (non-trivial) implications from the data shaped according to the SON or aligned to it.

1.2 Purpose of the Deliverable and Document Outline

This deliverable complements the Deliverable D6.2 "Initial Ontology Network Specification" with the major updates to the SON occurred during the period M13-M24. In summary this report includes the description of: 1) two ontologies for representing User Profile and Communities (devised based on the results of the Work Package (cf. Section 2.1 and 2.2) 3); 2) an ontology formalizing the Curry's theory on moral values (cf. Section 2.4); 3) an ontology, called Value Core, developed to generalize the various ontologies formalizing theories on Moral Values (i.e. Curry, Haidt, Schwartz) (cf. Section 2.3); 4) an ontology called "Atlas of Emotions" aimed at integrating multiple theories of emotions (i.e. Ekman, Pluchick, Ortony-Clore-Collins and Shaver) (cf. Section 3.1); 5) an ontology dealing with symbolic meaning (cf. Section 4.1); 6) an ontology for supporting thematic reasoning (cf. Section 5.1); 7) an ontology for supporting formal comparison of non-formal theories (cf. Section 5.2).

Finally, this document provides an overview of how the ontologies of the SPICE ontology network are adopted in the case studies.

[1] https://github.com/spice-h2020/SON

2 User and Community Knowledge Area

The User and Community Knowledge area provides models for representing information about users and communities. The requirements on which these ontologies have been built upon come from the results of the WP2, WP3 and WP7 which aim at building models able to describe users' characteristics and interests.

2.1 Community Ontology

The main goal of the community model is supporting the interpretation-reflection loop (cf. D2.1, D2.2, D2.4 and D3.1). Specifically, it is responsible for discovering Communities of Interest (*implicit communities*) to reason about inter and intra relationships among *explicit communities* for promoting social cohesion, suggesting alternative perspectives to broaden the framework of dialogue, and understanding.

In the SPICE project, **communities** are key elements to search and browse contents of interests, to identify similarities and differences across users and their contributions, to provide alternative interpretations of objects, to promote the social contagion among users and to emphasize the similarities and differences within and across communities.

The information related to communities (e.g., communities characteristics and members) may be connected and integrated with other information about users their interests etc. Such landscape of information may be valuable for multiple applications, e.g., tools for visualising, exploring, reasoning over, making sense of the collected information. This calls for a common data model enabling applications to access this information with a shared semantics.

2.1.1 Conceptual Overview

The deliverable D3.1 provided an initial overview of the types of communities involved and SPICE and their main characteristics. The, the overview has been refined in the deliverable D3.3. These analyses guided the design of the Community Ontology. Here, we briefly summarize the main concepts:

- **Community.** A community is a group of users sharing certain characteristics.
- **Explicit Community.** If the set of characteristics consider for grouping users together can be explicitly established, the community is said to be "explicit". Explicit communities are defined on demand by museum curator. Examples of explicit communities are the personas defined in some of the project use cases (in WP7) that represent user archetypes summarizing common behaviours (like teachers in the children school visits).
- **Implicit Community.** If the communities are autonomously detected by the clustering and community detection algorithms (cf. D3.5), in this case they are called "implicit" community. Implicit communities are discovered based on user personal attributes and the information extracted from user interactions (interaction attributes).
- **Users' Characteristics of Interest for the Community Model.** The set of characteristics to consider for detecting communities are: 1) Personal Information defined by the User Model (e.g., demographics, age, sex) (cf. D3.1 and D3.3); 2) Users' opinions on the items s/he interacts with (c.f. T3.2); 3) Information related to the items s/he interacts with (cf. WP4 and WP6).
- **Persistent Community.** A persistent community is community that is stable in time.
- **Virtual Community.** A virtual community is a community having a temporary and dynamic character and arise with new users, new opinions, stories and/or reflections. This kind of community can become persistent if required.
- **Community of Practice (CoP).** A community of Practice (CoP) is a group of people who get involved in a process of collective work in a shared domain of human endeavour.

- **Community of Interest (CoI).** A community of Interest (CoI) is a particular CoP in which people share a common interest.
- **Persona.** A persona is a realistic interpretation of our end users. A persona represents a user type that might use the system in a similar way. Although an *explicit community is not a persona* there are analogies in the community model and use personas as source for explicit communities.

2.1.2 Description of the ontology

The SON's Community ontology and its documentation are available at https://w3id.org/spice/SON/CommunityOntology/0.0.2. The Ontology defines classes for expressing information about all the different types of communities. Moreover, it defines a taxonomy of explicit communities identified so far in the SPICE project and the formally defines the characteristics of each community.

A formal definition of all the types of communities is depicted in the following Figure.

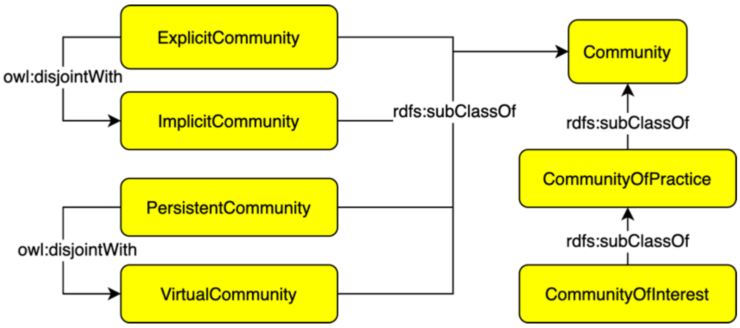

Figure 1 A formal classification of the community types.

As described in the previous Section, a community can be classified as: Explicit, Implicit, Persistent, Virtual, Community of Practice, and Community of Interest. These different types of communities are formalised as sub-classes of the class Community. Moreover, the ontology also declares disjointness among these subclasses: an explicit community cannot be also implicit and a persistent community cannot be also virtual. These disjoint axioms enable us to guarantee the coherence of the data specified according to this ontology.

The Figure below depicts the main pattern of defined in the Community ontology.

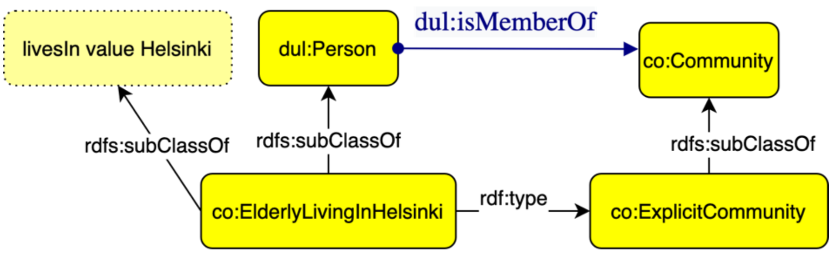

Figure 2 The main patter of the Community ontology.

The object property dul:isMemberOf is used to associate a Person (i.e., a dul:Person) to the Community it belongs to.

Leveraging the OWL2 punning pattern which allows to declare entities as both classes/properties and individuals, the explicit community are defined as both an individual belonging to the class explicit community and a sub class of the class dul:Person. This pattern allows: 1) to classify the

Community with respect to its inherent kind (e.g., the Community "Elderly living in Helsinki" is classified as an explicit community); 2) to "group" people according to the specific type of community they belong to (e.g., Emma belongs to the class "Elderly living in Helsinki"); 3) to make the characteristics of a community to be inherited by the people belonging to the community itself (e.g., the fact, precisely the assertion, that Emma lives in Helsinki is automatically deduced from the fact that Emma belongs to the class of "Elderly living in Helsinki"); 4) to formally describe characteristics of explicit communities thus allowing to assign someone to a community on the basis of its characteristics (e.g., the fact that Emma belongs to the explicit category "Elderly living in Helsinki" can be induced by knowing that Emma lives in Helsinki and Emma is 70 years old). It is worth noticing that the 3) and 4) describe two kinds of reasoning forms enabled by the model: point 3) describes a deduction process (i.e., the characteristics of the person are inherited from the class the person belongs to); and point 4) describes an induction process (i.e., the class - that is, the community - a person belongs to is induced from her/his characteristics).

Characteristics of the explicit communities are expressed via OWL restrictions. In the Figure 2 the restriction "livesIn value Helsinki" identify a class of individuals associated with a value Helsinki by means of the property livesIn which intuitively identifies a class of individuals living in Helsinki. Therefore, all the individuals of its subclasses (e.g., ElderlyLivingInHelsinki) inherits such characteristic (i.e., living in Helsinki).

Finally, the pattern has been instantiated for each explicit community identified in the context of case studies. It is worth noticing that the ontology is a "living object" which is likely to evolve in future. In fact, the communities that are currently formalised in the ontology are not to be considered as definitive, and new communities can be included in the ontology instead. To include a new community in the ontology, one can instantiate the pattern showed in Figure 2.

The communities are hierarchically organised. The hierarchy of communities is showed in the Figures below. Figure 3 shows the top-level explicit communities which are further specialized in Figure 4, Figure 5, Figure 6, Figure 7 and Figure 8.

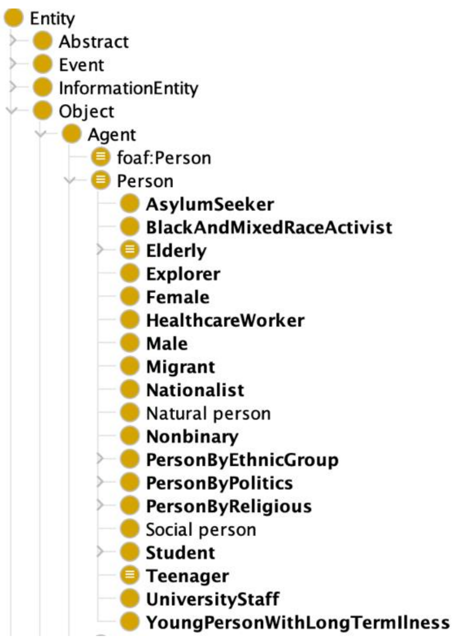

Figure 3 Top-level explicit communities.

Figure 4 Communities of Elderly people

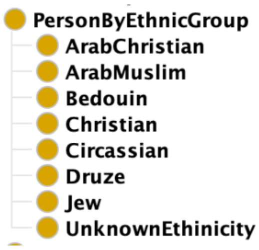

Figure 5 Communities of people by its Ethnic Group

Figure 6 Communities of people by its political orientation

Figure 7 Community of people by its religious practice as identified in the HECHT case study.

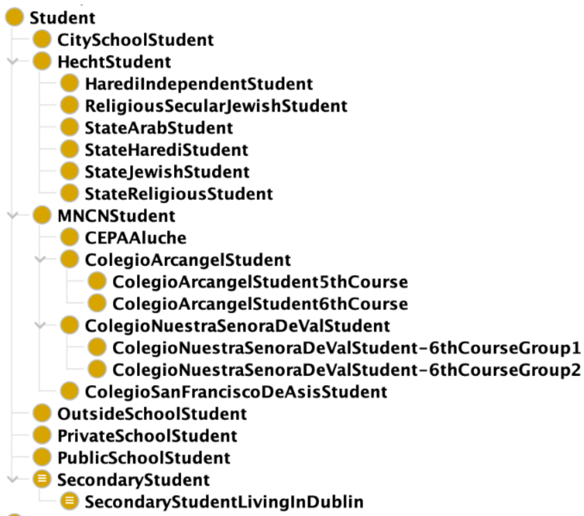

Figure 8 Explicit communities of students as identified in MNCN experiment.

2.2 User Profiling Ontology

User models aim representing characteristics of individuals interacting with the system so to guide the process of content recommendation to them. The user modelling activity carried out in the Work Package 3 (cf. D3.1 and D3.3) selected a series of users' characteristics that are relevant for the project. The significance of the users' characteristics is not limited to the recommender system only, but potentially several applications may benefit of the profiles of the users. Therefore, an ontology is needed for enabling the access to this data with a shared semantics.

2.2.1 Conceptual Overview

Here we briefly summarize the main concepts described in the deliverable D3.3 revolving around the user model.

- **User Model.** A user model is a collection of properties associated with a specific user.
- **User.** Any citizen.
- **Properties.** Any personal information Each property has a name, a set of constraints (only certain values are allowed for a property), and an aggregation strategy which determines how multiple values associated to a certain property are aggregated together (e.g., keep only the last value, compute the mean of all values etc.). Contextual information may be associated to a user's property (e.g., what is the source of the property, how the property has been derived).
- **Categories of properties.** Each property belongs to a category among the following:
    - **Identity.** Properties for identifying the user (e.g., ID, email, password).
    - **Demographics.** Population based-factors such as age, gender, place of birth.
    - **Traits.** Information about the personality of the user.
    - **Beliefs/Values.** Information about items that the user considers to be important.
    - **Interests.** Items liked by the user.
    - **Skills.** Things the user believes s/he is good at.
    - **Communities.** Implicit/Explicit communities the user belongs to.
    - **Contexts.** Information about the user's current environment (e.g., the software system s/he is using).

2.2.2 Description of the ontology

The SON's User Profile eXtended (UpX) ontology and its documentation are available at https://w3id.org/spice/SON/upX/0.0.2.

The UpX extends the User Profile (UP) Ontology[2], a state of the the art ontology for specifying user models. Specifically, the UpX ontology derives and extends the main pattern of the UP ontology. The pattern is depicted in Figure 9.

[2] http://purl.oclc.org/NET/UNIS/up#

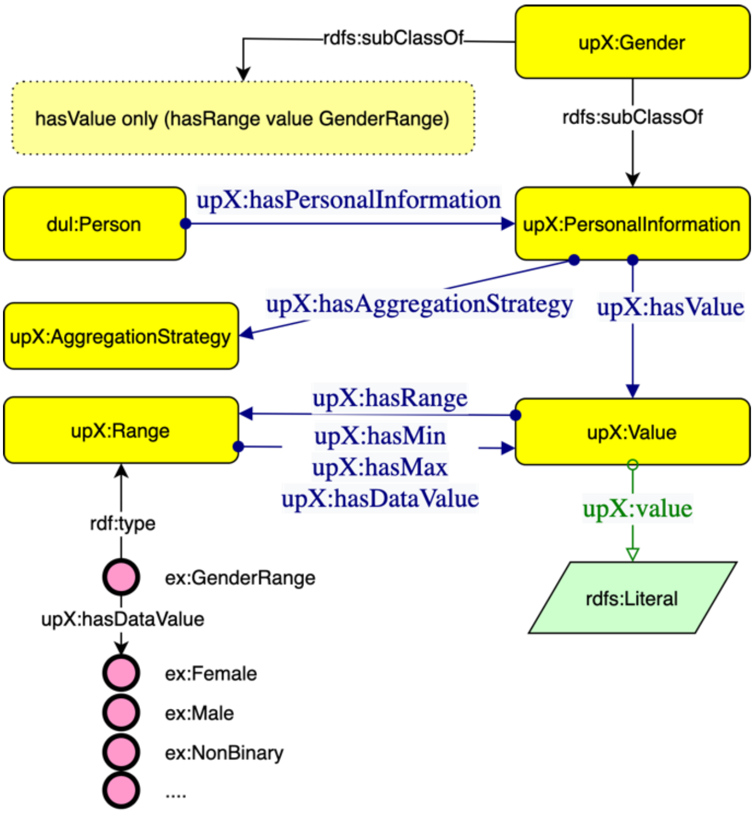

Figure 9 User Profile eXtended (upX) Ontology main pattern

Such pattern associates a dul:Person with its personal information (i.e., a user's characteristic, e.g. gender) by means of the property upX:hasPersonalInformation. A upX:PersonalInformation is associated with a value (e.g., ex:Male) and an Aggregation Strategy. The value is defined according to a range which delimits the set of possible values for a given characteristic (e.g., ex:Male, ex:Female, ex:NonBinary etc.).

The upX:PersonalInformation class is specialized by a number of classes each representing a category of user's characteristics.

Figure 10 depicts the hierarchy of Personal Information defined in the upX ontology. This hierarchy reflects the categories of user's characteristics defined in D3.1.

The range of possible values of a given personal information is bounded by a set of class restriction associated with upX:PersonalInformation's subclasses. In other words, each subclass of upX:PersonalInformation (e.g., upX:Gender) is defined according to a class restriction (e.g., `hasValue only (only hasRange GenderRange)`) which constraints the set of possible values which may occur for a given personal information (e.g., ex:Male, ex:Female, ex:NonBinary). This allows us to spot possible inconsistencies in the data.

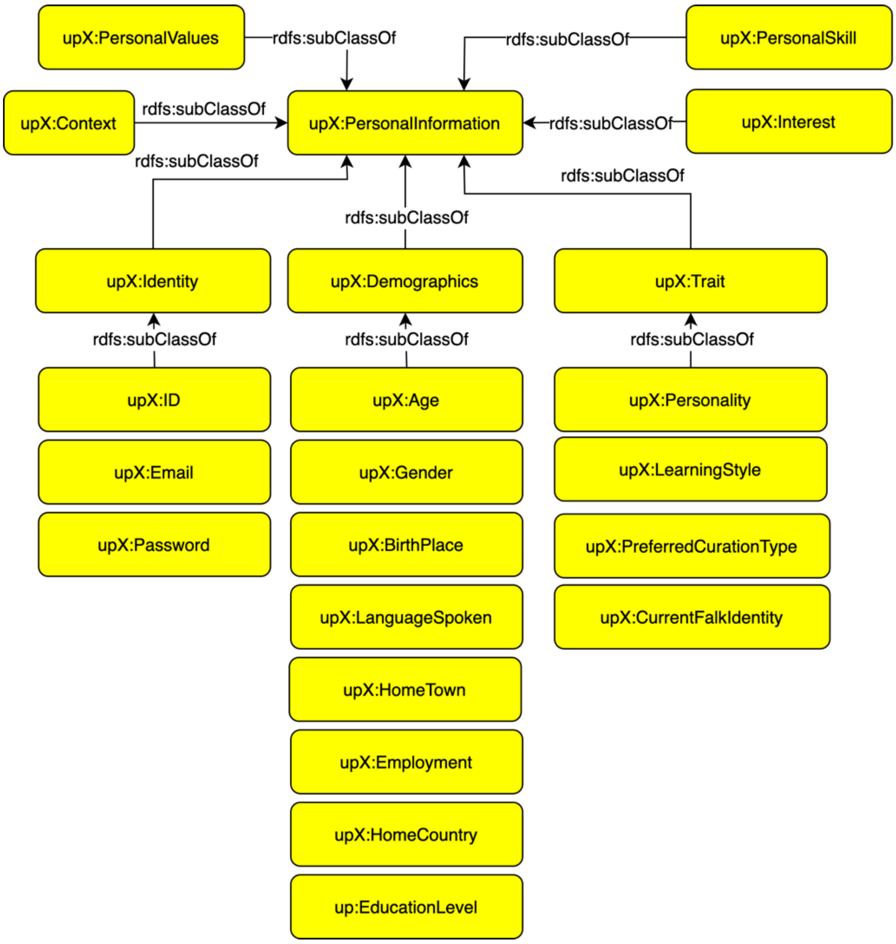

Figure 10 The hierarchy of Personal Information defined in the upX ontology.

2.3 Value Core Ontology

The Value Core module, as described in D6.2, is the core module of the Value Ontology, consisting in the minimal vocabulary to talk about values. Several theories are mentioned in D2.4 Sect. 3.1.2, and some of them were already introduced in the ontological module, namely Moral Foundations Theory by Graham and Haidt (Graham et al., 2013) and Theory of Basic Human Values by Schwartz (Schwartz, 2012). The Value Core module is now enriched with values from Curry Moral Molecules Theory, described here in Sect. 2.4. During the period M13-M24, the Value Core ontological module is furthermore enriched via introducing each value of each theory as individual to be used in the Value Reasoner (described in D6.3).

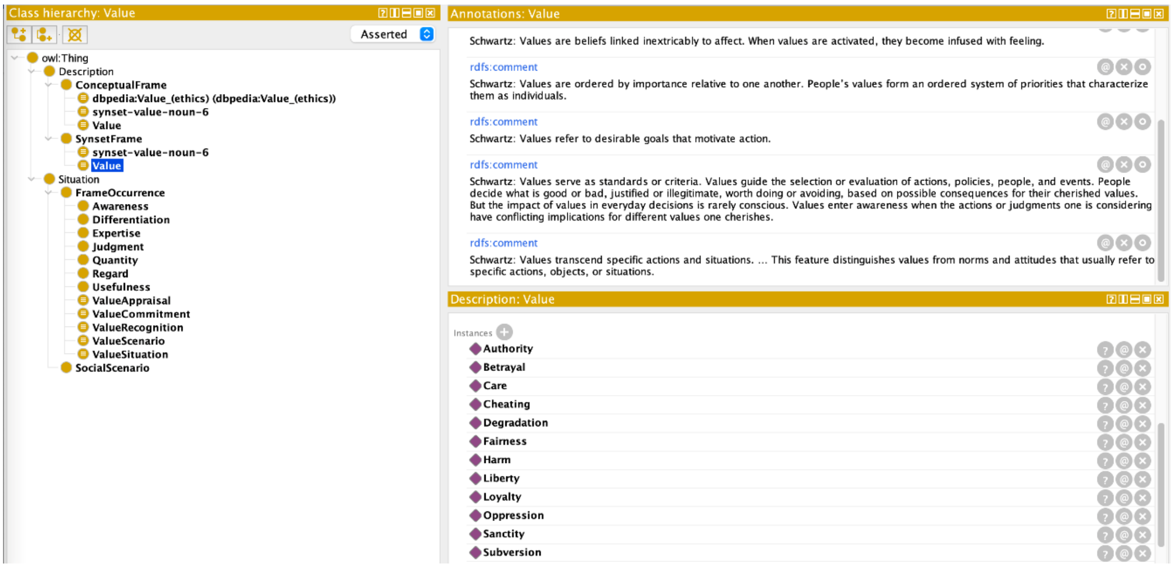

Figure 11 ValueCore current version with values from different theories represented as intensional individuals

Figure 11 shows the current version in which values from different theories (in figure in particular the instances shown are values and violations from Moral Foundation Theory ontological module) are represented as intensional individuals of the class `vc:Value`, which is subclass of the `fschema:Frame` class (reused from the Framester schema), namely the class of all frames which can be evoked by some concept of "Value".

2.4 Moral Molecules Ontology

This module is the ontological version of the Morality as Cooperation Theory, updated to year 2021, as it was elaborated in (Curry 2005, 2016).

2.4.1 Introduction

The Moral Molecules ontology aims at representing moral values theoretical implant as in (Curry 2005, 2016). It considers positive and negative moral elements which can be combined in chains of morally complex events and situations. This combinatorial approach of moral "atoms" makes this theory particularly interesting from an ontological perspective.

2.4.2 State of the art

This theory is based on the idea that humans descend from social primates who have spent 50 million years living in social groups (Shultz et al. 2011), and two million years making a living as intensely collaborative hunter-gatherers (Tooby & DeVore, 1987). During this long permanence interacting in the same environment as social agents, a range of different problems of cooperation arose. Humans evolved accordingly elaborating solutions to those problems, to benefit of mutual cooperation. These cooperative solutions come in different shapes: instincts, intuitions, inventions and institutions. These optimal solutions provide the criteria by which humans evaluate the behaviour of others. According to the Moral Molecules theory in fact, "'Morality' is the label that philosophers and others have attached to these cooperative solutions".

2.4.3 Description of the ontology

Curry et al. individuate seven cooperation strategies that generates Moral Elements, which in turn have as negative counterpart some Negative Moral Elements.

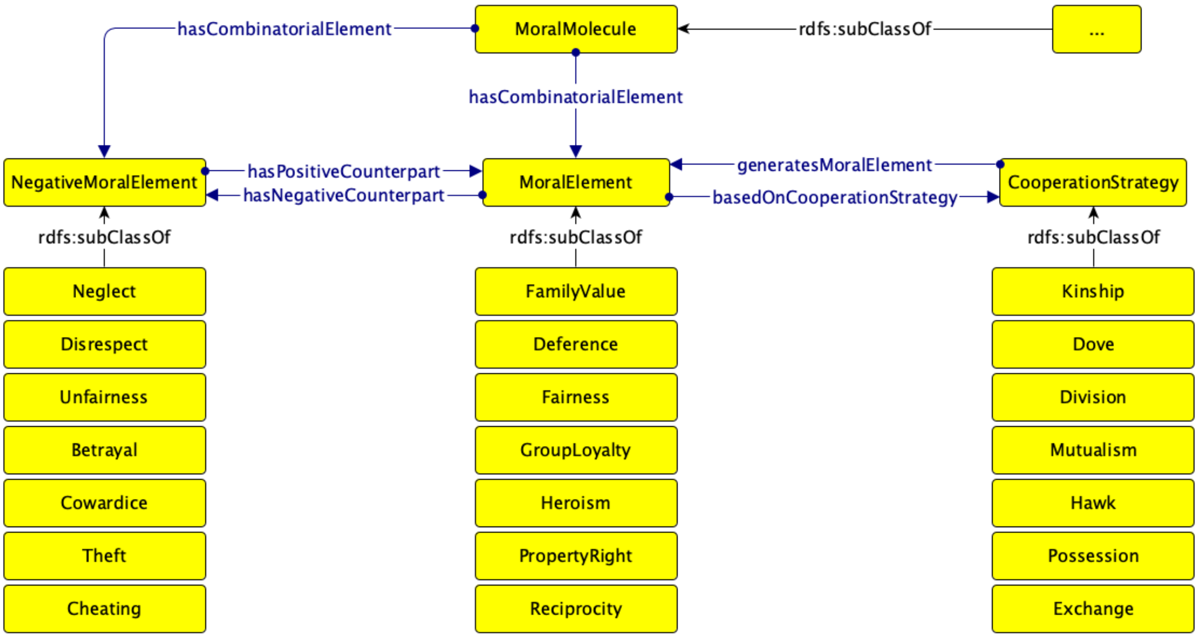

Figure 12 Moral Molecules Theory ontological module

Moral Molecules are the result of each possible combination of each Moral Element with some other Moral Element or Negative Moral Element (resulting in several thousands of possible combinations).

The Moral Molecules ontology allows to answer the following Competency Questions:

- **CQ1:** is an Entity an instance of a Moral Element?
- **CQ2**: is an Entity an instance of a Negative Moral Element?
- **CQ3**: What are the “atoms” (Moral Elements) in some Event or Situation?
- **CQ4**: What is the Value Profile (namely the composition of the Moral Molecule) of some Event or Situation?

3 Emotion Knowledge Area

The Emotion Knowledge Area aims at modelling emotions triggered by the interaction between users and cultural heritage objects. The Deliverable D2.4 gives an overview of the theoretical foundation of the emotional theories on which the ontologies lay upon and discusses how emotional theories are currently being applied by the case-studies, how they might support pilots and how they relate to cultural heritage and social cohesion dimensions. Here, we focus on the formalization of such theories as computational objects for supporting multiple tasks. In fact, ontologies of this area are being already adopted elsewhere in the project. It has been already mentioned in the D6.2 that the ontologies of the emotion area have been adopted as reference model for annotating text (cf. D3.2). Emotion ontologies constitute the logical foundation of the DEGARI reasoning system described in D6.3. More recently, (Diaz-Agundo et al., 2021) use the Pluchick ontology module for evaluating the perception of users of similarity metrics of artworks.

3.1 Atlas of Emotions

The Atlas of Emotion is conceived to be an ontological meta-module for the Emotion Ontology Network.

Its main purpose is to represent different existing theories about emotions, considering the emotion concept represented as a semantic frame, for which each theory focuses on some possible knowledge about emotions, namely covers some of the roles of the Emotion frame. This theoretical implant and formal transposition allow to consider diverse perspectives explicitly adopted in considering emotions and their cognitive, behavioural, sensorimotor manifestations as well as their basic or complex nature.

Atlas of Emotions (AoE) uses as a backbone the Exuviae methodology (Described in Section 5.2), representing as ontological structure different and often informal emotion theories. The modules in the ontology include modules developed in order to represent the nature of emotions, analysed from a more linguistic perspective (Plutchik module), linguistic and expressive perspective (Shaver and Ekman modules), and with a cognitive approach (Ortony-Clore-Collins module); in addition to these another previous external module was integrated: MFOEM ontology (Hastings et al., 2014). AoE is grounded in DUL (Gangemi et al. 2002) and reuses its classes and axioms as foundational backbone, as well as the Description and Situation ontology design pattern to introduce in the same ontology emotions intended as intensional concepts and as extensional classes of situations.

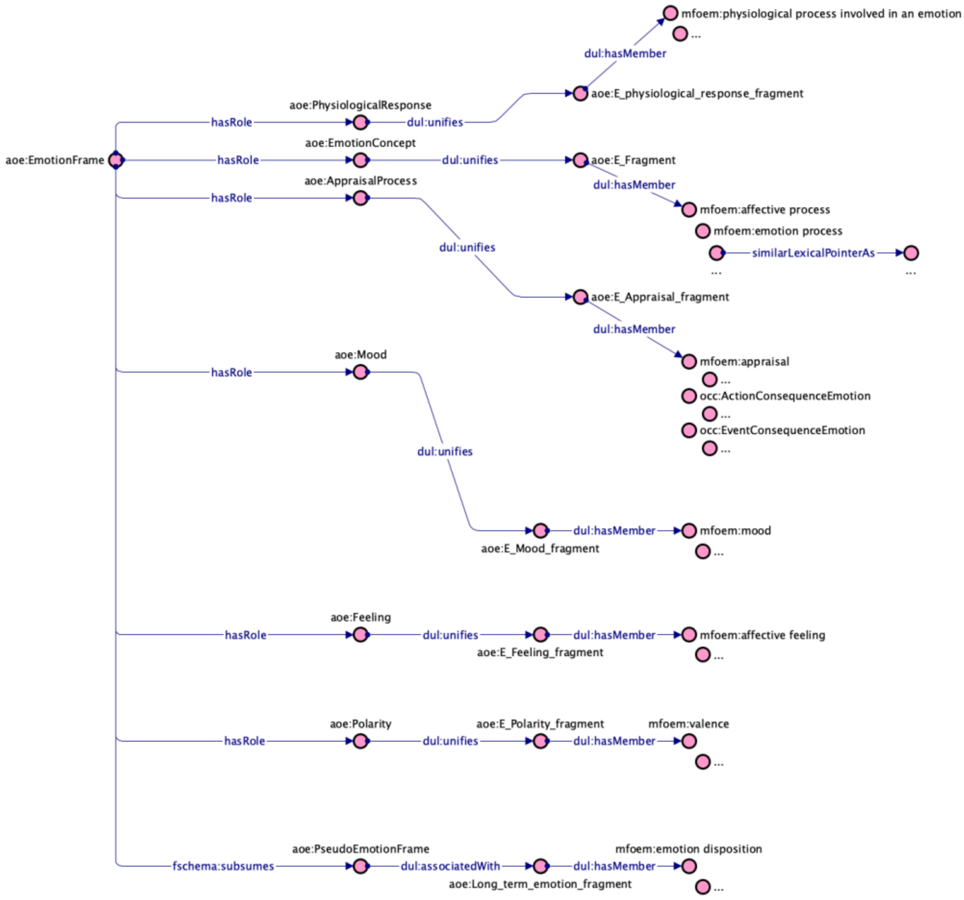

Figure 13 General Emotion frame and its plausible relation with emotions aspects expressed in many different theories

Figure 13 shows an intensional view of the emotion classes with a draft of the plausible generalization of relations considering a general `aoe:EmotionFrame` and some of its possible roles, derived from many and different modules.

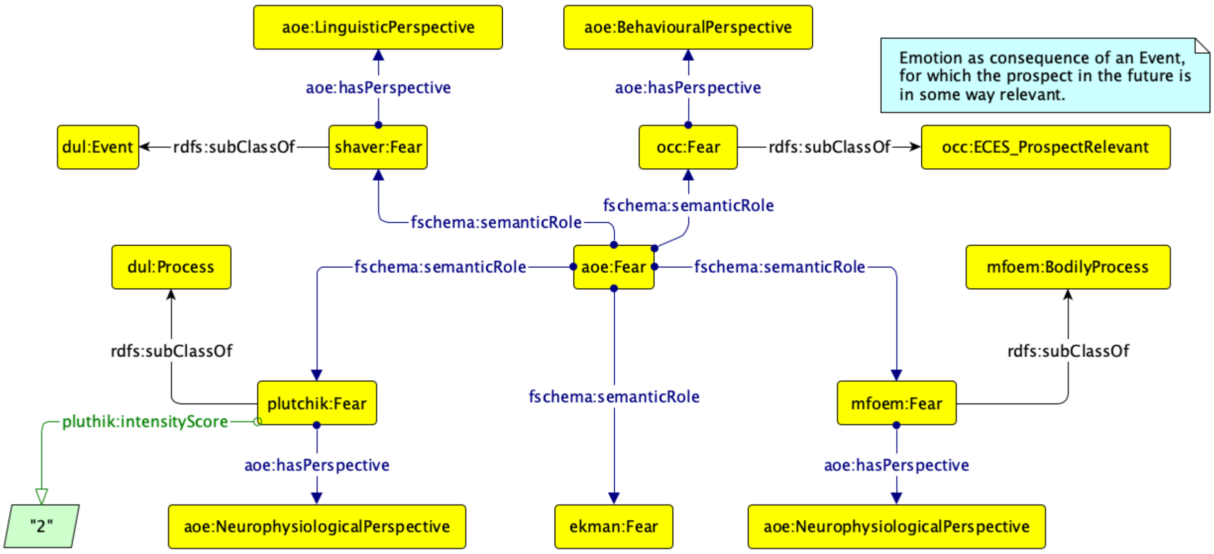

Figure 14 Example of possible emotion frame takng the use case of "Fear" and its perspectives described in different theories and represented in their dedicated ontological modules

Figure 14 shows an example of the `aoe:Fear` frame intended as class of situation which takes as roles the different classes of "fear" in many ontological modules, considering their different perspective coverage, resulting in a complex multifaceted frame.

4 Symbolism Knowledge Area

The Symbolism Knowledge Area addresses al the symbolic aspects of artefacts and the interpretation made by users.

4.1 Simulation Ontology

The Simulation ontology (Sartini et al., 2021) deals with symbolic relationships in cultural contexts. It defines symbolism as a set of relationships linked to a N-Ary class, called Simulation. A simulation is intended as the relationship between a symbolic element and its meaning. The meaning expressed in a simulation is different from the literal meaning of the element. Lion as a symbol of courage (Olderr, 2012) is a simulation, lion as "a large wild animal of the cat family with yellowish-brown fur that lives in Africa and southern Asia" ("Lion", n.d.) would not be considered as a simulation. The simulacrum is the symbolic element, it is the representation of something else. The reality counterpart is the "something else" represented by the simulacrum, not the literal meaning of the simulacrum itself. An olive branch (simulacrum) represents "peace" (reality counterpart). The simulation "olive branch-peace" is the symbolic relationship that links these two elements. Simulations are not universally valid; some only exist in specific settings or contexts. An owl is the symbol of death in Hindu, Japanese, and Mayan contexts. That means that the simulation owl-death exists in those contexts. On the other hand, in a Siberian context, owls are symbols of helpful spirits (Olderr, 2012). The simulation class is linked to the simulacrum class with the property `hasSimulacrum`, and to the reality counterpart class with the property `hasRealityCounterpart`. The context is linked to the simulation with the `hasContext` property. Simulations are linked to their source with the PROV-O (Lebo et al., 2013) property `prov:wasDerivedFrom`. The complete class and properties structure of the ontology can be seen in Figure 15. An example of a simulation can be seen in Figure 16.

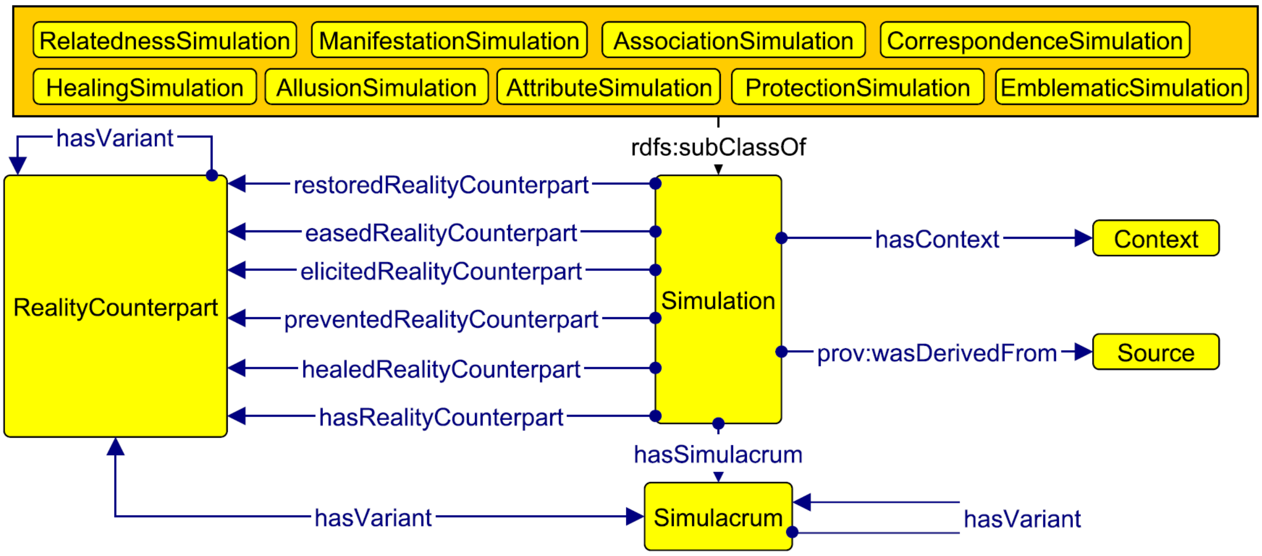

Figure 15 Simulation ontology - classes and properties

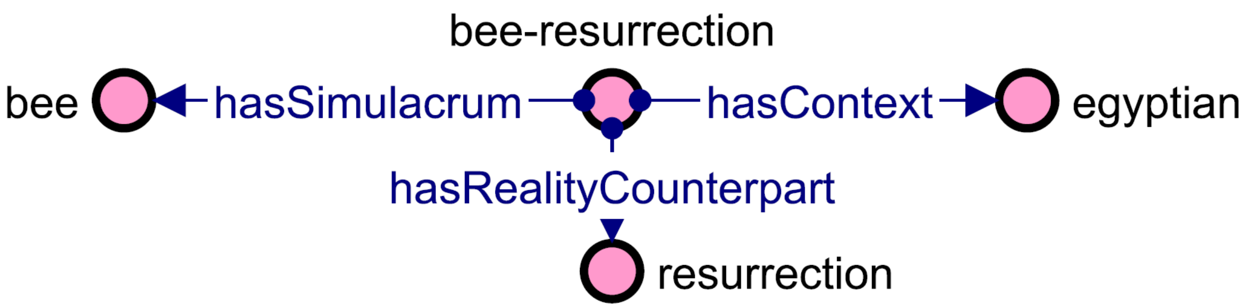

Figure *16* Graphical rendering of the bee-resurrection simulation

Simulations are linked to the Spice ontology networks as types of the `Variable` class in the scripting ontology (see Scripting ontology in 6.2 deliverable). The type of variables is express through the property `belongsTo`, so simulation individuals will be linked to variables in the scripting ontology using this property.

Simulation ontology is available at **Error! Hyperlink reference not valid.**

4.2 HyperReal KG

HyperReal (Sartini et al., 2021) is a knowledge graph that contains cultural symbols developed through the conversion of different structured and unstructured sources such as dictionaries of symbols, DBpedia, Wordnet. Its structure follows the Simulation Ontology model. All instances of the knowledge graph have recently been aligned to Babelnet, DBpedia and Wordnet and have been assigned to macro categories derived by the entity alignment (i.e., if an entity was linked to https://dbpedia.org/resource/Dog it was automatically assigned to the macro category of https://dbpedia.org/page/Fauna). This new alignment and corresponding selection of macro categories is essential to group symbols according to different criteria than the cultural context in which they exist. Figure 17 explains the alignment of HyperReal to babelnet through the example of Mary Magdalene.

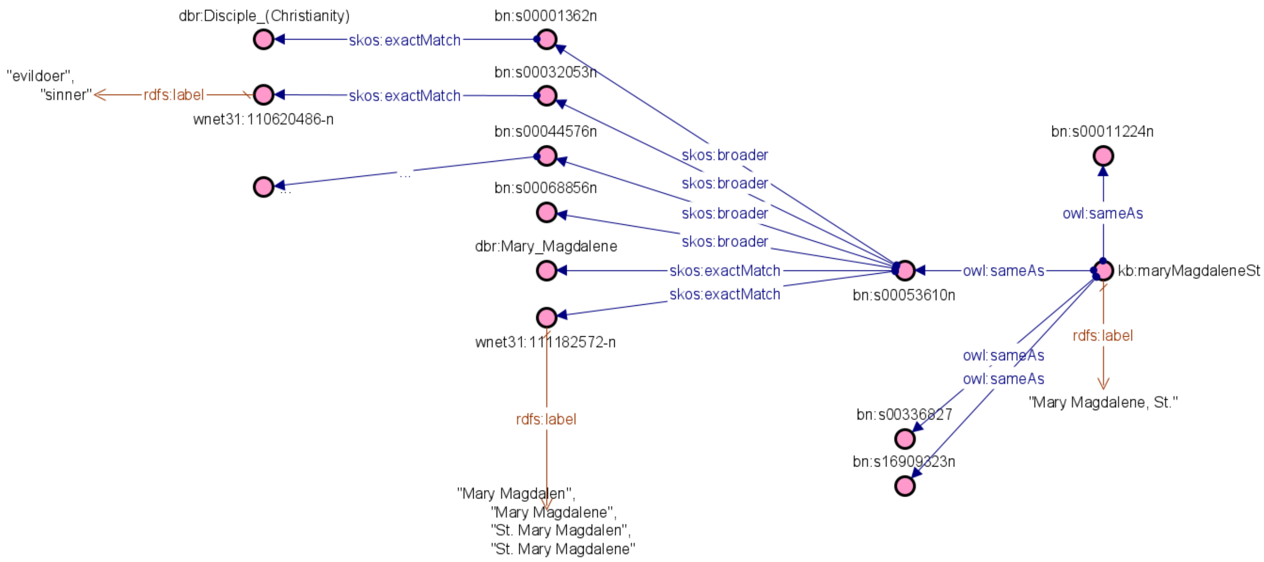

Figure *17* Example of Babelnet alignment and macro-category expansion applied to Mary Magdalene simulacrum in HyperReal

4.2.1 Use of HyperReal in SPICE

HyperReal grants some stable URIs for symbolic meanings that may be interpreted by users in the context of the SPICE project. If a simulation extracted by the user's interpretation already exists in

HyperReal, more information about it can be automatically inferred such as the macro categories of the symbolic elements that are interpreted and the primary cultural context in which that simulation exists (more on example 1b below). Studying these matchings will give an overview of the most symbolically significant elements (and their macro categories) of the SPICE userbase. Additionally, if only one element of the interpretation is matched as either a simulacrum (symbol) or reality counterpart (symbolic meaning), the interpretation of the user can be compared to the interpretations of those elements according to the knowledge graph (more on example 1b below). Finally, according to the interpretation given, the users could be showed more cultural heritage object who were interpreted with the same symbolic meaning that they are given, enhancing the experience (example c below).

Examples:

A. User A looks at the Guernica painting and writes that it symbolizes death. The simulation `guernica-death` can be generated, where `guernica` is the simulacrum and `death` is the reality counterpart.
B. User B looks at the same painting and writes that the horse depicted in it in their culture (for example Japanese) is the symbol of war. A simulation horse-war can be generated, with a Japanese context. Because both horse and war are individuals of the Hyper Real knowledge graphs, macro categories can be inferred. In this case, *horse* refer to *animal* and *war* refers to *concept*. Finally, *horse* in the Hyper Real knowledge graph is linked to more simulations, such as *courage* and *fertility.* The comparison between user interpreted simulations and the ones that come from the knowledge graph (which itself has authoritative sources for simulation) can be a starting point to quantitatively study user interpretations compared to authoritative interpretations.
C. User A is presented to other cultural items that symbolize death or contains symbols of death. The symbols of deaths are extracted my matching the elements that are depicted in cultural items with the entities in knowledge graphs. In this case, in the extraction process only *simulacra* that appear in simulations with death as a reality counterpart would be extracted.

5 Ontologies for supporting the reasoning process

The Deliverable D6.3 presents three knowledge-based sensemaking tools (i.e., DEGARI, Thematic Reasoner and Value Reasoner). Such tools operate over knowledge bases conforming to the SPICE Ontology Network, namely, they use data formalised according to SON to derive new data. Moreover, the reasoning process carried out by the sensemaking tools is supported by other ontology models provided by SON itself. This are called meta-models since they don't address modelling issues relative to the domain of interest, but they aim at supporting the sense-making process. The description of the reasoning process can be found in the dedicated deliverable (the D6.3 and the upcoming D6.6), here, we focus on the description of the underlying ontologies.

5.1 Theme Ontology

The Theme Ontology is a lightweight ontology module aimed at supporting the Thematic Reasoner in its activities. The Thematic Reasoner aims at detecting the thematic subject of an (a collection of) artifact a person interacts with, thus allowing to classify visitors with respect to their interests. For example, this enables the creation of communities of people with same/similar/connected interests and use the communities to recommend (c.f. WP3) a thematic exploration of exhibitions or finding interpretations having themes same/similar/connected to the interests of the community.

Specifically, the Theme Ontology enables us to assert that something is associated with a theme. This association may be weighted or not. The weighted association allows us to specify the strength of such relation by means of a numerical value.

The ontology is depicted in Figure 18. The class owl:Thing is the class of the OWL language which encloses all possible individuals. The theme is formalized as a skos:Concept. SKOS[3] is a common data model for sharing taxonomy of concepts. The class WeightedTheme represents the weighted relation between something (i.e., an owl:Thing) and a theme (i.e., a skos:Concept). The object property hasTheme can be used if the relation is not weighted since it directly connects the Thing with its associated concepts.

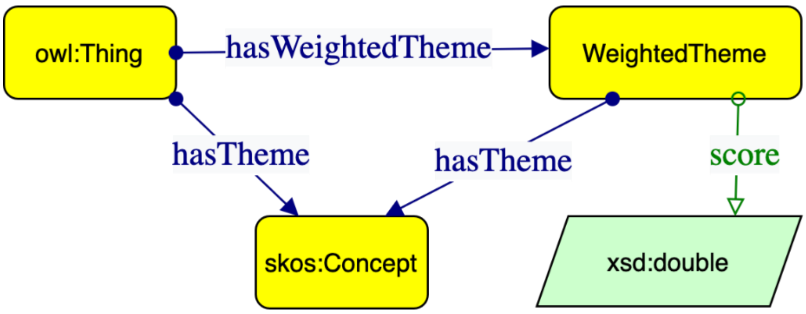

Figure 18 The Theme Ontology

5.2 Exuviae Ontology

Exuviae ("In biology, exuviae are the remains of an exoskeleton and related structures that are left after ecdyso-zoans - including insects, crustaceans and arachnids - have moulted."[4]) is an ontology used to represent and explain epistemic choices done while modelling and comparing elements of the same or different theories.

[3] https://www.w3.org/2009/08/skos-reference/skos.html
[4] https://en.wikipedia.org/wiki/Exuviae

5.2.1 Introduction

Exuviae ontological module is intended as a pragmatic logical framework, which provides a conceptual ”exoskeleton” to formally compare sets of floating fragments. Exuviae ontology is not meant in the first place to determine the superiority of one theory over another, nor to discredit theories developed in a less formal way, but rather aims to do exactly the opposite, in agreement with Habermas (Habermas, 1988) conception of SSH:

> *“Whereas the natural and the cultural or hermeneutic sciences are capable of living in mutually indifferent, albeit more hostile than peaceful coexistence, the social sciences must bear the tension of divergent approaches under one roof.”*

Exuviae methodology is composed by three main steps:

1. Explicit formal representation of a “floating fragment”: a theory, perspective or interpretation is modelled in OWL language. Entities described in the concepts and relations are distinguished, and related by means of logical axioms or vector spaces.
2. Where possible, concepts and relations are aligned to foundational theories (e.g. ontological dimensionality such as 2D or 3D entities, topology, mereology, identity, process models, participation, scalar models, common sense or specific frames, etc.), or ad hoc reference domain frameworks (“core ontologies”).
3. Formal comparison, resolution and (eventually) selection: alignment facilitates a formal comparison by using correspondences as a backbone. It is now possible to determine “what a fragment is talking about” e.g. the different types of entities, frames, focus etc. Similarity and clusters may now emerge, and possible equivalences, conflicts, and mutual completions may arise, facilitating the integration of multiple floating fragments. Also, the criteria emerge, for which a fragment is relevant, and possibly more relevant than another, as well as fragments competing for the same role in a theory, eventual overlap, differences that can be made more explicit etc.

5.2.2 State of the art

Science, technology, engineering, and mathematics (STEM) disciplines concentrate on causal explanation as a primary criterion for theory preference and evolution (modulo the social and political dynamics studied e.g. by Fleck (Fleck, 1994), Kuhn (Kuhn, 1962) and Feyerabend (Feyerabend, 2018)). However, social sciences and humanities (SSH) often host alternative theories about phenomena not easily coerced to causal explainability, like emotional spectrum theories, motivation of personal beliefs, moral foundation value theories, framing of historical or argumentative perspectives, etc., which are trending topics in the social information semiosphere that pervades “onlife” (Floridi, 2015) in the so called post-truth era. This has also created difficulty in comparing alternative theories, in the absence of causal criteria. As a consequence, SSH concepts and their relations’ semantics are often unstable. In addition, lacking a causal foundation, semantic instability becomes a primary concern for comparison and selection across alternative theories. We call these theories ”floating theory fragments” that categorise, explain, or even generate an empirical spectrum of phenomena.

Exuviae aims to deal with phenomena like “Conceptual Drift” as presented in Kuukkanen (Kuukkanen, 2008) and Wang (Wang et al., 2011) via representing in ontological form specifications of extensional change corresponding to intensional modification of the concept itself. Finally, Exuviae embraces Betti and Van Den Berg (Betti and Van Den Berg 2014) position about conceptual modelling and interpretations and it aims to operationalize it via ontological structure:

“Making an interpretive framework explicit in fact provides the best defence against the risks of interpretative biases in the writing of intellectual history, and furthers the comprehension of texts.”

5.2.3 Description of the ontology

Here we list the main classes, object, data and annotation properties. This list is not intended to be concluded but open to the introduction of new entities, especially properties, on the basis of the use case.

5.2.3.1 Classes

The main classes are:

- `:TheoreticalFragment` : a TheoreticalFragment is a collection of related ontol- ogy elements from one or multiple theories. The fragment is the hub useful to compare different theories and derive some element by applying epistemological choices made based on some criterion, eventually leading to a selection result.
- `:EpistemicComparison` : the hub for epistemic operations on theory fragments with the purpose to compare and select one.
- `:CriterionMeasurement` : the Measurement of the Criterion chosen to compare a Fragment against another. e.g. better literature grounding, more soundness, better resources at disposal, more operationalizable structure etc.;
- `:ReframingModus` : the way in which some entity is conceptually derived from a theory but with some modifications.
- `:SelectionCriterion` : if the final purpose is a Selection, the Criterion based on which the Selection is made.
- `:SelectionResult` : if Selection is the final purpose, the result of the Selection based on some SelectionCriterion.

5.2.3.2 Object Properties

The main object properties are:

- `:conceptuallyDerivedFrom` : Property to state the intellectual debt of some entity towards another e.g. a concept was elaborated starting from some clue, intuition, concept, rule or theory that gave the input in a more or less decisevely way to a cognizer for its cognition of the concept. It’s the super-property of all the followings.
- `:contradicts` : Some Entity or part of it is derived and then contradicted or negated, totally or partially.
- `:explicates` : A way to express some logical or formal conclusion explicitly declared by the conceptually derived entity and implied, but not declared explicitly by the source.
- `:generalizes` : The derived entity corresponds to a broader extension than the source, this property is similar to the skos:broadMatch property, but referred to conceptual objects.
- `:reframes` : The derived entity is :conceptuallyDerivedFrom some source but reframed in some way. It could be a stricter formalization, a different range or domain declaration or anything else. In case of need it is highly recommended to create subproperties which specify the type of reframing, if not already covered by other properties.
- `:reuses` : The derived entity is copied and reused (cloned), with possible minimal and not substantial nuanced distinctions e.g. re-labeling without new semantic commitment.

- `:specifies` : The derived entity corresponds to a narrower extension than the source, this property is similar to the skos:narrowMatch property, but referred to conceptual objects.

5.2.3.3 Annotation Properties

The most notable annotation property is:

- `:bibRef` : Annotation of the bibliographical reference of some fragment, concept or even whole theory including the original definition, detailed occurrences reference location record and year of publication. It is meant to track back the original definition of each entity modelled, in order to allow users to understand and retrieve original information about the entity.

6 Adoption of the Ontology Network in the Case Studies

This section provides an overview of how the ontologies of the SPICE ontology network have been adopted in the case studies so far. Specifically, we will show how the data collected in the case studies and shared via Linked Data Hub has been projected into the Knowledge Level shaped and formalized according to SON (this activity is also called *remodelling*).

It is worth noticing that:

1. Not all the ontologies of the network are meant to be used for expressing data, some of them serve for supporting other project tasks (e.g., Sensemaking cf. Section 5 or reasoning over value and emotional data). Therefore, the following discussion doesn't involve all the ontologies of the network.
2. Not all the datasets of the Linked Data Hub need remodelling. In fact, there are datasets (e.g., those generated by the Semantic Annotator or by DEGARI) that are originally shaped and uploaded to the LDH according to the SPICE Ontology Network.
3. There are ontologies (e.g., those for user and community modelling) of the network to be used as soon as data is ready on the Linked Data Hub.
4. The ontologies from the network not only address the information needs of the case studies, but also model the project's domain of interest. Therefore, it is reasonable to have ontologies or parts of them that are not currently used, but they are likely to be used either during the third year of the project or to contribute to other related projects.

In this section, we focus only on datasets available via the Linked Data Hub which needed of remodelling for being compliant with the Ontology Network.

Data stored in the Linked Data Hub is automatically mirrored to RDF by the SPARQL Anything engine. This convenient representation in a shared format enables us to specify the remodelling rules by means of CONSTRUCT queries written in SPARQL language. A CONSTRUCT query returns a single RDF graph according to a *graph template* specified in the CONSTRUCT clause. This graph template uses a set of variables which comply with a *graph pattern* specified in the WHERE clause. The result of the query is an RDF graph formed by taking each query solution (i.e., a binding of the variables of the graph pattern) in the solution sequence, substituting for the variables in the graph template, and combining the triples into a single RDF graph by set union. Therefore, in a remodelling activity the CONSTRUCT clause must comply with the target ontology (i.e., the vocabulary of terms the designer aims at project data into) and the WHERE clause must comply with the ontology in which data is currently specified (in our case the SPARQL Anything schema, namely, the Façade-X metamodel).

In the following, we go through the datasets of the Linked Data Hub and for each dataset we report the query used for remodelling data according to SON.

6.1 MNCN Artifacts

The MNCN Artifacts dataset[5] contains information about the artifacts owned by the MNCN. Such artifacts can be interpreted as ArCo's Cultural Property. Therefore, data contained in the dataset can remodelled according to the ArCo ontology with the following CONSTRUCT query.

```
PREFIX arco: <https://w3id.org/arco/ontology/arco/>
PREFIX xyz: <http://sparql.xyz/facade-x/data/>
PREFIX arco-cp: <https://w3id.org/arco/ontology/context-
```

[5] https://spice.kmi.open.ac.uk/dataset/details/71

```
description/>
PREFIX arco-core: <https://w3id.org/arco/ontology/core/>
CONSTRUCT {
?s a arco:CulturalProperty .
     ?s arco-cp:title ?title .
     ?s arco-cp:depiction ?image .
     ?s arco-core:description ?description .
} WHERE {
     ?s xyz:image ?image ; xyz:description ?description .
     ?s xyz:title ?title .
}
```

6.2 GAM Dataset

The GAM dataset[6] contains information about the artifacts owned by the GAM. Such artifacts can be interpreted as ArCo's Cultural Property. Therefore, data contained in the dataset can remodelled according to the ArCo ontology with the following CONSTRUCT query.

```
PREFIX arco: <https://w3id.org/arco/ontology/arco/>
PREFIX xyz: <http://sparql.xyz/facade-x/data/>
PREFIX arco-cp: <https://w3id.org/arco/ontology/context-
description/>
PREFIX arco-dd: <https://w3id.org/arco/ontology/denotative-
description/>
PREFIX arco-core: <https://w3id.org/arco/ontology/core/>
PREFIX cis: <http://dati.beniculturali.it/cis/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dc: <http://purl.org/dc/elements/1.1/>

CONSTRUCT {
  ?s a arco:CulturalProperty .
  ?s cis:isMemberOf ?collectionIRI .
  ?collectionIRI arco-cp:title ?collectionTitle .
  ?collectionIRI a cis:Collection .
  ?s arco-dd:hasMeasurement ?measurementIRI .
  ?measurementIRI a arco-dd:Measurement .
  ?measurementIRI rdfs:label ?measurementLabel .
  ?culturalPropertyTypeIRI a arco-dd:CulturalPropertyType .
  ?s arco-dd:hasCulturalPropertyType ?culturalPropertyTypeIRI .
  ?s rdfs:label ?definizione .
  ?s cis:identifier ?identifier .
  ?s arco-core:description ?description .
  ?s arco-cp:title ?title .
  ?s arco-cp:depiction ?image .
  ?s arco-dd:hasMaterialOrTechnique ?technique .
  ?technique a arco-dd:TechnicalCharacteristic .
  ?technique rdfs:label ?mt ,
  ?s arco-cp:explanationNote ?note .
  ?s arco-cp:subject ?subject .
  ?s arco-cp:hasAuthorshipAttribution ?authorshipIRI .
  ?s arco-cp:hasAttributedAuthor ?authorIRI .
  ?authorIRI rdfs:label ?author .
  ?s arco-cp:hasAcquisition ?acquisitionIRI .
```

[6] https://spice.kmi.open.ac.uk/dataset/details/62

```
    ?acquisitionIRI a arco-cp:Acquisition .
    ?acquisitionIRI rdfs:label ?source .
    ?s arco-cp:hasDating ?datingIRI .
    ?datingIRI a arco-cp:Dating .
    ?datingIRI rdfs:label ?y .

  } WHERE {

    ?s xyz:Collezione ?collectionTitle .
    ?s xyz:Definizione ?definizione .
    ?s xyz:Dimensioni ?measurementLabel .
    ?s xyz:Inventario ?identifier .
    ?s dc:description ?description .
    ?s dc:title ?title .
    ?s xyz:image ?image .
    ?s xyz:Note%20Blind ?note .
    ?s xyz:Materiale%20e%20Tecnica ?mt .
    ?s xyz:Soggetto ?subject .
    ?s xyz:author ?author .
    ?s xyz:source ?source .
    ?s xyz:year ?y .
    BIND(CONCAT(str(?s), "_collection") AS ?collectionIRI)
    BIND(CONCAT(str(?s), "_cpType") AS ?culturalPropertyTypeIRI)
    BIND(CONCAT(str(?s), "_measurement") AS ?measurementIRI)
    BIND(CONCAT(str(?s), "_author") AS ?authorIRI)
    BIND(CONCAT(str(?s), "_authorship") AS ?authorshipIRI)
    BIND(CONCAT(str(?s), "_acquisition") AS ?acquisitionIRI)
    BIND(CONCAT(str(?s), "_dating") AS ?datingIRI)
  }
```

6.3 Semantic Annotator

The Semantic Annotator dataset[7] contains text annotated by the Semantic Annotator (cf. D3.2). Annotations are originally specified according to the SPICE Ontology Network, therefore there is no need to remodel data. Details of how such annotations are specified in RDF are provided in D3.2 and D6.5.

6.4 GAM Game Story Definitions

The Gam Game Story Definitions[8] dataset contains information about the stories provided by the users participating in the GAM GAME. Each activity user recorded in the dataset can be interpreted, according to scripting ontology, as an action executing a particular task of a certain script. Therefore, data provided by the dataset can be projected to the scripting ontology schema by the following CONSTRUCT query.

```
PREFIX arco: <https://w3id.org/arco/ontology/arco/>
PREFIX xyz: <http://sparql.xyz/facade-x/data/>
PREFIX arco-cp: <https://w3id.org/arco/ontology/context-
description/>
PREFIX arco-dd: <https://w3id.org/arco/ontology/denotative-
description/>
PREFIX arco-core: <https://w3id.org/arco/ontology/core/>
PREFIX cis: <http://dati.beniculturali.it/cis/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
```

[7] https://spice.kmi.open.ac.uk/dataset/details/59
[8] https://spice.kmi.open.ac.uk/dataset/details/58

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX scripting: <https://w3id.org/spice/SON/scripting/>

CONSTRUCT {
  ?scriptExecIRI a scripting:ScriptExecution .
  ?scriptExecIRI rdfs:label ?activityTitle .
  ?scriptExecIRI scripting:includesAction ?actionIRI .
  ?actionIRI a scripting:Action .
  ?roleInTimeIRI a scripting:RoleInTime .
  ?roleInTimeIRI scripting:forAction ?actionIRI .
  ?roleInTimeIRI scripting:isRoleInTimeOf ?agentIRI .
  ?agentIRI a scripting:Agent  .
  ?agentIRI rdfs:label ?authorId .
  ?actionIRI scripting:executesTask ?taskIRI .
  ?taskIRI a scripting:Task .
  ?taskIRI scripting:involves ?artworkIRI .
  ?artworkIRI a arco:CulturalProperty .
  ?actionIRI scripting:generated ?textIRI .
  ?textIRI rdfs:label ?text .

  ?actionIRI scripting:generated ?emojiIRI .
  ?emojiIRI rdfs:label ?emoji .
  ?actionIRI scripting:generated ?tagIRI .
  ?tagIRI rdfs:label ?tag .

} WHERE {

  ?activity xyz:title ?activityTitle .
  ?activity xyz:activityId ?activityId .
  BIND( CONCAT("https://w3id.org/spice/ScriptExecution/",
?activityId) AS ?scriptExecIRI )
  ?activity xyz:authorId ?authorId .
  BIND( CONCAT("https://w3id.org/spice/RoleInTime/", ?activityId)
AS ?roleInTimeIRI )
  BIND( CONCAT("https://w3id.org/spice/Agent/", ?authorId, "-",
?activityId) AS ?agentIRI )
  BIND(STR(NOW()) AS ?id)
  BIND( CONCAT("https://w3id.org/spice/Action/", ?activityId, "-",
?textTemplate) AS ?actionIRI )
  ?multimediaDataObject xyz:textTemplate ?textTemplate .
  BIND( CONCAT("https://w3id.org/spice/Task/", ?textTemplate) AS
?taskIRI )
  ?activity xyz:parts ?partContainer .
  ?partContainer ?slot ?part .
  ?part xyz:artworkId ?artworkId .
  BIND( CONCAT("https://w3id.org/spice/Artwork/", ?artworkId) AS
?artworkIRI)
  ?part xyz:multimediaData ?multimediaDataObjects .
  ?multimediaDataObjects ?slot2 ?multimediaDataObject .
  ?multimediaDataObject xyz:text ?text .
  BIND( CONCAT("https://w3id.org/spice/Text/", ?id) AS ?textIRI)
  OPTIONAL {
    ?multimediaDataObject xyz:emojis ?emojisObjects .
    ?emojisObjects ?slot2 ?emojisObject .
    ?emojisObject xyz:locationX ?locX .
    ?emojisObject xyz:locationY ?locY .
```

```
    ?emojisObject xyz:emoji ?emoji .
    BIND( CONCAT("https://w3id.org/spice/Emojii/", ?id) AS
?emojiIRI)
  }
  OPTIONAL {
    ?multimediaDataObject xyz:tags ?tagObjects .
    ?tagObjects ?slot3 ?tagObject .
    ?tagObject xyz:locationX ?locXTag .
    ?tagObject xyz:locationY ?locYTag .
    ?tagObject xyz:tag ?tag .
    BIND( CONCAT("https://w3id.org/spice/Tag/", ?id) AS ?tagIRI)
  }
}
```

6.5 GAM Game Activity Definitions

The Gam Game Activity Definitions[9] dataset contains information about the activities of the GAM GAME. Each activity of this dataset can be interpreted, according to scripting ontology, as a Task of a certain script. Therefore, data provided by the dataset can be projected to the scripting ontology schema by the following CONSTRUCT query.

```
PREFIX xyz: <http://sparql.xyz/facade-x/data/>
PREFIX arco-cp: <https://w3id.org/arco/ontology/context-
description/>
PREFIX arco-dd: <https://w3id.org/arco/ontology/denotative-
description/>
PREFIX arco-core: <https://w3id.org/arco/ontology/core/>
PREFIX cis: <http://dati.beniculturali.it/cis/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX scripting: <https://w3id.org/spice/SON/scripting/>

CONSTRUCT {

  ?taskIRI a scripting:Task .
  ?taskIRI rdfs:label ?title .
  ?taskIRI rdfs:comment ?des .
  ?taskIRI scripting:hasConditionalOutput ?responseTypeIRI .
  ?responseTypeIRI a scripting:Variable .
  ?responseTypeIRI rdfs:label ?fillRes .
  ?taskIRI scripting:involves ?artworkIRI .
  ?artworkIRI a scripting:CulturalProperty .


} WHERE {
 ?activity xyz:%5Fid ?activityId .
 ?activity xyz:activityTitle ?title .
 ?activity xyz:description ?des .
 BIND(CONCAT("https://w3id.org/spice/Task/",?activityId) AS
?taskIRI)
 ?activity xyz:allowedResponseTypes ?resTypes .
 ?resTypes ?slotRes ?fillRes .
 BIND(CONCAT("https://w3id.org/spice/ResponseType/",?fillRes) AS
?responseTypeIRI)
 ?activity xyz:artworks ?artworks .
```

[9] https://spice.kmi.open.ac.uk/dataset/details/58

```
 ?artworks ?slotArtwork ?artworkID .
 BIND(CONCAT("https://w3id.org/spice/Artwork/",?artworkID) AS
?artworkIRI)

}
```

6.6 GAM Game DEGARI

The GAM Game Degari dataset[10] contains text annotated by the DEGARI reasoner (cf. D6.3). Annotations are originally specified according to the SPICE Ontology Network (specifically, according to the ontologies belonging to the Emotion Knowledge Area), therefore there is no need to remodel data. Details of how such annotations are specified in RDF are provided in D6.3.

6.7 IMMA Viewpoints Artworks

The IMMA Viewpoints Artworks dataset[11] contains information about the artifacts owned by the IMMA and involved in the Viewpoints experiments. Such artifacts can be interpreted as ArCo's Cultural Property. Therefore, data contained in the dataset can remodelled according to the ArCo ontology with the following CONSTRUCT query.

```
PREFIX arco: <https://w3id.org/arco/ontology/arco/>
PREFIX xyz: <http://sparql.xyz/facade-x/data/>
PREFIX arco-cd: <https://w3id.org/arco/ontology/context-
description/>
PREFIX arco-dd: <https://w3id.org/arco/ontology/denotative-
description/>
PREFIX arco-core: <https://w3id.org/arco/ontology/core/>
PREFIX cis: <http://dati.beniculturali.it/cis/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX scripting: <https://w3id.org/spice/SON/scripting/>

CONSTRUCT {

  ?artworkIRI a arco:CulturalProperty .
  ?artworkIRI arco-cd:title ?title .
  ?artworkIRI arco-core:description ?description .
  ?artworkIRI arco-cd:depiction ?image .
  ?artworkIRI arco-cp:hasDating ?datingIRI .
  ?datingIRI a arco-cp:Dating .
  ?datingIRI rdfs:label ?date .
  ?artworkIRI rdfs:seeAlso ?URL .

} WHERE {

 ?artwork xyz:%5Fid ?artworkID .
 ?artwork xyz:name ?title .
 ?artwork xyz:description ?description .
 ?artwork xyz:image ?image .
 ?artwork xyz:date ?date .
 ?artwork xyz:URL ?URL .
 BIND(CONCAT("https://w3id.org/spice/Artwork/",?artworkID) AS
?artworkIRI)
```

[10] https://spice.kmi.open.ac.uk/dataset/details/54
[11] https://spice.kmi.open.ac.uk/dataset/details/46

```
BIND(CONCAT("https://w3id.org/spice/Artwork/",?artworkID,"_dating")
AS ?datingIRI)

}
```

6.8 IMMA Viewpoints Responses

The IMMA Viewpoints Reponses[12] dataset records information about the responses provided by the users participating in the IMMA Viewpoints experiment. Each response recorded in the dataset can be interpreted, according to scripting ontology, as an action executing a Question Answering task of Therefore, data provided by the dataset can be projected to the scripting ontology schema by the following CONSTRUCT query.

```
PREFIX arco: <https://w3id.org/arco/ontology/arco/>
PREFIX xyz: <http://sparql.xyz/facade-x/data/>
PREFIX arco-cp: <https://w3id.org/arco/ontology/context-
description/>
PREFIX arco-dd: <https://w3id.org/arco/ontology/denotative-
description/>
PREFIX arco-core: <https://w3id.org/arco/ontology/core/>
PREFIX cis: <http://dati.beniculturali.it/cis/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX scripting: <https://w3id.org/spice/SON/scripting/>

CONSTRUCT {

  ?questionTaskIRI a scripting:FreeTextAnswering .
  ?questionTaskIRI scripting:hasInput ?questionIRI .
  ?questionIRI rdfs:label ?questionAsked .
  ?questionTaskIRI scripting:involves ?artworkIRI .
  ?artworkIRI a arco:CulturalProperty .
  ?responseIRI a scripting:Action .
  ?responseIRI scripting:executesTask ?questionTaskIRI .

  ?questionTaskIRI scripting:hasOutput ?responseVariableIRI .
  ?responseVariableIRI a scripting:Variable .
  ?responseIRI scripting:generated ?responseTextIRI .
  ?responseTextIRI rdfs:label ?response .

} WHERE {
 ?activity xyz:%5Fid ?activityId .
 ?activity xyz:questionID ?questionID .
 ?activity xyz:questionAsked ?questionAsked  .
 ?activity xyz:artworkID ?artworkID .
 ?activity xyz:response ?response .
 BIND(IRI(CONCAT("https://w3id.org/spice/",?questionID)) AS
?questionTaskIRI)

BIND(IRI(CONCAT("https://w3id.org/spice/",?questionID,"/question"))
AS ?questionIRI)
 BIND(CONCAT("https://w3id.org/spice/Artwork/",?artworkID) AS
?artworkIRI)
```

[12] https://spice.kmi.open.ac.uk/dataset/details/47

```
 BIND(CONCAT("https://w3id.org/spice/Response/",?activityId) AS
?responseIRI)
 BIND(CONCAT("https://w3id.org/spice/ResponseText/",?activityId) AS
?responseTextIRI)
}
```

7 Conclusions

This document presented further developments of the SPICE Ontology Network (SON) occurred during the period M13-M24. This document complements the D6.2 deliverable with the final specification of the SPICE Ontology Network, and reports on the usage of the ontology in the context of the project.

This report included the description of the novel ontologies introduced in the network to accommodate the requirements emerged during the second year. Specifically, a model for representing User Profile and Communities were devised based on the results of the Work Package 3. The Curry's theory on moral values were formalized and specified in an ontology. An ontology, called Value Core, was developed to generalize the various ontologies formalizing theories on Moral Values (i.e., Curry, Haidt, Schwartz). Similarly, the ontology called "Atlas of Emotions" aims at integrating the multiple theories on emotions (i.e., Ekman, Pluchick, Ortony-Clore-Collins and Shaver). Finally, during the reporting period were developed: 1) an ontology dealing with symbolic meaning; 2) An ontology for supporting thematic reasoning; 3) an ontology for supporting formal comparison of non-formal theories.

Moreover, this document provides an overview of how the ontologies of the SPICE ontology network are adopted in the case studies. We remind that due to the initial stage of data gathering and design in the project, no strict ontological commitment was enforced on data, but we demonstrated that the SPICE's technological framework (in particular, Linked Data Hub and SON) gives the ability of *projecting* the raw data into an ontological space. This enables us to integrate, access, and validate data through the lenses of the formal space modelled by the ontology network by means of simple CONSTRUCT queries (as those presented in Section 6). This solution ensured that data was exchanged in a very flexible manner without losing its semantic characteristics which are used when needed.

Even if this deliverable is aimed to provide the final specification of the ontology, the work on SON won't be concluded at month 24. In fact, besides the maintenance of the ontology and the refinement of its documentation, we plan to foster its adoption in the case studies, to develop ontology-based approaches for addressing tasks related to the project's activities (e.g., an ontology-based approach for computing similarity between artworks on the basis of the ontological representation of the artwork itself and its related themes is planned to be realised in collaboration with WP3 during Y3) and to possibly address new requirements that might emerge from the pilots.

We finally remind the reader that ontologies can change during the third year of the project due to emerging requirements and fixes, and new developments in SPICE use cases could lead to the design of new ontologies in SON.

8 References

(Betti and Van Den Berg 2014) Betti, A., & Van den Berg, H. (2014). Modelling the history of ideas. *British Journal for the History of Philosophy*, *22*(4), 812-835.

(Curry, 2005) Curry, O. S. (2005). Morality as Natural History An adaptationist account of ethics.

(Curry, 2016) Curry, O. S. (2016). Morality as cooperation: A problem-centred approach. In *The evolution of morality* (pp. 27-51). Springer, Cham.

(Diaz-Agundo et al., 2021) Díaz-Agudo, Belén, Guillermo Jimenez-Diaz, and Jose Luis Jorro-Aragoneses. "User Evaluation to Measure the Perception of Similarity Measures in Artworks." *International Conference on Case-Based Reasoning*. Springer, Cham, 2021.

(Feyerabend, 2018) Feyerabend, P. (2018). *Science in a free society*. Verso Books.

(Fleck, 1994) Fleck, L. (1994). Entstehung einer wissenschaftlichen Tatsache–Einführung in die Lehre vom Denkstil und Denkkollektiv. *Frankfurt/Main*.

(Floridi, 2015) Floridi, L. (2015). *The onlife manifesto: Being human in a hyperconnected era* (p. 264). Springer Nature.

(Gangemi et. al., 2002) Gangemi, A., Guarino, N., Masolo, C., Oltramari, A., & Schneider, L. (2002, October). Sweetening ontologies with DOLCE. In *International Conference on Knowledge Engineering and Knowledge Management* (pp. 166-181). Springer, Berlin, Heidelberg.

(Graham et. al., 2013) Graham, J., Haidt, J., Koleva, S., Motyl, M., Iyer, R., Wojcik, S. P., & Ditto, P. H. (2013). Moral foundations theory: The pragmatic validity of moral pluralism. In *Advances in experimental social psychology* (Vol. 47, pp. 55-130). Academic Press.

(Habermas, 1988) Habermas, J. (1988). Historical consciousness and post-traditional identity: remarks on the Federal Republic's Orientation to the West. *Acta Sociologica*, *31*(1), 3-13.

(Hastings et al., 2014) Hastings, J., Brass, A., Caine, C., Jay, C., & Stevens, R. (2014). Evaluating the Emotion Ontology through use in the self-reporting of emotional responses at an academic conference. *Journal of biomedical semantics*, *5*(1), 1-17.

(Kuhn, 1962) Kuhn, T. (1962). The structure of scientific revolutions. *International Encyclopedia of Unified Science*, *2*(2).

(Kuukkanen, 2008) Kuukkanen, J. M. (2008). Making sense of conceptual change. *History and theory*, *47*(3), 351-372.

(Lebo et al. 2013) Lebo, Timothy, Satya Sahoo, Deborah McGuinness, Khalid Belhajjame, James Cheney, David Corsar, Daniel Garijo, Stian Soiland-Reyes, Stephan Zednik, and Jun Zhao. 2013. 'PROV-O: The PROV Ontology'.

("Lion", n.d.) Lion'. n.d. Accessed 1 April 2022.

https://dictionary.cambridge.org/dictionary/english/lion.

(Olderr, 2012) Olderr, Steven. 2012. *Symbolism a Comprehensive Dictionary*. 2nd ed. London: McFarland.

(Sartini et al., 2021) Bruno Sartini, Marieke van Erp, and Aldo Gangemi. 2021. Marriage is a Peach and a Chalice: Modelling Cultural Symbolism on the Semantic Web. In Proceedings of the 11th on

Knowledge Capture Conference (K-CAP '21). Association for Computing Machinery, New York, NY, USA, 201–208. DOI:https://doi.org/10.1145/3460210.3493552

(Schultz et al., 2011) Shultz, S., Opie, C., & Atkinson, Q. D. (2011). Stepwise evolution of stable sociality in primates. *Nature*, *479*(7372), 219-222.

(Schwartz, 2012) Schwartz, S. (2012). Toward refining the theory of basic human values. In *Methods, theories, and empirical applications in the social sciences* (pp. 39-46). VS Verlag für Sozialwissenschaften.

(Tooby & DeVore, 1987) Tooby, J., & DeVore, I. (1987). The reconstruction of hominid behavioral evolution through strategic modeling. *The evolution of human behavior: Primate models*, 183-237.

(Wang et al., 2011) Wang, S., Schlobach, S., & Klein, M. (2011). Concept drift and how to identify it. *Journal of Web Semantics*, *9*(3), 247-265.