The dynamics of specialized knowledge representation: simulational reconstruction or the perception-action interface

PAMELA FABER
University of Granada

Abstract

Dynamicity is the condition of being in motion, and thus, is characterized by continuous change, activity, or progress. Not surprisingly, dynamicity is generally acknowledged to be an important part of any kind of knowledge representation system or knowledge acquisition scenario. This means that it might be a good idea to reconsider concept representations in Terminology, and modify them so that they better reflect what the nature of conceptualization in the mind and brain.
In this sense, recent theories of cognition have emphasized that situated or grounded experiences are activated in cognitive processing (Louwerse and Jeuniaux 2010; Barsalou 1999; Zwaan 2004). According to these theories, meaning construction heavily relies on perceptually simulating the information that is presented to the comprehender. Specialized knowledge representation that facilitates knowledge acquisition could thus be conceived as a situation model or event that enables comprehenders to use communicated information to better interact with the world.

Keywords: knowledge representation; knowledge acquisition; situated cognition; concept system; terminology resources

1. Introduction

Dynamicity is the condition of being in motion, and thus, is characterized by continuous change, activity, or progress. If a frequency check were made in Terminology literature, *dynamic* would be high on the key word list. This is only natural since specialized language is dynamic, and its representation should be so as well. Accordingly, dynamicity is acknowledged to be an important part of any kind of knowledge representation system or knowledge acquisition scenario. However, an in-depth study is needed of the dynamicity of conceptualization itself, and how the nature of human perception influences the representation of concept systems in specialized knowledge contexts.

As is well-known, a major focus in Terminology and Specialized Communication has always been conceptual organization. In fact, a great deal has been written on the topic

(Budin 1994; Puuronen 1995; Meyer and Mackintosh 1996; Meyer, Eck, and Skuce 1997; Pozzi 1999; Pilke 2001; Feliu 2004; Tebe 2005; Faber et al. 2007; León 2009, *inter alia*). Given the fact that terms are specialized knowledge units that designate our conceptualization of objects, qualities, states, and processes in a specialized domain, any theory of Terminology should aspire to psychological and neurological adequacy. In this sense, knowledge of conceptualization processes as well as the organization of semantic information in the brain should underlie any theoretical assumptions concerning the access, retrieval, and acquisition of specialized knowledge as well as the design of specialized knowledge resources.

It is true that one of the basic premises of Terminology theory from Wüster (1968) onwards is the conceptual organization of terminology resources. Although many resources do not offer a graphical representation of the conceptual organization of specialized knowledge domains, conceptual information is included in term records in the form of definitions and information concerning related terms. Nevertheless, Terminology has not as yet seriously taken on board recent research advances in cognition and cognitive neuroscience, which point to the inadequacy of standard theories of cognition (Gallese and Lakoff 2005). As is well-known, standard theories of cognition are based on abstract, amodal representations of entities, events, and processes that do not take into account the human and contextual factor of processors, their focus of attention, and spatiotemporal situation. As it happens, these conventional (though inadequate) theories of cognition are the same theories upon which mainstream conceptual representations in Terminology are currently based. This is reflected in Terminology textbooks as well as in the design of specialized knowledge resources.

For example, most of these manuals mention the fact that part of terminology work is the elaboration of a graphical representation of a concept system of the specialized field with the help of an expert and the use of specialized thesauri:

> A concept system is made up of a structured set of concepts organized into concept classes. The major concept classes and sub-classes, as well as concepts of the same class, are related on the basis of the characteristics they share or by their use in reality [...] Structures are usually represented in tree diagrams (Cabré 1999: 135).
>
> In terminology work, the knowledge acquired in a given subject field is structured according to the hierarchical and associative relationships between the concepts that make up the subject field (Pavel and Nolet 2001: 15).

However, very little is ever said about how this representation is created, and the premises upon which it is based. Various authors have expressed discontent with the current shape of concept systems (e.g. Nuopponen 1994; Cabré 2000; Temmerman 2000). Rogers (2004: 221) criticizes the fact that each node in the representation of a concept system is conventionally labeled by a decontextualized lexeme despite the fact that knowledge, as represented in texts, is conceptually dynamic and linguistically varied. Quite understandably, dynamicity is difficult to capture and believably portray in a static representation. Perhaps for this reason, there is a certain lack of proposals or viable alternatives to the current state of affairs.

The explicit representation of conceptual organization does not appear to have an important role in the elaboration of terminological resources. Most resources that do offer such information merely provide an overview of a specialized field, primarily based on the ISA or TYPE_OF conceptual relation. This overview usually consists of graphical representations of concepts in the form of tree or bracket diagrams. However, even this type of organization is a fairly rare occurrence since the great majority of terminological resources available on Internet contain very little information regarding the location of specialized knowledge concepts in larger knowledge configurations (Faber et al. 2006).

Even when conceptual representations are included, they do not correspond to current theoretical accounts of how conceptualization takes place in the mind. Mental representations are much richer and more flexible than such representations of conceptual structure. Part of this perceived richness (as well as the difficulty in describing it) is due to the inherent dynamicity of conceptual processing and conceptualization, which involves change over time (Langacker 2001).

Because of their dynamic nature, grounded or situated cognition theories are of vital interest for the representation of specialized knowledge, which is a major focus in Terminology and specialized communication. Since knowledge resources should reflect, to the extent possible, conceptual categories and the processes that actually occur in the brain, it is time that terminologists took note of recent advances in cognition, and made an effort to model specialized knowledge representations accordingly. The question is how an awareness of the nature of mental processes can be applied to and incorporated in the representation of specialized knowledge concepts.

2. New theories of cognition

Recent research in cognitive psychology and neuroscience highlights the dynamic nature of categorization, concept storage and retrieval, and cognitive processing (Louwerse and Jeuniaux 2010; Aziz-Zadeh and Damasio 2008; Patterson, Nestor and Rogers 2007; Gallese and Lakoff 2005). This work underlines the inadequacy of standard theories of cognition that claim that knowledge resides in a semantic memory system separate from the brain's modal systems for perception, action, and introspection. According to standard theories, representations in modal systems are not greatly influenced by the perceiver and the context of perception, and are transduced into amodal symbols, which are not specific of the mode of perception. These symbols represent knowledge about experience in semantic memory (Barsalou 2008: 618; Mahon and Caramazza 2008: 59).

However, there is an increasing consensus in favor of a more dynamic view of cognitive processing or situated cognition, which reflects the assumption that cognition is typically grounded in multiple ways. These include simulations, situated action, and even bodily states. The embodied or grounded cognition hypothesis equates understanding with sensory and motor simulation. This hypothesis claims that interactions between sensorimotor systems and the physical world underlie cognition. When we encounter a physical object, our senses represent it during perception and action. Processing the object involves partially capturing property information on these modalities so that this information can later be reactivated (Damasio and Damasio 1994).

For example, to represent the concept, PEACH, neural systems for vision, action, touch, taste and emotion partially reenact the perceiver's experience of a peach. These reenactments or simulations are not the same thing as mental imagery, which is consciously evoked in working memory. Unlike mental imagery, these simulations seem to be relatively automatic processes that lie outside of our awareness (Simmons, Martin and Barsalou 2005: 1602).

To date, brain-imaging experiments have largely involved everyday objects such as cups, hammers, pencils, and food, which, when perceived, trigger simulations of potential actions. For example, the handle of a cup activates a grasping simulation (Tucker and Ellis 1998, 2001). Food activates brain areas related to gustatory processing as well as areas in the visual cortex representing object shape (Simmons, Martin and Barsalou 2005). Neuroimaging research thus confirms that simulation is a key part of conceptual processing (Martin 2001, 2007). When conceptual knowledge about objects is represented, brain areas that represent their properties during perception and action become active. In particular, brain areas that represent the shape and color of objects, the motion they exhibit, and the actions that agents perform on them become active to represent these properties conceptually.

Such reenactments not only occur in the presence of the object itself, but also in response to words and other symbols. It would thus appear that simulations have a central role in the representation of conceptual knowledge (Barsalou 2003; Martin 2001, 2007). For precisely this reason, they should be taken into account in Terminology. To my knowledge, few if any neuropsychological experiments of this type have ever been performed with specialized concepts, but there is no reason to suppose that the brain would work any differently.

For example, when reading about hockey, experts were found to produce motor simulations absent in novices (Holt and Beilock 2006). In all likelihood, a similar result would be obtained if the object were a tide gauge, pluviometer, or anemometer. The expert's brain would show motor simulations in brain areas that would not be activated in the case of non-experts to whom the object was unfamiliar. The information regarding simulated interaction is thus a vital part of conceptual meaning.

The nature of such simulations is componential rather than holistic. In other words, they are not continuous streamed video recordings, but rather contain many small elements of perception, which arise from all modalities of experience. These modalities are contextually constrained and vary in accessibility (Simmons, Martin and Barsalou 2005). This would (or should) have a significant effect on how concepts are defined and how the definition is structured. The way that objects are represented in our brain seems to suggest that current methods and ways of elaborating specialized knowledge representations should be modified in order to take this information into account.

3. The dynamics of Terminology

Yet, we may well ask ourselves if such research on the dynamicity of cognition, however valuable, has any feasible application in Terminology and specialized communication. Terminological dynamicity has been explored from a wide variety of perspectives. For example, our knowledge of specialized fields evolves, and the terms used to describe the concepts in them also change (Bowker and Pearson 2002: 48). Dynamicity is a property of term formation as explored in Kageura (2002). It underlies the idea of the emergence of terms, the coherent coming into existence of new forms through ongoing intrinsic processes. Dynamism is also reflected in the historical evolution of term meaning within sociocultural context (e.g. *splicing*, Temmerman 1995, 2007). Moreover, the dynamic nature of terms and their constant change in meanings may require human intervention in the form of terminological control (Felber 1988; Oeser and Budin 1995). However, what underlies all of these dynamic perspectives is the fact that conceptualization or concept formation itself is dynamic. This is the process through which we access and acquire knowledge.

In reference to dynamic conceptualization, Wright (2003) and Antia et al. (2005) refer to Damasio (1994) and the dynamic variability of his earliest model of concept formation. The model of memory described is reconstructive. Concepts take the form of fleeting perceptions, which are essentially instantaneous convergences of perceptual aspects that combine at a given point in time and space. The main conclusion seems to be that concepts stem from a series of iterative processing events, and are in constant flux in the brain. Such extreme dynamism initially seems to have a very limited practical application because it is impossible to capture a process that is in perpetual motion and so individual.

However, the position that semantic memory arises from universal connectivity in the brain without a corresponding stable neural architecture is no longer tenable (Patterson, Nestor and Rogers 2007: 976). Although current theoretical positions regarding semantic memory share the view that much of our semantic memory relates to perception and action, in order to be able to generalize across concepts that have similar semantic significance, there must also be a single convergence zone or hub that supports the interactive activation of representations in all modalities for semantic categories (Patterson, Nestor and Rogers 2007: 977).

The question is how such theories can affect or be applied to terminological work, including the creation of terminological resources. Actually, they have a range of possible applications in Terminology that are just beginning to be explored. First of all, situated conceptualizations underline the fact that concepts are not processed in isolation, but are typically situated in background situations and events (Barsalou 2003). This signifies that context is all-important in knowledge representation. At any given moment in the perception of the entity, people also perceive the space surrounding it, including the agents, objects, and event present in it (Barsalou 2009: 1283).

This can be directly applied to specialized knowledge modeling to ensure the comprehensiveness of terminological entries. In fact, it can act as a safeguard against omitting other closely related concepts in the same knowledge domain. For example, EROSION is the wearing away of the earth's surface, but whether conceptualized as a process or the result of this process, erosion cannot be conceived in isolation. It is induced by an agent (wind, water, or ice) that affects a geographic entity (the Earth's surface) by causing something (solids) to move away. Moreover, any process takes place over a period of time, and can be divided into smaller segments. In this sense, erosion can happen at a specific season of the year, and may take place in a certain direction. All of this information about erosion should be available for potential activation when the user wishes to acquire knowledge about it. The meaning of a concept is constructed on-line, and is modulated by context.

Secondly, although dynamicity has been regarded primarily as an attribute of event and action concepts (Pilke 2001; Puuronen 1995, *inter alia*), as shall be seen, grounded or situated cognition means that object concepts are also dynamic since they are processed as part of a frame or dynamic context which highlights the type of action that they participate in. This, in turn, affects how concepts should be represented in order to facilitate knowledge acquisition and understanding.

Thirdly, research results in this area indicate that knowledge acquisition requires simulation of human interaction with objects, and this signifies that horizontal or non-hierarchical relations that define the goal, intended purpose, affordances, and result of the manipulation and use of an object (e.g. HAS_FUNCTION, AFFECTS, HAS_RESULT, etc.) are just as important as vertical or hierarchical ones, such as TYPE_OF or PART_OF.

4. Frame-based Terminology and dynamic knowledge representation

Simulation represents the way we interact with an entity and how entities interact with each other. This means that no specialized knowledge concept can be activated in isolation, but rather as part of an event. When this is applied to Terminology and specialized communication, this has the effect of making context or situation a crucial factor in knowledge representation. Our knowledge of a concept initially provides the context or event in which it becomes meaningful for us. A knowledge resource that facilitates knowledge acquisition should thus provide conceptual contexts or situations in which a concept is related to others in a dynamic structure that can streamline the action-environment interface. Rather than being decontextualized and stable, conceptual representations should be dynamically contextualized to support diverse courses of goal pursuit (Barsalou 2005: 628).

Frame-based terminology (Faber, Marquez and Vega 2005; Faber et al 2006; Faber, Leon, Prieto and Reimerink 2007) uses a modified version of Fillmore's Frames (Fillmore 1982, 1985; Fillmore and Atkins 1992) coupled with premises from Cognitive Linguistics to configure specialized domains on the basis of definitional templates and create situated representations for specialized knowledge concepts. The compatibility of Cognitive Semantics with neuropsychological research on category-specific semantic deficits is underlined in Rodriguez (2004).

4.1. Event representation

In Frame-based Terminology, conceptual networks are based on an underlying domain event as well as a closed inventory of both hierarchical and non-hierarchical semantic relations. We have used these premises to construct an environmental knowledge base called EcoLexicon (http://ecolexicon.ugr.es). The main focus is on conceptual relations as well as a concept's combinatorial potential, extracted from corpus analysis. This prototypical domain event or action-environment interface (Barsalou 2003) provides a template applicable to all levels of information structuring.

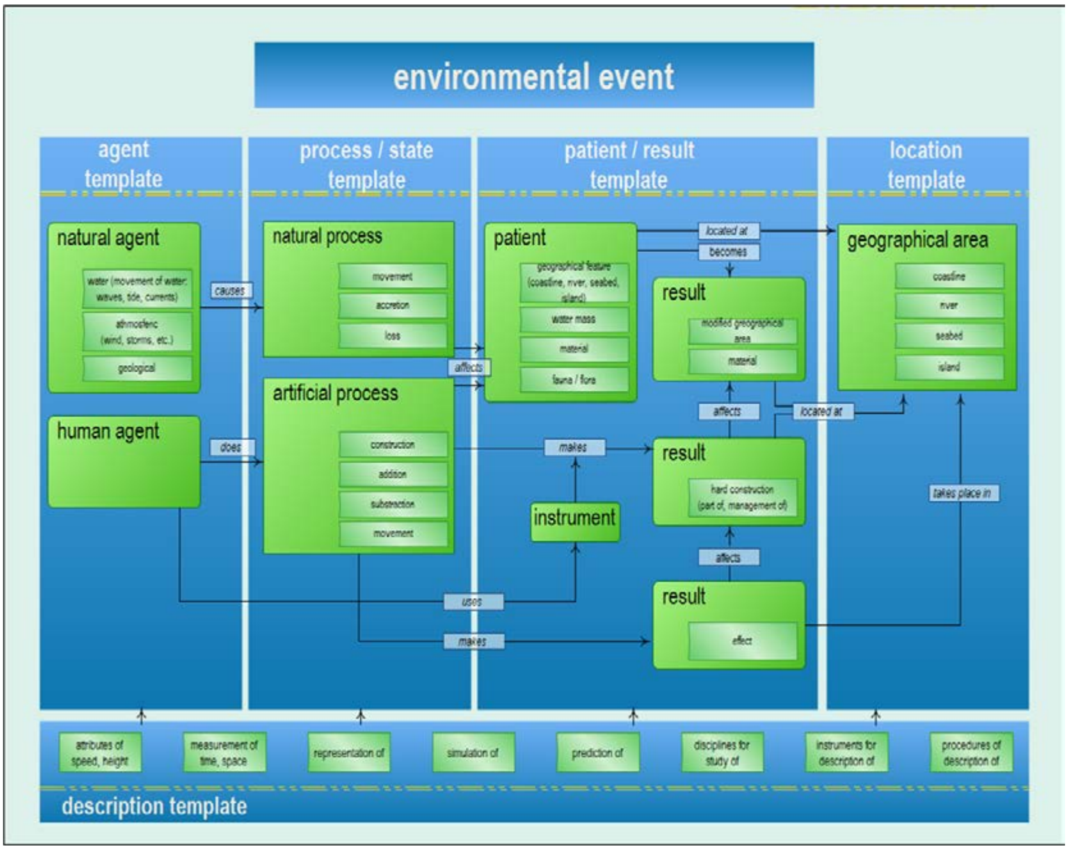

Figure 1. Environmental Event

In EcoLexicon, knowledge can be accessed from top-level categories to more specific relational structures. The most generic level is the Environmental Event (EE), which provides a frame for the organization of all concepts in the knowledge base. As shown in Figure 1, the EE is conceptualized as a dynamic process that is initiated by an agent (either natural or human). This process affects a patient (an environmental entity), and produces a result. These categories (agent, process, patient, etc.) are the concept roles characteristic of this specialized domain. Additionally, there are peripheral categories which include instruments that are typically used during the EE, as well as a category where the concepts of measurement, analysis, and description of the processes in the main event are included. This event-based representation facilitates knowledge acquisition in text processing since conceptual categories are bound together by event knowledge.

Proof of the usefulness of event knowledge can be found in written communication since a comprehender's knowledge of events plays a central role in sentence processing. This knowledge interacts with structural interpretation at the earliest possible moment (Elman 2009: 549). Evidently, terms, whether they designate objects or processes, are powerful cues for the wider event knowledge targeted. In this regard, the choice of a specific term is enough to generate expectations and predictions that constrain the range of likely events.

4.1.1. EXTREME EVENT

For example, one of the concepts in EcoLexicon is EXTREME EVENT in its sense of natural disaster. Disasters in the environment include great earthquakes, floods, giant sea waves, hurricanes, tornadoes, etc., and their consequences. The concept of EXTREME EVENT is very complex since it is a natural agent that initiates a process (i.e. earthquakes or volcanic eruptions can produce tsunamis) but it can also be the process itself, which occurs in time and space. This information is represented in EcoLexicon as shown in Figure 2.

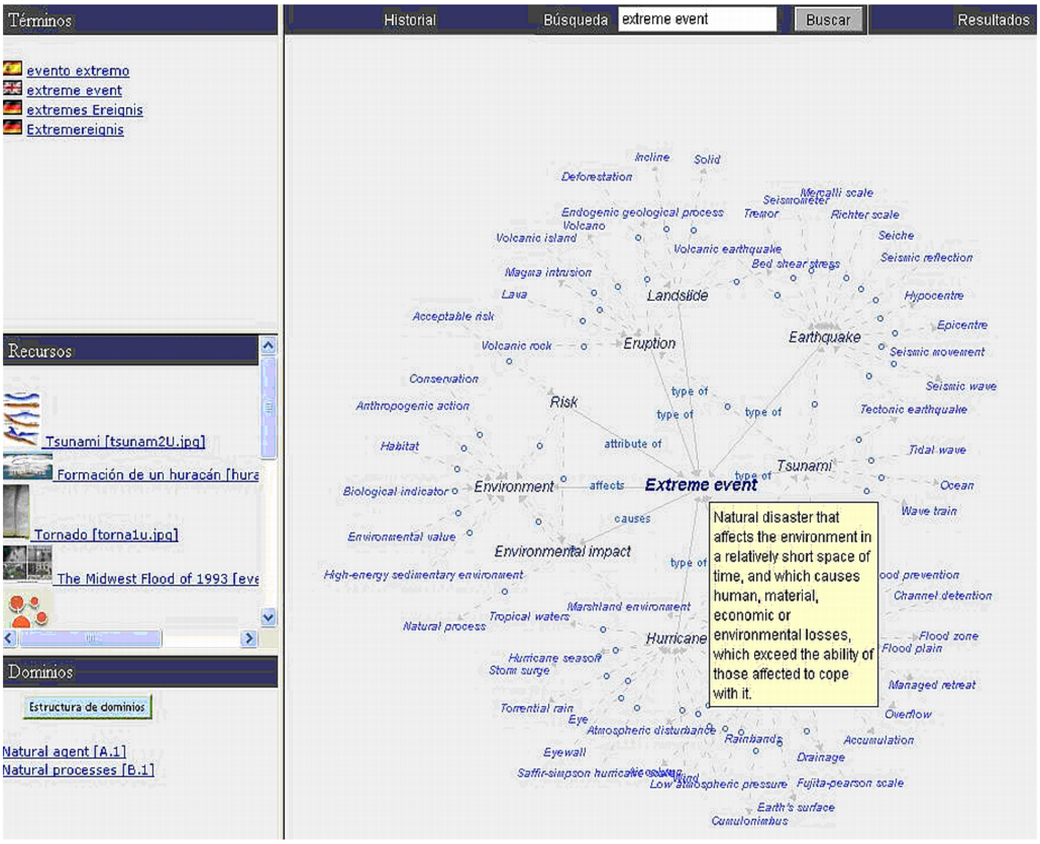

Figure 2. Representation of EXTREME EVENT in EcoLexicon

As shown in Figure 2, all of the concepts closest to the central concept are connected to it by a series of conceptual relations that are explicitly named (e.g. TYPE-OF, CAUSES, AFFECTS, etc.). These conceptual relations are the graphical representation of the information implicit in the definition, which appears when the cursor is placed on the main concept.

Since EXTREME EVENT is a very general concept, the only visual information that can be associated with it is that of its subtypes (HURRICANE, TORNADO, EARTHQUAKE, FLOOD, etc.). The majority of relations at this level are thus TYPE_OF. However, EXTREME EVENT also activates non-hierarchical relations typical of the general event frame. As such, its principal attribute is RISK; it AFFECTS the environment; and CAUSES an environmental impact. As for the TYPE_OF relations, they can be regarded as access routes to more prototypical base-level concepts (Rosch 1978), which do have a mental image, and can activate specific contexts. This set of subtypes (hurricane, tornado, flood, tsunami, etc.) take the form of constellations, each with their own set of subordinate concepts and conceptual relations, which encode more specific sub-event knowledge and representations.

4.1.2. Recontextualization: HURRICANE

According to Barsalou (2005), a given concept produces many different situated conceptualizations, each tailored to different instances in different settings. Thus, context can be said to be a dynamic construct that triggers or restricts knowledge. This general event that codifies a natural disaster can thus be recontextualized at any moment to center on any of the more specific subevents. For example, when the EXTREME EVENT representation is recontextualized to focus on HURRICANE, it takes the following form.

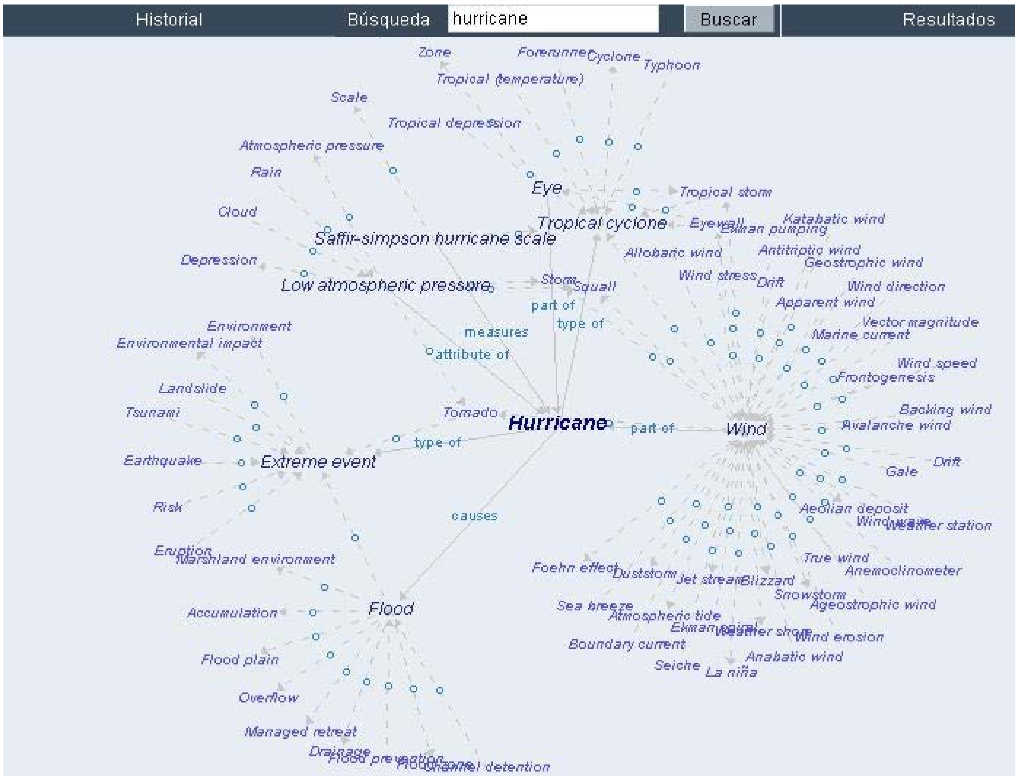

Figure 3. Representation of HURRICANE in Ecolexicon

This type of recontextualization of EXTREME EVENT still contains a sector of the previous information, but varies the focus of attention so that hurricane is now the center of focus. Besides communicating the fact that hurricane is a type of extreme event, this new representation highlights the fact that wind and flooding are crucial participants in the event. Wind is part of a hurricane, and a hurricane causes floods. Not surprisingly, WIND and FLOOD are concepts that are susceptible to simulation since they can directly affect human life and health. It also mentions the attribute of low atmospheric pressure as well as the scale used for hurricane measurement (Saffir-Simpson hurricane scale), which codifies an important aspect of expert interaction with a hurricane.

4.2. Object representation

Object concepts can also be represented dynamically as parts of events. They are stored in semantic memory, a major division of declarative memory, which contains information about the meaning of objects and words. This is the part of our mind (or at least a small section of it) that terminologists are trying to model each time they try to make a concept map. How knowledge is modeled largely depends on how objects are defined, their focal properties, their perceived relations with other concepts, and how the user understands them.

Accordingly, one of the basic characteristics underlying the representation of objects is knowledge of whether they can be manipulated and if so, exactly how this is done. In the case of man-made objects, another important property is their function, or how they can be used. This would mean that an important part of the information in the representation of specialized engineering instruments would evidently involve how they are used by humans, for what purpose, and what is the result of the manipulation.

4.2.1. RECORDING INSTRUMENT

For example, a RECORDING INSTRUMENT (e.g. marigraph, pluviograph, anemograph, etc.) is a subtype of INSTRUMENT. As a man-made manipulable artifact, a recording instrument has a function (i.e. recording) as well as an object that is recorded (tides, rain, wind, etc.). As a tool, it is strongly susceptible to human interaction, and activates a simulation frame in which much of the perceiver's knowledge of the artifact involves his/her ability to handle it and in some way to extract information from it.

For example, Figure 4 shows the representation of PLUVIOGRAPH.

The representation of PLUVIOGRAPH, of course, includes TYPE_OF information. A pluviograph is a recording instrument, and has subtypes, such as digital pluviograph and portable pluviograph. However, it is also part of what might be called a RECORDING EVENT in which a human agent causes the machine to record and generate a representation of something (RAINFALL). The recording instrument used in this event is a pluviograph, which produces (or effects) a PLUVIOGRAM. As can be observed in Figure 4, this process is reflected in the non-hierarchical relations REPRESENTS and EFFECTED_BY.

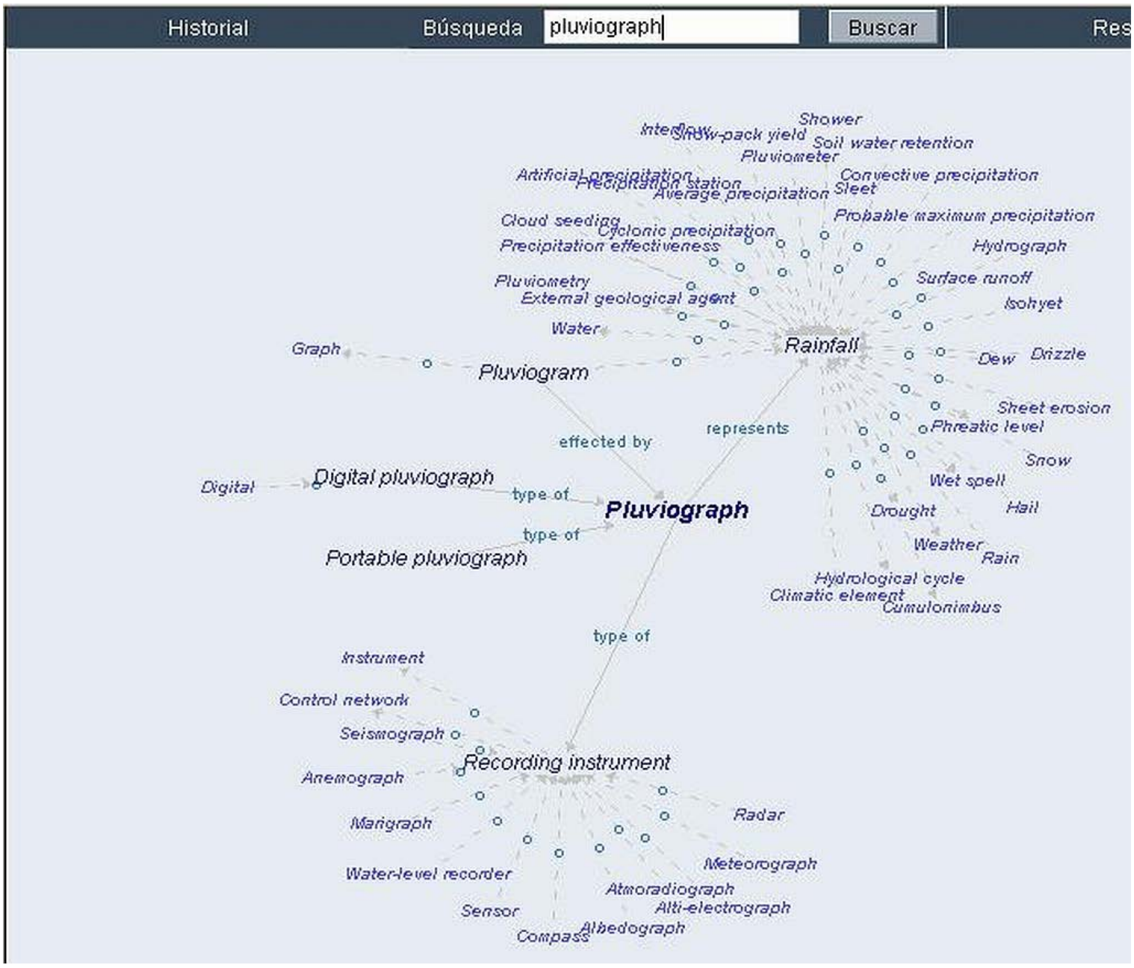

Figure 4. Representation of PLUVIOGRAPH in EcoLexicon

4.3. Domain-specific representation

Recent research in cognitive neuroscience also has implications for specialized domains and their organization. Whether conceived as a conceptual category (e.g. GEOGRAPHIC OBJECT, STORM-EVENT, MARITIME CONSTRUCTION, etc.) or as a specialized field of knowledge (e.g. GEOLOGY, ENGINEERING, etc.), domains and domain structure are central to any theory of Terminology and specialized communication. Not surprisingly, domains have also been found to exist in the brain in some form, as shown in the large body of research on category-specific semantic deficits (Warrington and McCarthy 1983, 1987; Warrington and Shallice 1984; Humphreys and Forde 2001; Caramazza and Mahon 2003; Martin 2007; Mahon and Caramazza 2008, 2009, *inter alia*).

Although initially research did not provide conclusive evidence of the important role of categories, the domain-specific hypothesis (Caramazza and Shelton 1998) assumes that the first-order constraint on the organization of information within the conceptual system or the organization of conceptual knowledge in the brain is object domain. In this model, object domain and sensory, motor, and emotional properties jointly constrain the organization of conceptual knowledge. In addition, object domain is a first-order constraint on the organization of information at both a conceptual level as well as at the level of modality-specific visual input representations (Mahon and Caramazza 2009: 34). Although Mahon and Caramazza (2009: 30) restrict basic domains to those with an evolutionary relevant history (e.g. living animate, living inanimate, conspecifics, and tools), their observation that domains are constrained by the nature of concept members has evident implications for Terminology.

One conclusion that can be derived from this hypothesis is the fact that not all categories are structured in the same way, and that organization is constrained in some significant way by the nature of the category itself. Accordingly, the analysis of the properties shared by category members provides a general representational template for each category, which makes the definition of category members more systematic. In this way, definitions acquire a more uniform structure that complements the information encoded in the conceptual system, and directly refers to and evokes the underlying event structure of the domain. Such templates can even be considered a kind of conceptual grammar (Faber, Leon, Prieto and Reimerink 2007). However, category templates are made up of different clusters of conceptual relations that depend on the nature of the category.

4.3.1. Domains as conceptual categories

In Terminology, there are two different ways of conceiving specialized domains. Domains can either be viewed as conceptual categories or as specialized knowledge fields. When domains are conceptual categories, categories are constrained by the nature of category members that share properties. For example, the categories of specialized instruments and geographic objects are quite different from each other. This can be observed in the conceptual relations that reflect their interconnections with other entities.

As previously mentioned, the INSTRUMENT domain is primarily constrained by information regarding properties related to manipulation, function, and result. This is in vivid contrast to a domain such as GEOGRAPHIC OBJECTS (estuary, marshland, channel, etc.) which is constrained by other types of information, directly linked to the nature of the concepts. AS Smith and Mark (1999) point out, the specificities of geographic objects are the following:

- Geographic objects are intrinsically tied to their location in space [LOCATION_OF].
- They are often size- or scale-dependent [SIZE_OF].
- They are often the products of delineation within a continuum in which other objects, including human agents, live and move [DELIMITED_BY].

This cluster of relations stem from the fact that geographic objects are presumably simulated in a different way from instruments, atmospheric phenomena, coastal defense structures, or marine fauna, and this affects their conceptualization and representation. Although this would require further study, the simulation of geographic objects would involve the activation of brain areas connected with location and orientation. For this reason, within this category, emphasis has been placed on information pertaining to spatial orientation.

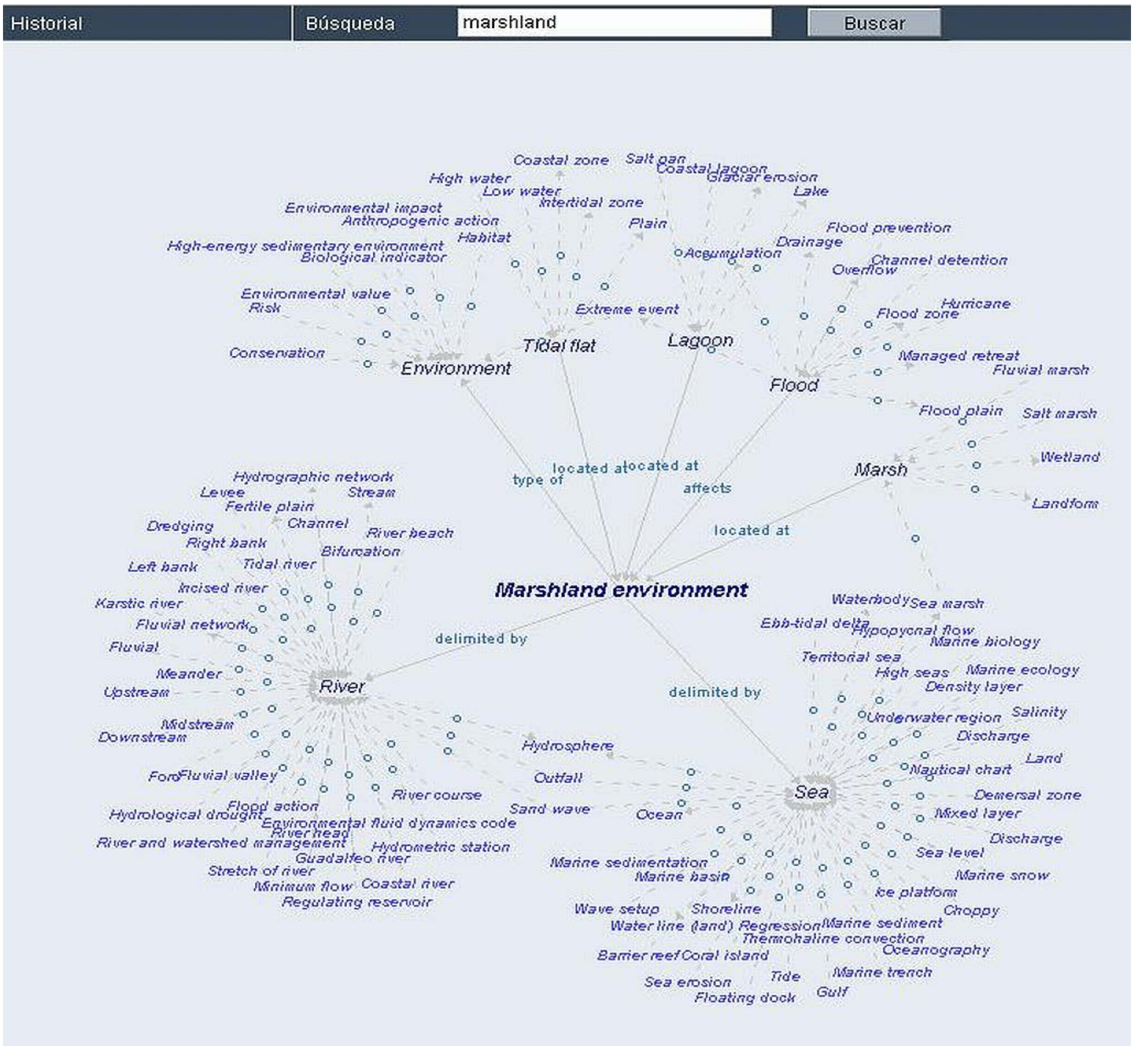

Figure 5. Representation of MARSHLAND in EcoLexicon

As shown in Figure 5, the representation of MARSHLAND ENVIRONMENT activates a different set of relations from event and disaster concepts. As a geographic concept, MARSHLAND ENVIRONMENT is represented as being delimited by the sea or a river. It is an environmental area affected by floods. Lagoons, tidal flats and marshes are also geographic objects located in MARSHLAND ENVIRONMENT. This is indicative of its ample size, which means that it can include a wide variety of geographic concepts.

4.3.2. Domains as specialized knowledge fields

As has been shown, concepts within a domain are internally constrained by the nature of the domain. When domains are conceived of as specialized knowledge fields, such as Chemistry, Geology or Engineering, they provide further contexts in which versatile concepts are recontextualized (Leon, Magaña, and Faber 2009; Leon and Magaña, 2010). This is another source of dynamicity.

For example, even though WATER is not a specialized concept *per se*, it must be included in any environmental knowledge base since it is central to many specialized environmental processes and object representations. Given that WATER is a concept that participates in so many other representations of environmental concepts, the conceptual information linked to it must be contextualized so as not to generate an information overload. This means that contextual constraints must be applied so as only to activate the conceptual relations relevant to WATER in a given specialized field (Leon, Magaña and Faber 2009; Leon and Magaña 2010). This is the only way to eliminate undesired information. In Figure 6, the representation of WATER emphasizes the affordances that water has for engineering.

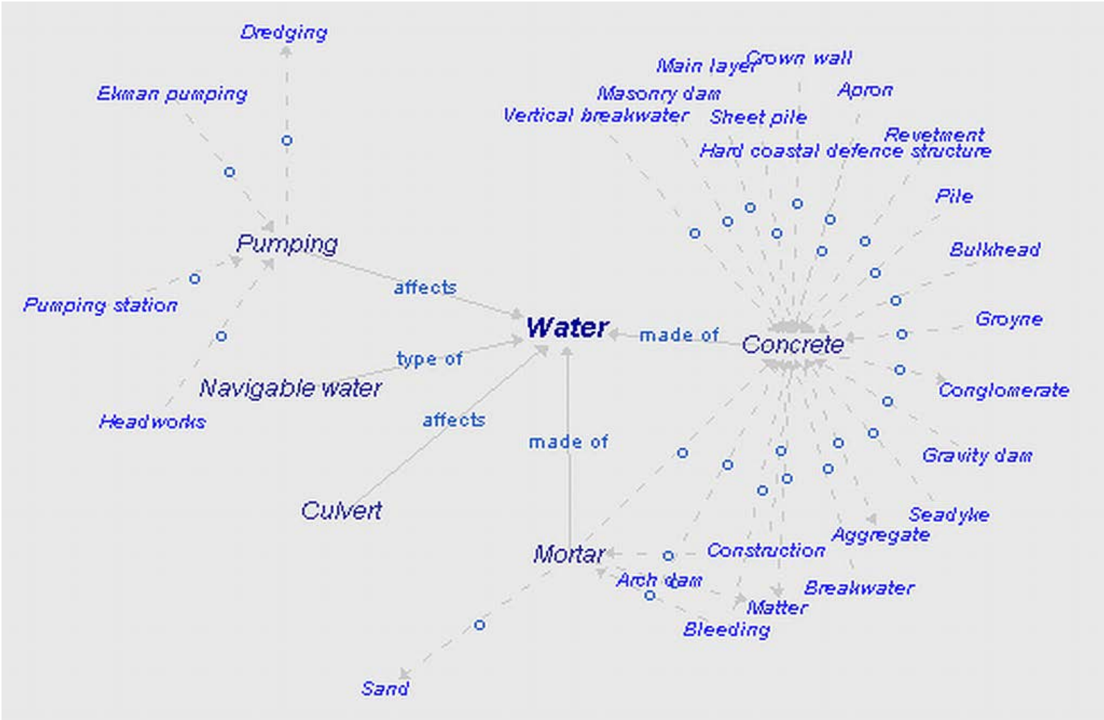

Figure 6. WATER in the context of Engineering

More specifically, it highlights the fact that water is a building material for engineering structures, and is used in processes such as pumping and dredging. The most salient conceptual relations are thus MADE_OF and AFFECTS. In contrast, when water is recontextualized within the geology context, its representation is quite different since in this context, information regarding how water interacts with soil and landscape is much more important. Consequently, another set of concepts and relations are activated.

Evidently, the number of conceptual relations varies from one network to another. Relation types also differ, which highlights the changing nature of water's internal structure according to each semantic role. For example, in Engineering, most relations to WATER are MADE_OF and AFFECTS, whereas in Geology, CAUSES and TYPE_OF are the most salient conceptual relations (Leon and Faber 2010).

In this sense, in EcoLexicon, we are currently exploring the possibility of establishing contextual field-related constraints on the activation of conceptual relations. This would be applied to general objects and processes, such as WATER, OCEAN, SEDIMENTATION, EROSION, etc., which otherwise would generate an excess of information.

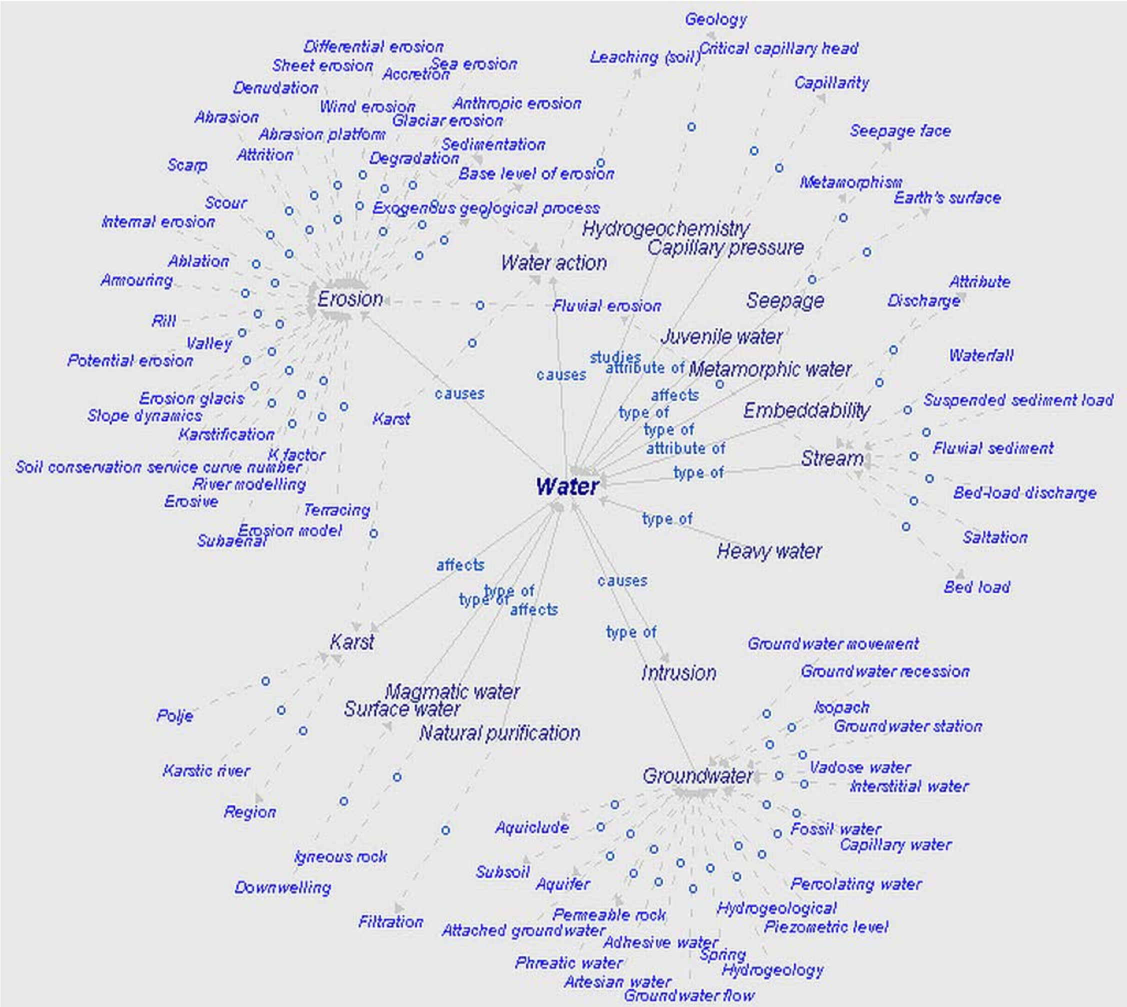

Figure 7. WATER in the context of Geology

Nevertheless, recontextualization does not involve a clear-cut distinction between different context domains since they can also share certain conceptual propositions. This is due to the fact that multidisciplinarity gives rise to fuzzy category boundaries and as a result, contextual domains can form their own hierarchical structure. Moreover, they are also dynamic flexible structures that should evolve over time according to the type and amount of information stored in our knowledge base (León and Magaña 2010).

4. Conclusion

Dynamicity is a crucial issue in Terminology because it lies at the root of specialized communication and knowledge representation. However, it is rarely adequately reflected in terminological resources. Reasons for this include the difficulty of portraying dynamic processes by means of conceptual trees. Such representations stem from standard theories of cognition, based on the abstract, amodal representation of entities, events, and processes. However, a more dynamic view of cognition, derived from recent research in neuroscience, claims that understanding is largely based on sensory and motor simulation with possibly a single convergence zone that affords the possibility to generalize across concepts that have similar semantic significance. This has evident applications to Terminology and its dynamic nature, which include the following:

1. No specialized knowledge concept should be activated in isolation, but rather as part of a larger structure or event.
2. A specialized knowledge resource that facilitates knowledge acquisition should thus provide conceptual contexts or situations in which a concept is related to others in a dynamic structure that can streamline the action-environment interface. Within this context, all concept types are regarded as dynamic because they are part of a process or event.
3. Since knowledge acquisition and understanding requires simulation, this signifies that non-hierarchical relations defining goal, purpose, affordance, and result of the manipulation and use of an object are just as important as hierarchical generic-specific and part-whole relations.
4. Research proposals, such as the domain-specific hypothesis (Caramazza and Shelton 1998) also have implications for Terminology since it asserts that domains are constrained by the nature of their members. In Terminology, this is reflected in clusters of conceptual relations that make up the general representational template, characterizing different categories.

All of these conclusions have been illustrated by examples from EcoLexicon, an environmental knowledge base (available at: http://ecolexicon.ugr.es). EcoLexicon is a conceptually-organized, frame-based terminological resource that facilitates knowledge acquisition since it presents concepts as part of larger knowledge structures and permits dynamic processes such as the recontextualization of knowledge representations.

They also point to the fact that the representation of specialized knowledge concepts should incorporate dynamicity at some level. Only in this way will terminological resources be more effective and facilitate knowledge acquisition.

Acknowledgements

This research was funded by the Spanish Ministry of Science and Innovation (project FFI2008-06080-C03-01/FILO).

References

Antia, B, E., Budin, G., Picht, P., Rogers, M., Schmitz, K. D. and Wright, S. E. 2005. Shaping translation: a view from terminology research. META 50 (4). Available at: http://id.erudit.org/iderudit/019907ar

Aziz-Zadeh, L. and A. Damasio. 2008. "Embodied semantics for actions: Findings from functional brain imaging." *Journal of Physiology – Paris* 102, 35–39.

Barsalou, L. W. 1999. "Perceptual symbol systems." *Behavior and Brain Sciences* 22, 577–660.

Barsalou L. W. 2003. "Situated simulation in the human conceptual system." *Language and Cognitive Processes* 18, 513–62.

Barsalou, L. W. 2005. "Situated conceptualization. In Cohen, H. and Lefebvre, C. (eds.), *Handbook of Categorization in Cognitive Science*. St. Louis: Elsevier.

Barsalou, L. W. 2008. "Grounded cognition." *Annual Review of Psychology* 59, 617–645.

Barsalou, L. W. 2009. "Simulation, situated conceptualization, and prediction." *Philosophical Transactions of the Royal Society B,* 1281–1289.

Barsalou, L. W., C. Breazeal, and L. B. Smith. 2007. "Cognition as coordinated non-cognition." *Cognitive Processing* 8(2), 79–91.

Bowker, L. and J. Pearson. 2002. *Working with Specialized Language. A Practical Guide to Using Corpora*. London/New York: Routledge.

Budin, G. 1994. "Some hypotheses about concept representations." In *Proceedings of the 9th European Symposium on LSP*, Bergen, Norway, 2-6 August, 1993. Bergen: Fagbokforlaget.

Cabré, M. T. 1999. *Terminology Theory, Methods and Applications*. Amsterdam/ Philadelphia: John Benjamins.

Cabré, M. T. 2000. "Theories of Terminology." *Terminology* 6(1), 35–57.

Caramazza, A. and B. Z. Mahon. 2003. "The organization of conceptual knowledge: the evidence of category-specific semantic deficits." *Trends in Cognitive Sciences* 7(8), 354–361.

Caramazza, A. and J. R. Shelton. 1998. "Domain specific knowledge systems in the brain: the animate-inanimate distinction." *Journal of Cognitive Neuroscience* 10, 1–34.

Damasio, A. 1994. *Descartes' Error: Emotion, Reason, and the Human Brain.* New York: Avon.

Damasio, A. and H. Damasio. 1994. "Cortical systems for retrieval of concrete knowledge: the convergence zone framework." In Koch, C. and J. Davis (eds.), *Large-scale Neuronal Theories of the Brain*. Cambridge, MA: MIT Press.

Elman, J. L. 2009. "On the meaning words and dinosaur bones: lexical knowledge without a lexicon." *Cognitive Science* 33, 547-582.

Faber, P., P. León, J. A. Prieto, and A. Reimerink. 2007. "Linking images and words: the description of specialized concepts." *International Journal of Lexicography* 20, 39–65.

Faber, P., C. Márquez, and M. Vega 2005. "Framing Terminology: A Process-Oriented Approach." *META* 50 (4).

Faber, P., S. Montero, M. R. Castro, J. Senso, J. A. Prieto, P. León, C. Márquez, and M. Vega. 2006. "Process-oriented terminology management in the domain of Coastal Engineering." *Terminology* 12(2), 189–213.

Felber, H. 1988. *Korollierte Begriffsdynamik.* Berlin: Cedefop.

Feliu, J. 2004. *Relacions conceptuals I terminologia: analisi i proposta de deteccio semiautomatica.* PhD thesis, Barcelona: Universidad Pompeu Fabra, Instituto Universitario de Linguistica Aplicada (IULA).

Fillmore, C. J. 1982. "Frame semantics." In Linguistics Society of Korea (ed.), *Linguistics in the Morning Calm*. Seoul: Hanshin.

Fillmore, C. J. 1985. "Frames and the semantics of understanding." *Quaderni di Semántica* 6 (2), 222–254.

Fillmore, C. J. and B. T. S Atkins. 1992. "Towards a frame-based lexicon: the semantics of *risk* and its neighbours." In Lehrer, A. and E. Kittay (eds.), *Frames, Fields and Contrasts,* Hillsdale, NJ: Lawrence Erlbaum.

Gallese, V. and G. Lakoff. 2005. "The brain's concepts: the role of the sensory-motor system in conceptual knowledge." *Cognitive Neuropsychology* 22 (3/4), 455–479.

Glenberg, A. M. 1997. "What memory is for." *Behavioral and Brain Sciences* 20, 1–55.

Holt L. E. and S. L. Beilock. 2006. "Expertise and its embodiment: examining the impact of sensorimotor skill expertise on the representation of action-related text." *Psychonomic Bulletin and Review* 13, 694–701.

Humphreys, G. W. and E. M. Forde. 2001. "Hierarchies, similarity, and interactivity in object recognition: 'category specific' neuropsychological deficits." *Behavioral and Brain Sciences* 24, 453–4509.

Kageura, K. 2002. *The Dynamics of Terminology.* Amsterdam/Philadelphia: John Benjamins.

Langacker, R. 2001. "Dynamicity in grammar." *Axiomathes* 12, 7–33.

León, P. 2009. *Representación Multidimensional de Conocimiento Especializado*. PhD thesis. Granada: University of Granada.

León, P. and P. Faber. 2010. "Natural and contextual constraints for domain-specific relations." In *Proceedings of LREC 2010* (Workshop: Semantic Relations. Theory and Applications), 18–21 May 2010, Valetta, Malta.

Leon, P. and P. Magaña. 2010. "EcoLexicon: contextualizing an environmental ontology." In *Proceedings of the Terminology and Knowledge Engineering Conference* (TKE), 12–13 August, 2010, Dublin, Ireland.

León, P., P. Magaña, and P. Faber. 2009. "Building the SISE: an environmental ontology." In Hřebíček, J., J. Hradec, E. Pelikán, O. Mírovský, W. Pilmmann, I. Holoubek, and R. Legat. (eds.), *Towards eEnvironment (Challenges of SEIS and SISE: Integrating Environmental Knowledge in Europe*). Available at: http:/www.e-envi2009.org/proceedings/.

Louwerse, M. M. and P. Jeuniaux. 2010. "The linguistic and embodied nature of conceptual processing." *Cognition* 114, 96–104.

Mahon, M. Z. and A. Caramazza. 2008. "A critical look at the embodied cognition hypothesis and a new proposal for grounding conceptual content." *Journal of Physiology–Paris* 102, 59–70.

Mahon, M. Z. and A. Caramazza. 2009. "Concepts and categories: A cognitive neuropsychological perspective." *Annual Review of Psychology* 60, 27–51.

Martin A. 2001. Functional neuroimaging of semantic memory. In Cabeza, R. and A. Kingstone (eds.), *Handbook of Functional NeuroImaging of Cognition*, Cambridge, MA: MIT Press.

Martin, A. 2007. "The representation of object concepts in the brain." *Annual Review of Psychology* 58, 25–45.

Meyer, I. and K. Mackintosh 1996. "Refining the terminographer's concept-analysis methods: How can phraseology help?" *Terminology* 3 (1), 1–26.

Meyer, I., K. Eck, and D. Skuce. 1997. "Systematic concept analysis within a knowledge-based approach to terminology." In Wright, S. E. and G. Budin (eds.), *Handbook of Terminology Management*. Amsterdam/Philadelphia: John Benjamins.

Nuopponen, A. 1994. "Causal relations in terminological knowledge representation." *Terminology Science and Research* 5 (1), 36–44.

Oeser, E. and G. Budin 1995. "Controlled conceptual dynamics: from ordinary language to scientific terminology – and back." *Terminology Science and Research* 6 (2), 3–17.

Patterson, K., P. J. Nestor, and T. T. Rogers. 2007. "Where do you know what you know? The representation of semantic knowledge in the human brain." *Nature Reviews Neuroscience* 8, 976–988.

Pavel, S. and D. Nolet. 2001. *Handbook of Terminology.* Canada: Minister of Public Works and Government Services.

Pilke, N, 2001. "Field-specific features of dynamic concepts – What, when and why?" In Mayer, F. (ed.), *Language for Special Purposes: Perspective for the New Millennium*. Tübingen: Gunter Narr.

Pozzi, M. 1999. "The concept of 'concept' in Terminology: a need for a new approach." In Sandrini, P. (ed.). *TKE'99 Terminology and Knowledge Engineering Proceedings*, Fifth International Congress on Terminology and Knowledge Engineering, 23–27 August, 1999. Vienna: TermNet.

Puuronen, N, 1995. "On describing dynamic concepts – A philosophical and terminological approach." In Budin, G. (ed.), *ITTF Proceedings of the 10th European LSP Symposium*. Vienna: TermNet.

Rodriguez, A. L. 2004. "Aspects of cognitive linguistics and neurolinguistics: conceptual structure and category-specific semantic deficits." *Estudios Ingleses de la Universidad Complutense* 12, 43–62.

Rogers, M. 2004. "Multidimensionality in concepts systems." *Terminology* 10 (2), 215 – 240.

Rosch, E., 1978. "Principles of categorization." In Rosch, E. and B. B. Lloyd (eds.), *Cognition and Categorization*. Hillsdale, NJ: Erlbaum.

Simmons, W. K., A. Martin, and L W. Barsalou. 2005. "Pictures of appetizing foods activate gustatory cortices for taste and reward." *Cerebral Cortex* 15, 1602–1608.

Smith, B. and D. Mark. 1999. "Ontology with human subjects testing: An empirical investigation of geographic categories." *American Journal of Economics and Sociology* 582, 245–272.

Tebe, C. 2005. *La representacio conceptual en terminologia: l'atribucio tematica en els bancs de dades terminologiques*. PhD thesis. Barcelona: Universidad Pompeu Fabra, Instituto Universitario de Lingüística Aplicada (IULA).

Temmerman, R. 1995. "The process of revitalisation of old words: 'Splicing', a case study in the extension of reference." *Terminology* 2 (1), 107–128.

Temmerman, R. 2000. *Towards new ways of terminology description. The sociocognitive approach*. Amsterdam/Philadelphia: John Benjamins.

Temmerman, R. 2007 "Sociocultural situatedness of terminology in the life sciences: The history of splicing." In Frank, R., R. Dirven, J. Zlatev, and T. Ziemke (eds.), *Language and Mind. Vol II. Interrelations between Biology, Linguistics and Culture*. Berlin: Springer.

Tucker, M. and R. Ellis. 1998. "On the relations between seen objects and components of potential actions." *Journal of Experimental Psychology: Human Perception and Performance* 24, 830–46.

Tucker, M. and R. Ellis. 2001. "The potentiation of grasp types during visual object categorization." *Visual Cognition* 8, 769–800.

Warrington, E. K. and R. McCarthy. 1983. "Category specific access dysphasia." *Brain* 106, 859–878.

Warrington, E. K. and R. McCarthy. 1987. "Categories of knowledge: further fractionations and an attempted integration." *Brain* 110, 1273–1296.

Warrington, E. K. and T. Shallice. 1984. "Category-specific semantic impairment." *Brain* 107, 829–854.

Wright, S. E. 2003. From the semiotic triangle to the semantic web. *Journal of the International Institute for Terminology Research* 14, 111–135.

Wüster, E. 1968. *The Machine Tool; an Interlingual Dictionary of Basic Concepts.* London: Technical Press.

Zwaan, R. A. 2004. "The immersed experience: Toward an embodied theory of language comprehension." In Ross, B. H. (ed.), *The Psychology of Language and Motivation*, New York: Academic Press.