HANDBOOK OF TERMINOLOGY

VOLUME 1

EDITED BY
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The *Handbook of Terminology* (*HOT*) aims at disseminating knowledge about terminology (management) and at providing easy access to a large range of topics, traditions, best practices, and methods to a broad audience: students, researchers, professionals and lecturers in Terminology, scholars and experts from other disciplines, such as linguistics, life sciences, metrology, chemistry, law studies, machine engineering, and any other expert domain. In addition, the *HOT* addresses experts in (multilingual) terminology, translation, interpreting, localization, editing, etc., such as communication specialists, translators, scientists, editors, public servants, brand managers, engineers, and (intercultural) organization specialists.

All chapters are written by specialists in the different subfields and are peer-reviewed.

Volume 1

Handbook of Terminology
Edited by Hendrik J. Kockaert and Frieda Steurs

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Table of contents

Introduction

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Terminology has started to explore unbeaten paths since Wüster, and has nowadays grown into a multi-facetted science, which seems to have reached adulthood, thanks to integrating multiple contributions not only from different linguistic schools, including computer, corpus, variational, socio-cognitive and socio-communicative linguistics, and frame-based semantics, but also from engineering and formal language developers. In this ever changing and diverse context, Terminology offers a wide range of opportunities ranging from standardized and prescriptive to prototype and user-based approaches. At this point of its road map, Terminology can nowadays claim to offer user-based and user-oriented, hence user-friendly, approaches to terminological phenomena, when searching, extracting and analysing relevant terminology in online corpora, when building term bases that contribute to efficient communication among domain experts in languages for special purposes, or even when proposing terms and definitions formed on the basis of a generally agreed consensus in international standard bodies.

Terminology is now ready to advance further, thanks to the integration of meaning description taking into account dynamic natural language phenomena, and of consensus-based terminology management in order to help experts communicate in their domain-specific languages. In this volume of the *Handbook of Terminology* (*HoT*), which is the first of a series of five volumes, the symbiosis of Terminology with Linguistics allows a mature and multi-dimensional reflection on terminological phenomena and principles, which will eventually generate future applications that have not been tested yet in natural language.

Generally, Volume I discusses and revisits long standing terminology principles, with a view to developing best practices of terminology management in today's changing data processing environments. It introduces new applications in terminology management by implementing terminological principles and practices in ontology building, localisation, translation oriented terminology, and expert terminology.

This volume aims at disseminating knowledge about terminology (management) and at providing easy access to a large range of topics, traditions, best practices, and methods to a broad audience: students, researchers, professionals and lecturers in Terminology, scholars and experts from other disciplines (among which linguistics, life sciences, metrology, chemistry, law studies, machine engineering, and actually any expert domain). In addition, it addresses any of those with a professional or

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personal interest in (multilingual) terminology, translation, interpreting, localization, editing, etc., such as communication specialists, translators, scientists, editors, public servants, brand managers, engineers, (intercultural) organization specialists, and experts in any field.

Like all the coming volumes, it offers added value, in that it is the first book series with this scope in Terminology which has both a *print edition* (also available as a PDF e-book) and an *online version*. The *HoT* book series is linked to the *Handbook of Translation Studies*, not in the least because of its interdisciplinary approaches, but also because of the inevitable intertwining between translation and terminology.

In this introduction, we already announce the thematic focus of the next volume, which will be published in Fall 2015.

Volume II will examine communities of practice and language communities facing the challenges and exploiting the power of the global computing environment, much of which is manifested on the Internet. Traditional discussion of terminology and terminology management has focused on discourse or "language-purposed" terminology resources designed to support writing, translating, and interpreting. "Subject-purposed" terminology has given us thesauri and controlled vocabularies, all of which are also referred to as "terminologies" by their practitioners. In the Internet environment, communities of practice laying claim to terminology include metadata experts defining data element names and concepts, as well as enumerated values used in data management. Corpus linguists define metadata tags used to mark up text corpora, and ontologists assign words and terms to nodes in ontological systems, supplemented by appropriate (or sometimes not) definitions. Indexes, initially on paper, but now expressed as semantically informed data, support information retrieval through both aggregated and non-related data stores as well as from unmarked, running text.

Close analysis reveals that these onomasiological resources are often incompatible, despite keen interest in interoperability. Underlying the vast mechanism that is the Web, language codes and language tags weave a support structure for the network of words and terms, providing stability, but themselves reflecting the effects of dynamic change and occasional linguistic inaccuracy. All the while this massive repository of words and knowledge burgeons at an exponential rate, some languages struggle to assert themselves due to issues such as the absence of white space – a world of words depends on both man and machine knowing what is a word – and complex morphologies, which challenge basic strategies such as lemmatization and disambiguation. In response, new initiatives like the World Wide Web's Internationalization Tag Set are addressing the concerns of non-Roman and non-alphabetical character sets. The intent of Volume II will be to provide a coherent overview of the challenges facing an array of terminology-purposed communities in the middle of the second decade of the 21st century.

The chapters of all the volumes are written by specialists in the different subfields and are peer-reviewed.

Volume 1 counts 6 parts:

I. Fundamentals for Term Base Development;
II. Methods and Technology;
III. Management and QA;
IV. Case Studies;
V. Language and Terminology: Planning and Policy;
VI. Terminology and Interculturality.

Pius ten Hacken starts the debate in a challenging way when discussing terminology in relation to the *Prototype Theory*. In the traditional understanding of terminology, a terminological definition gives necessary and sufficient conditions for a concept. However, natural concepts are based on prototypes. Prototypes are marked by typicality effects with fuzzy boundaries determined by approximate, scalar conditions and preference rules.

Another theoretical challenge is presented by Pamela Faber, who discusses *Frame Based* Terminology. Terminology work involves the collection, analysis, and distribution of terms. Frame-Based Terminology (FBT) is a cognitive approach to terminology that is based on frame-like representations in the form of conceptual templates underlying the knowledge encoded in specialized language. Loïc Depecker takes us to a more philosophical and fundamental discussion on the *conceptualisation in terminology : de Saussure revisited*. He takes us through a number of fundamental theoretical questions that have an impact on terminology, both in the construction of data bases and ontologies, neologisms and general linguistic management. Other fundamental issues such as the discussion, the interface and the differences between *words and terms*, are being addressed in the paper on Terminology and Lexicography by Kyo Kageura.

A very important part in the theoretical discussion on terminology and ontologies, deals with definitions and relations, and the types of knowledge representations. Five interesting articles deal with this topic:

First Georg Löckinger, Hendrik J. Kockaert and Gerhard Budin discuss the aspects of *intensional definitions*, which are one of the most widely used types of definition. The chapter is mainly meant to be a concise, yet comprehensive practical tool for language professionals and domain experts alike. Next to intensional definitions, Henrik Nilsson guides us into the field *of extensional and partitive definitions*. Although intensional definitions are preferred, extensional definitions are used alongside. Why, in what situations and what effect does the ordering have?

Next, Paul Sambre and Cornelia Wermuth address *the associative relations and instrumentality in causality* Traditionally, associative conceptual relations, unfolding over time, have been analysed less by (prescriptive) terminology than hierarchical ones. The authors claim that cognitive linguistics may be fruitful as a framework for the descriptive terminology of these relations.

Christophe Roche discloses *ontological definitions*. By recognizing terminology's double conceptual and linguistic dimension – terminology is both a science of objects and a science of words – ontology yields a distinction between a *definition in the term's language* (its linguistic explanation) and an *ontological definition of the concept,* itself a formal specification.

Claudia Santos and Rute Costa describe a *mixed methodology for terminological knowledge representation*. The authors focus on the functionality of semasiological and onomasiological approaches and their application.

Claudia Dobrina will finally enlighten us on the more practical work, getting to the core of a terminological project. In this chapter a tentative classification of terminological projects is suggested based on the following key features: terminological needs which a terminological project is intended to meet, its objective, target user group, and properties of a terminology resource to be created.

The second part of this volume deals with the usefulness of different methods and technological support in the terminology work.

One of the first methodological issues terminologists have to decide upon, is how to extract or select term candidates. Kris Heylen and Dirk De Hertog lead us into a discussion on *Automatic Term Extraction* (ATE). This method aims to identify words that are typical for a specialized domain, the so-called Term Candidates (TC), based on the computerized analysis of text corpora. ATE serves to replace or, at least, alleviate the resource intensive task of Manual Term Extraction performed by a domain expert and/or terminologist for a domain for which no terminological information is available. It is also often applied to domains that exhibit a rapidly changing vocabulary, such as technological domains, to expand and update the list of known terms.

Terminology Tools are very often difficult to evaluate. Frieda Steurs, Ken De Wachter and Evy De Malsche address this question: which tools are available to support terminology management? For this chapter, five terminology tools representative of the currently available tools have been selected and will be examined and compared based on a number of important and transparent parameters.

Concept Modeling vs. Data Modeling in Practice : The usefulness of terminological concept modeling as a first step in data modeling is discussed by Bodil Nistrup Madsenand Hanne Erdman Thomsen.

First, terminological concept modeling with terminological ontologies, i.e. concept systems enriched with characteristics modelled as feature specifications are explained. Then the authors proceed by discussing how terminological ontologies can be used as the basis for developing conceptual and logical data models.

Multilingual Terminology management in relation to Machine Translation and Translation Memories will be revealed by Peter Reynolds. This article gives more insight into how terminology is used in combination with machine translation

and translation memory technologies. With both these technologies there is consensus that good terminology management will improve the quality of the target translation. The article will detail best practices for using terminology within these technologies.

The topic of methodology and tools brings us to a third section in this volume : *quality assurance and workflow management.*

A rather new phenomenon is *crowdsourcing* and how it can help in Terminology Work Barbara Inge Karsch examines *crowdsourcing in the framework of terminology tasks*. The goal is to enable terminologists and terminology project managers to make use of crowdsourcing strategies.

Lynne Bowker addresses the use of *terminology resources in translation*: Translators have long been targeted as users of terminology resources such as term banks; however, translators are also playing an increasing role in the development and management of terminology resources, such as term bases that are integrated with computer-aided translation tool suites. This chapter examines the role and goals of translation-oriented terminology management, beginning with a brief discussion of some of the benefits to be gained by managing terminology effectively in a translation context, as well as the risks associated with not doing so.

Silvia Cerrella Bauer brings us the state-of-the-art in *project management and certified terminology management*. Terminology management is a horizontal business process that crosses different organizational units, even spanning different locations, languages and time zones. Introducing centralized, standardized and systematic terminology management in an organization can be met with some objection. This paper provides readers interested in professionally managing corporate terminology with tools and practical instruments on successfully implementing terminology management in an organization, from the definition and drafting of a project plan in both its strategic and operational dimension, through to project execution.

Much has been said and written about terminology management in recent years from the terminologists' perspective but relatively little has been done to demonstrate the role and methodology for managing terminology in the context of the actual translation quality assurance (QA) process. Monika Popiolek deals with this issue in a chapter on *Terminology Management within a Translation Quality Assurance Process*

In this chapter the author tries to define the place and role of terminology within the QA process and describe how terminology management fits in and affects quality assurance of the translation process, both at the systemic and tool level.

We then shift to *commercial environments* : In this chapter, Kara Warburton explores terminology management from a commercial perspective, that is, how and why terminology is managed in companies. Elements of a theoretical and methodological framework for managing terminology in commercial environments are proposed in her contribution.

Alan K. Melby discusses *TBX* as a format to be used in the translation and localization industry, an XML-based family of terminology exchange formats. The main purpose of an exchange format is to separate data and software, which allows for data asset protection, terminological consistency and software interoperability. The design requirements for any terminology exchange format are proposed and TBX is evaluated according to them. Finally, probable future developments of TBX are discussed.

Another section of this volume is dedicated to case studies, to show a number of good practices in actual terminology work.

Janine Pimentel discloses how a *bilingual lexical resource on legal terminology* has been built using Frame Semantics. JuriDiCo was designed to be a free online bilingual (Portuguese-English) lexical resource that describes legal terminology. JuriDiCo allows users interested in legal terminology, namely translators and technical writers, to perform semasiological as well as onomasiological searches and, most importantly, it provides users with suitable translation equivalents.

Terminology and localization

Klaus-Dirk Schmitz explores in which way the information technology industry depends on the creation of new terms referring to the new concepts and products developed. In the case of software products user interfaces, terminology is particularly important because the terms are operational components of the product itself. Therefore, effective and diligent terminology management is critical to the development and use of software products. Special attention is paid to mechanisms for coining new terms and to criteria for selecting good terms.

Terminology: Planning and policy

Apart from theory, methodology and case studies, it is also interesting to look at aspects of terminology as societal challenges : language planning and policy also entails good terminology management.

We first look at an example from a multilingual African country : *Language Policy and Terminology in South Africa*. Bassey E. Antia describes the development of the language policy programme of post-apartheid South Africa. It highlights both the place of terminology in this policy programme and some of its achievements.

Nelida Chan takes us to the world of the public services in Canada.

This chapter looks at key policies formulated by federal, provincial and territorial governments to examine how *Canadian language policies have influenced terminology policies and used terminology management* as an implementation tool.

Finally, we close this volume with the topic Terminology and Interculturality

Anja Drame leads us into the world of intercultural communication in her contribution : *The Social and Organizational Context of Terminology Work: Purpose, Environment and Stakeholders.* TermNet – The International Network for Terminology work plays an important role in and for society at large or parts thereof. Its purpose is usually to aid people to communicate better. Terminology work thus plays an important role not only in corporate or specialized communication, but also for social issues, culture and national identity.

Foreword

Dirk Geeraerts
KU Leuven

Terminologies - the lexical components of specialized languages – emerge from theoretical and technological innovation: new scientific insights and novel tools enrich the conceptual and practical environment of the specialists, and in the process expand their vocabularies. But these forces apply just as well to terminology as a discipline, i.e. to the linguistic analysis of terminologies and their practical description in a lexicographical format: changes in the theory and practice of terminological studies correlate with developments in their scientific and technological environment. The exceptional importance of the current Handbook, which takes stock of the current state of terminological studies, can therefore be best appreciated if we see it against the background of crucial developments in the theoretical and practical environment in which the discipline operates.

On the theoretical side, the relationship between terminological studies and linguistics is undergoing a fundamental change. Throughout the second half of the previous century, the links between the study of terminology and contemporary linguistics were very much restricted, in the sense that terminology constituted a peripheral area of linguistics at best, and at worst, a theoretically irrelevant practice. The indifference was in a sense mutual. On the one hand, terminology as a discipline tended to confine itself rather strictly (that is to say, without much innovation or internal criticism) to the standard theory of terminology, i.e. the approach that was laid out by Eugen Wüster in the 1930s and that established itself as the main framework for terminological studies in the course of the 1960s. On the other hand, the dominant trends in the development of linguistics in the second half of the 20th century were not favourable for an enterprise like terminology: lexically oriented rather than focusing on syntax, with an applied and language-specific rather than universal and theoretical perspective, and based on a theoretical framework that largely derived from structuralist lexicology, terminology inevitably ended up at a wide distance from generativism-dominated theoretical linguistics. In the meantime, however, the situation in theoretical linguistics has changed considerably. With the emergence of post-chomskyan and cognitive-functional approaches to language, the former divide between terminological studies and linguistics has narrowed considerably.

Crucially, the study of the lexicon has not only received a major impetus as such in post-chomskyan linguistics, but the lexicon has so to speak acquired a more prominent position in the ranking of linguistic disciplines. The former development takes

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the form of various ideas emerging from cognitive linguistics: prototype theory, conceptual metaphor theory, frame semantics, and more generally, the revived interest in lexical semantics, polysemy phenomena, and categorization phenomena in natural language. This major revival of lexicology and lexical semantics then contributes to the second phenomenon. Linguistic categorization does not just happen at the level of the lexicon, and therefore the descriptive frameworks developed in lexical studies may serve as a guide for investigating meaning and categorization at other levels of linguistic structure. Adding to the increased respectability of lexical studies is the internal development of syntactic theory: there has been a gradual lexicalization of syntax, in the form of a realization that syntactic patterns can only be adequately described by specifying the lexical classes to which they apply.

This growing theoretical interest in the lexicon is not only an opportunity for terminological studies to narrow the gap with theoretical linguistics, it is also a challenge, because it forces the terminologist to think about ways in which the new models of description can be incorporated, and to reconsider the specificity of specialized language compared to other forms of language use. Polysemy and metaphoricity, for instance, hardly have a place in the standard conception of terminology, while they are considered pervasive in a contemporary view of the lexicon: so how do they fit into the terminological framework? Similarly, a Wüsterian approach assumes that specialized language more or less constitutes a realm of its own, clearly separated from ordinary language, while contemporary cognitive-functional approaches to lexicology would rather emphasize the continuity between general and specialized vocabularies. Part of the dynamism of current terminology resides precisely in the way in which it incorporates ideas coming from lexicology at large.

Turning now to the technological side of the terminological environment, the changes and challenges are possibly even bigger than on the theoretical side. They are also more obvious, and therefore need less introductory description: the digital revolution is deeply affecting the terminological playing field. Three dimensions of this invasive change need to be singled out. First, the abundant availability of digital texts provides an unprecedented amount of documentation for the terminologist: more texts than ever are available for terminological analysis and description. Like the rest of lexicology and lexicography, contemporary terminology necessarily teams up with corpus linguistics and computational linguistics to explore and exploit the wealth of available language documentation. Second, the terminographical end product now takes a digital form: again as in lexicography in a broader sense, data bases and digital reference works replace the classical paper dictionary. And third, the digital environment is changing the behaviour of the language users. The broad availability of expert, specialized information on the Internet implies an increased exposure of the average language user to specialized language: digitized resources (not just reference works, but specialized and topic-specific websites in general) reach a much wider audience

than the traditional terminographical audience of experts and experts-to-be. As a consequence, specialized language becomes less specialized in terms of its distribution in the language community: more people than ever before now have easy access to expert lexical information. The challenges issuing from this technological revolution are considerable: terminological studies are stimulated to rethink their descriptive procedures, their training programmes, their dissemination format, and to some extent even their audiences.

The present Handbook, then, needs to be welcomed and applauded for introducing the discipline of terminology in a period of major change. Facing the challenges as much as it charts the achievements, the Handbook is likely to become a long-term reference point for terminological studies, not just because it systematically draws the panorama of present-day terminology, and because it brings together a stellar line-up of internationally renowned terminologists, but specifically also because it takes the changing theoretical and technological landscape of the discipline as its point of departure. These are exciting times for the study of terminology, and this Handbook eminently captures the thrill of the era.

PART I

Fundamentals for term base development

Terms and specialized vocabulary

Taming the prototypes

Pius ten Hacken
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In the traditional understanding of terminology, a terminological definition gives necessary and sufficient conditions for a concept. However, natural concepts are based on prototypes. Prototypes are marked by typicality effects with fuzzy boundaries determined by approximate, scalar conditions and preference rules.

For a significant part of specialized vocabulary, imposing a terminological definition is problematic, because it is a fairly arbitrary decision to fix precise boundaries in a continuum. The relevant concepts are based on prototypes, in the same way as natural concepts. We only find strict terminological definitions when it is necessary to determine exact boundaries. Such a need arises in legal and scientific contexts. The enforcement of laws and the evaluation of scientific claims depends on precise definitions of the underlying concepts.

Imposing a terminological definition can be problematic for various reasons. One is that the concept may already exist in people's competence and thus have a prototype structure. Another reason may be that different theories use different concepts with the same name. It should also be taken into account that new insights may require adaptation of the definition. Linguistically, a terminological definition creates a new, abstract object that exists independently of speakers' linguistic competence.

Keywords: Terminological definition; Lexicographic definition; Prototype

1. Introduction

One of the central concerns of Terminology is the proper definition of terms. In trying to formulate such definitions, classical approaches struggle with some of the inherent properties of language. In this chapter, I will first present the classical terminological approach to definitions (Section 1) and then the main source of problems (Section 2). Against this background, I will propose an analysis of terminology in which terminological definitions apply only when required (Section 3) and describe how this approach can handle some typical challenges (Section 4).

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2. Terminological definitions

On 24 August 2006, the International Astronomical Union (IAU) adopted a new definition of "planet", published in IAU (2006). This definition is given in (1):

(1) [A planet is] a celestial body that is:
   a. in orbit around the Sun,
   b. has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and
   c. has cleared the neighbourhood around its orbit.

The definition in (1) is a typical example of a well-formed, classical terminological definition. It starts by specifying a hyperonym of "planet" and then specifies three conditions that distinguish "planet" from its co-hyponyms, i.e. other types of "celestial body". Terminological definitions are understood to give necessary and sufficient conditions (Bessé 1997). This means that (1) can be interpreted as an algorithm for determining whether something, let us call it X, is a "planet" or not. The first step is to determine whether X is a celestial body. If not, we are ready and the answer is no. If it is, we go to (1a). This condition excludes, for instance, the stars and the Moon, which is in orbit around the Earth. Then we go to (1b). This excludes, for instance, most of the asteroids and all comets, because they are too small. Finally, we come to (1c). This excludes, for instance, Pluto as well as the remaining asteroids. All and only the objects that fulfil all of these conditions are planets. There is no room for additional intuitive judgements, saying for instance that Pluto should nevertheless be a planet or that Mercury is really too small to be a planet.

In recent years, the idea that terminology should aim for terminological definitions such as (1) has come under attack from the so-called "Sociocognitive Approach" to terminology, originally proposed by Temmerman (2000). Advocates of this approach claim that the traditional approach to terminological definitions imposes constraints that are not realistic, because linguistic meaning is based on prototypes. Both terms and their definitions belong to language, so that there is no way to escape from the limitations language imposes on definitions.

3. Prototypes

In classical sources, for example Aristotle, we find that the approach to definitions exemplified in (1) is also applied to natural language concepts. A well-known example is that an "*anthropos*" ('human being') is defined as an animate being with two legs and no feathers. In a classical study, Labov (1973) showed that this approach does not

work for general-language concepts such as "cup". COED (2011) defines the relevant sense of "cup" as in (2):

(2) a small bowl-shaped container for drinking from, typically with a handle

In principle, we can interpret (2) in the same way as (1). In (2), "container" has the role of the hyperonym and the size, shape, purpose and handle are four further conditions. However, Labov found that in asking people to classify objects as cup, bowl or vase, the judgements varied both between people and for the same person at different occasions. When we start with an object that is a clear cup and present other objects such that they display a gradual elongation of the shape, we find more and more speakers judging that the object is a vase rather than a cup until we reach a point at which 50% of people think it is a vase. Beyond that, this proportion continues to rise until we reach the clear vases. The boundary between "cup" and "vase" is inherently vague. It depends on scalar properties such as the height-width relation and the size.

An interesting feature of (2) is the condition that a cup *typically* has a handle. This means that an object that might otherwise be classified as a vase is reclassified as a cup when it is given a handle. Having a handle is neither a necessary nor a sufficient condition, but it influences the application of scalar conditions. Jackendoff (1983, 137–138) calls such conditions "preference rules".

Labov's experiment shows that the meaning of words such as "cup" is not encoded in the speaker's mental lexicon as a set of necessary and sufficient conditions. A more likely encoding is as a prototype. A prototypical cup has a handle and a particular size and height-width relation and in judging whether an object X is a cup, we compare X to the prototype. If it is close enough, we say X is a cup, but if it is further away and there is another prototype, for example of "vase", that is closer, we say that X is rather a vase. In the absence of a closer prototype, we may also say that X is not a very good example of a cup without assigning it to another category.

As opposed to the terminological definition in (1), (2) is a lexicographic definition. As argued in ten Hacken (2009), dictionaries should not be interpreted as descriptions of a language, but as tools for users who need information in order to solve a problem. In this light, we can see (2) as an attempt to evoke the prototype of a cup. If you know the concept, you will probably recognize it. If you do not know the concept, you will at least get an initial image of what it refers to.

4. The distinction between terms and specialized vocabulary

On the basis of a study of terms in the life sciences, Temmerman (2000) argues that terms are not crucially different from words in the sense that both are based on

prototypes. This implies that terminological definitions should be interpreted in the same way as lexicographic definitions.

A good area to study this competition between different conceptions of *term* is that of Sherry production. Sherry is a special type of fortified wine, produced in the south of Spain, around the city of Jerez de la Frontera. There are various types of Sherry, two of the most famous being *Fino* and *Oloroso*. They differ in that *Fino* is made from wine that matures in casks in which the yeast naturally forms a protective film called "*flor*". *Oloroso* is made from wine where no "*flor*" forms in the cask. Sherry does not have a harvest year on the label, because it is traditionally made by carefully mixing wines of different ages in a system called "*solera*". In the "*solera*" system, casks are lined up such that the bottom casks contain the oldest wine. When the wine from the bottom casks is bottled, only a part is taken out and the remainder is filled up again from the next row and so on until reaching the top row. Casks are never completely full so that there is space for "*flor*" to form.

Expressions such as "*flor*" and "*solera*" are usually considered terms. They add up to the terms used in wine making more generally, designating specific tools, actions and substances used in the production process. These expressions differ from general language expressions in the sense that they are known by fewer speakers. Expressions such as "grape" and "harvest" are fairly general, but "must" and "first pressing" are only in the active vocabulary of speakers with a special interest in wine.

In wine production in general, grapes are pressed to produce "must". "Must" is the grape juice with the skins, seeds and stems of the fruit still in it. As described by Zambonelli (2003, 93–109), the "must" provides ideal conditions for a variety of microorganisms that are essential in wine making. At some point, the solid matter is separated from the juice. The first pressing yields the best quality of juice.

The difference between these expressions and general words like "cup" is that they are in the mental lexicon of a much smaller group of speakers. For wine makers, the noun "must" is as normal a word as "cup", but for many other speakers, "must" is only an auxiliary verb. In the case of "*flor*", it is even more specialized. Most wine does not involve "*flor*" in its production process. In Sherry production, the formation of "*flor*" is a crucial issue, but even many wine makers may not know the word. There is no reason to assume, however, that for the speakers who know "must" and "*flor*", they are of a different nature than "cup". They are based on a prototype. The full meaning of the concept is only acquired in the process of wine making, although other speakers may have a less richly developed meaning of these concepts in their mental lexicon. This is characteristic of what in ten Hacken (2008) is called "specialized vocabulary".

In the case of specialized vocabulary, there is no need for a terminological definition of the type illustrated in (1). Therefore, a lexicographic definition of the type illustrated in (2) is the best we can aim for. It is only when there is a need for a

terminological definition that speakers tolerate necessary and sufficient conditions to override their prototype-based characterization of a concept.

One context where terminological definitions are required is when the concept is the subject of legal dispute. In the case of Sherry, labels such as *Fino* and *Oloroso* are valuable, because wines with these labels can be sold at a higher price than without. Therefore, there is a certain pressure to produce a wine that fulfils the minimal requirements of these labels at the lowest cost. In order to protect the quality, these minimal requirements have to be defined by law. Junta de Andalucía (2011) sets out the conditions for different types of Sherry. This document specifies analytical properties (amount of alcohol and sugar) and properties of the colour and taste for each type of Sherry as well as a range of general conditions on the production process.

Not all of these properties are equally defining. However, where the need arises, the definition is tightened as required. Hard conditions are, for instance that *Fino* must have 15–17% alcohol and no more than 5g/l of sugar (Junta de Andalucía 2011, 1). Here it is possible to challenge a competitor. A soft condition is that its colour is "*amarillo pajizo a dorado pálido*" ('straw-like yellow to pale goldish') (Junta de Andalucía 2011, 2). This condition can only be contested in very obvious cases of violation. The condition that "*la totalidad de su proceso de crianza se ha desarollado bajo velo de flor*" ('during the entire maturation process, the wine is covered by *flor*') (Junta de Andalucía 2011, 2) is more specific, but one could imagine cases of dispute on the boundaries of the process or the minimal thickness of the layer of "*flor*". Wherever such conflicts arise, the definition can be tightened. Ten Hacken (2010a, 419–420) illustrates this procedure for the legal concept of "theft" in England and Wales. The definition in the *Theft Act (1968)* spans several pages and specifies that taking fruit from trees on someone else's land is theft, but taking mushrooms is not. Such elaborate conditions are typical of a case law system.

Another type of context where terminological definitions are required is when scientific claims are made. Zambonelli (2003, 149–150) gives an overview of the research that has been carried out on the formation, composition and effects of "*flor*". In order to make any claims, it is necessary to define what counts as "*flor*". Again, boundaries are only necessary as far as there is a reasonable discussion. Where a particular substance does not exist (either accidentally or because it has impossible physical properties), there is no need to specify a boundary.

The distinction between terms (in the narrow sense) and specialized vocabulary is determined by the need to resolve conflicts. Unless there is such a need, we can continue to use prototypes, which correspond to the natural state of concepts. A term is created when precise boundaries are defined. This process is triggered by legal or scientific conflicts. In this sense, defining a term is *taming* the natural prototype.

5. Challenges for terminological definitions

In formulating terminological definitions, we create a new type of object. This new object is an abstract entity which can be used as a standard for the evaluation not only of individual speakers' use, but also of their knowledge. Ten Hacken (2007) compares the nature of this object to that of a piece of music. Creating such an object changes the world. As such, it is understandable that there are various challenges facing such definitions.

One type of challenge can be illustrated on the basis of the term "species". In the case of "species", the central issue is to determine whether two individuals belong to the same species or not. As described by Wilkins (2009), there is a long history of debate on this question. A classical instantiation of the question is whether the leopard and the jaguar are the same species or not. Mayr (2004, 174–190) distinguishes three species concepts, which he calls "typological", "biological" and "ecological", each based on different criteria.

The *typological species concept* is the one underlying Linnaeus' taxonomy. The idea is to determine a number of crucial properties of a particular species. In the case of the leopard and the jaguar, this works well when we know that they are the same species or that they are different species, but it does not help us determine which of the two cases applies. The choice of properties to define "leopard" is entirely free, so we can make the concept so as to include jaguars or not.

The *biological species concept* is based on the possibility of having fertile offspring. This criterion can only be applied to populations, because the possibility cannot be tested on any random pair (they may be both males). As populations of leopards occur in Africa and populations of jaguars in South America, the geographical distance also causes a problem. Perhaps the worst problem, however, is that some species have asexual reproduction. Besides, for extinct species, there is no way to decide. In these cases, the criterion is entirely inapplicable.

The *ecological species concept* is based on the niche chosen in an ecosystem. Mayr (2004, 171–172) describes a number of technical problems with this concept which I will not go into here. An interesting development is the emergence of genetic research, resulting in the listing of DNA of individuals. However, the way this technique can contribute to a solution of the species problem is not crucially different from the typological approach. In order to apply a genetic criterion, we have to know which parts of the DNA to pay attention to. The choice of these sections of the DNA string is of the same type as the choice of properties used by Linneaus. Depending on what we want to prove, we can make the leopard and the jaguar the same or different species.

The difficulty of defining "species" does not prove that a definition is impossible or that any definition would be arbitrary. It only illustrates the difficulty of creating

the abstract entity corresponding to the terminological definition in such a way that it does not conflict too much with intuitive preconceptions. People have intuitions about what constitutes a "species". This indicates that "species" has a prototype-based, natural concept as its meaning in their mental lexicon. The purpose of defining it as a term is to make precise scientific discussion about it possible. This raises the question as to who is entitled to impose a definition.

In some cases, the conflict about terminological definitions takes a different form. An example is the linguistic term "morpheme". As noted by Stump (2011), there are two conflicting notions of this term. One is based on Bloomfield's (1933, 161) definition in (3):

(3) A linguistic form which bears no partial phonetic-semantic resemblance to any other form, is a *simple* form or *morpheme*.

Another notion is the one developed by Harris (1942). Harris outlines a procedure for morphemic analysis rather than providing a definition. Matthews (1974, 84) describes the notion used by Harris in (4):

(4) [A morpheme is] a class of allomorphs in complementary distribution.

The significance of the difference between (3) and (4) can be seen when we consider, for instance, Dutch nominal plurals. There are two regular endings, *-en* and *-s*, and the choice between them depends on various factors (Booij 2002, 21–34). According to (3), *-en* and *-s* are two morphemes. In the theory adopting (4), however, they are allomorphs of the same morpheme. Luschützky (2000) discusses the problems surrounding the definition of "morpheme" in more detail.

The technical nature of the concept of "morpheme" makes it unlikely that speakers, even expert linguists, have intuitions about what is a morpheme that would favour (3) or (4). The question in such a case is rather which concept, (3) or (4), serves us better. Therefore, in such a case, a conflict about terminology is not an indication that the term is vague or based on a prototype, but rather that there are two terms that have been given the same name and reflect different theoretical choices. Ten Hacken (2010b, 923–924) discusses the example of *compound* in the same vein.

Whereas in the case of "morpheme", the choice of a definition has an impact on linguistic theory, there are also cases where such a choice influences developments in the real world. An area where this often occurs is that of traffic law. In order to enforce the law, it is necessary to define such concepts as "car" quite precisely. This is the same type of situation as in the case of *Fino* in Sherry making, but for "car" any speaker of (British) English will have a prototype-based, natural concept in their mental lexicon. When it is legislated which vehicles one is allowed to drive with a specific driving licence or which speed limit applies to a particular vehicle, it is necessary to formulate

a terminological definition of concepts such as "car". For the UK, DVLA (2013, 8) gives the definition in (5):

(5) **Cars**: Motor vehicles
  a. with a MAM not exceeding 3,500 kg and
  b. designed and constructed for the carriage of no more than eight passengers in addition to the driver
  c. (i) with a trailer up to 750 kg or
    (ii) with a trailer over 750 kg where the combination MAM is not exceeding 3,500 kg.

In (5), The division in *a* and *b* has been added in order to make the structure of the terminological definition more transparent. In (5a), MAM stands for "Maximum Authorised Mass", another term which needs a definition. Line (5c) has been taken from separate definitions for the two cases as given by DVLA (2013, 8).

Whereas in general contexts, there is a continuum from "car" to "van" and "lorry" and from "car" to "minibus" and "coach", in the specific domain of traffic law, a precise boundary has to be imposed. Even speakers who do not know (5) are generally aware that there must be some definition of this type, because otherwise traffic laws cannot be enforced. Another aspect of (5), however, is that it influences the nature of the vehicles built and used in a country. As the status of "minibus" implies additional restrictions, it is unlikely that many vehicles will be sold that are designed for nine passengers in addition to the driver. In fact, there is a large choice of vehicles that are exactly at the boundary of "car" as defined in (5b). This shows that terminological definitions may have an impact on the real world by means of the conditions they specify.

As a final example, let us consider "planet" again. In (1) we encountered a terminological definition for this concept. It would be wrong to think of such a definition as representing an 'eternal truth', a historically immutable, entirely rigid concept. Temmerman (2000, 14–16) observes this as well and she uses it as an argument against the classical approach to terminology. However, even if definitions of astronomic categories do not influence the world, improvements in instruments, observation methods and theories change our understanding of the relevant part of the world. (1) stands in a long tradition and it is worth considering it briefly. A more detailed history is found in, for instance, Schilling (2007).

When the heliocentric model of the solar system had replaced the geocentric one after the work of Copernicus, Kepler and Galileo, there were two definitions of "planet" that were treated as equivalent. They can be formulated as (6) and (7):

(6) **planet**
celestial body which is in orbit around the Sun

(7) **planet**
Mercury, Venus, Earth, Mars, Jupiter or Saturn

Whereas (6) is an *intensional definition* giving general conditions, (7) is an *extensional definition*, listing the instances. Both can be treated as necessary and sufficient, but (6) lists necessary conditions and declares the list sufficient, whereas (7) lists sufficient conditions (e.g. if X is Mercury, X is a planet) and declares the list necessary. Intensional definitions are preferred in terminology, because they give a motivation for the concept by listing its common properties.

The technical possibilities of observing further planets were in place in the 17th century, as evidenced by the fact that Galileo put a star we now know as Neptune on one of his maps (Schilling 2007, 33). However, the strong belief that (6) and (7) were equivalent was only shocked in 1781, when William Herschel discovered Uranus. The realization that (6) is not equivalent to (7) triggered a search for further planets. Between 1801 and 1807, four more planets were discovered: Ceres, Pallas, Juno and Vesta. They are all in the space between Mars and Jupiter. As Schilling (2007, 22) describes, in the first half of the 19th century, books on astronomy presented the solar system as consisting of 11 planets. (7) was discarded as a definition.

The situation changed again after 1845 when more planets were discovered. Until 1849, five new objects were found between Mars and Jupiter, as well as one beyond Uranus – Neptune. By 1855, there were over thirty new planets. In 1851, the German astronomer Johann Franz Encke (1791–1865) proposed making a distinction between the smaller objects between Mars and Jupiter on the one hand and the traditional planets in (7), supplemented by Uranus and Neptune, on the other. For the former concept, he used the name "asteroid" (Chisholm 1911). This proposal was generally adopted. However, it was not felt necessary to define the boundary in size between asteroids and planets precisely. The diameters of the largest asteroid (Ceres, 960 km) and the smallest planet (Mercury, 4875 km) are far enough apart. Planets were thought of as fulfilling (6) and not being asteroids. An example of a definition of "asteroid" is (8), taken from Sparrow (2006, 220):

(8) **Asteroid**
A small rocky world orbiting in the inner Solar System. Nearly all asteroids are irregular in shape, and most orbit within the *asteroid belt*, confined between the orbits of Mars and Jupiter.

Taken from a popular-scientific work, (8) is a good example of a lexicographic rather than terminological definition of a scientific concept. The second sentence gives preference rules, as indicated by *nearly* and *most*. However, only when scientific developments made the vagueness created by these preference rules problematic, did the discussion of a new terminological definition of "planet" become necessary. These developments included the discovery of Pluto in 1930 and a range of other objects in orbits beyond Neptune. As (1a) restricts "planet" to the Solar system, a variant definition is necessary to cover so-called "exoplanets", planets orbiting other stars than

the Sun. This brief historical discussion of the definition of "planet" shows how the precision and the reformulation of terminological definitions are driven by scientific discoveries.

6. Conclusion

The classical approach to terminology, as initiated by Eugen Wüster (1898–1977) in the 1930s, aims for terminological definitions consisting of necessary and sufficient conditions. Problems in formulating such definitions arise from the fact that natural concepts, as they arise in people's minds, are based on prototypes (e.g. "cup"). Lexicographic definitions evoke such a prototype. In many contexts, even for specialized vocabulary, there is no need to make the extra effort of formulating a terminological definition. Only when conflicts about the precise boundary of the concept arise, for instance because of scientific claims or legal disputes, is it necessary to determine one. When a terminological definition applies to an empirically based, scientific concept, the degree of precision depends on the state of our knowledge. With progress in knowledge, periodic revision of definitions may be necessary (e.g. "planet"). In the case of legal concepts, the boundaries imposed by the definition will influence what is done in the real world (e.g. "car"). The precise definition of a term may be a matter of debate. As shown by the example of "morpheme", the debate is not so much about what the term *really* means, but about which term is the *best concept* to be used in a theory. However, as shown by the example of "species", this question may interact with intuitions based on prototypes.

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Frames as a framework for terminology

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Terminology work involves the collection, analysis and distribution of terms. This is essential for a wide range of activities, such as technical writing and communication, knowledge acquisition, specialized translation, knowledge resource development and information retrieval. However, these activities cannot be performed randomly, but should be based on a systematic set of theoretical principles that reflect the cognitive and linguistic nature of terms as access points to larger knowledge configurations. "Frame-Based Terminology" (FBT) is a cognitive approach to terminology that is based on frame-like representations in the form of conceptual templates underlying the knowledge encoded in specialized texts (Faber 2011, 21; 2012; Faber et al. 2007, 42). FBT frames can be regarded as situated knowledge structures and are linguistically reflected in the lexical relations codified in terminographic definitions. These frames are the context in which FBT specifies the semantic, syntactic and pragmatic behaviour of specialized language units. They are based on the following set of micro-theories: (1) a semantic micro-theory; (2) a syntactic micro-theory and (3) a pragmatic micro-theory. Each micro-theory is related to the information encoded in term entries, the relations between specialized knowledge units and the concepts that they designate.

Keywords: Terminology theory; Cognitive semantics; Concept modeling ; Frames

1. Introduction

"Frame-based Terminology" (FBT) is a cognitive approach to terminology, which directly links specialized knowledge representation to cognitive linguistics and semantics (Faber 2011, 2012). As such, it shares many of the same premises as Cabré Castellví's (1993, 1999) "Communicative Theory of Terminology" and Temmerman's (2000, 2001) "Sociocognitive Theory of Terminology", which also study terms by analysing their behaviour in texts. However, FBT differs from these approaches in that its methodology combines premises from psychological and linguistic models and theories such as the "Lexical Grammar Model" (Faber and Mairal 1999; Martín Mingorance 1989, 227–253), "Frame Semantics" (Fillmore 1985, 222–254; Fillmore 2006, 373–400), the "Generative Lexicon" (Pustejovsky 1995) and "Situated Cognition" (Barsalou 2003, 2008, 618–623).

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More specifically, the FBT approach to terminology applies the notion of "frame", defined as "a schematisation of experience (a knowledge structure), which is represented at the conceptual level and held in long-term memory and which relates elements and entities associated with a particular culturally embedded scene, situation or event from human experience" (Evans 2007, 85). Frames have the advantage of emphasising non-hierarchical as well as hierarchical conceptual relations. Although the frame-like representations in FBT initially stem from Fillmore (1985, 222–254; 2006, 373–400; Fillmore al. 2003, 298–332), they have been adapted to the structure of specialized knowledge units and their roles in specialized subject domains.

In EcoLexicon,[1] a multimodal environmental knowledge base which is the practical application of FBT, a "frame" is a representation that integrates various ways of combining semantic generalizations about one category or a group of categories, whereas a "template" is the representational pattern for individual members of the same category. In such specialized knowledge representations, a cultural component is also currently being integrated. This component is in the form of a "semplate", which refers to the cultural themes or linguistic patterns that are imposed on the environment to create, coordinate, subcategorize or contrast categories (e.g. geographical landforms and landscape concepts) (Burenhult and Levinson 2008, 144). "Frames" thus become large-scale representations that link categories by means of semantic relations. As shall be seen, they can be formalized in micro-grammars that codify these relations in specialized texts. They also provide a basis for the selection of knowledge-rich linguistic, cultural, and graphical contexts.

2. Frame-based terminology: Micro-theories

In scientific and technical texts, specialized knowledge units activate domain-specific semantic frames that are in consonance with the domain as well as with the user's background knowledge. These frames are the context in which FBT specifies the semantic, syntactic and pragmatic behaviour of specialized language units. They are based on the following set of micro-theories: (1) a semantic micro-theory; (2) a syntactic micro-theory and (3) a pragmatic micro-theory. Each micro-theory is related to the information encoded in term entries, the relations between specialized knowledge units and the concepts that they designate.

1. http://ecolexicon.ugr.es

2.1 Semantic micro-theory

In Lexicography, frame-based dictionaries have been proposed by Boas (2005) and Martin (2006). Such dictionaries are also applicable in Terminography, which focuses on the representation of specialized units that should be internally as well as externally coherent. Internal coherence refers to the information contained in the data fields of each entry, whereas external coherence refers to how entries are interrelated within the context of the knowledge resource as a whole (Faber et al. 2007, 40).

2.2 Internal representation

In FBT, frames are systematically reflected in the lexical relations and meaning components codified in terminographic definitions. Definitions are based on information extracted from other specialized knowledge resources as well as from a corpus of specialized texts, which is the main source of the semantic, syntactic and pragmatic information conveyed by the specialized knowledge unit. As underlined by Martin (1998, 191), frames can act as definition models to offer more consistent and flexible representations of conceptual structure. In FBT, these models or mini-knowledge representations are based on Pustejovsky's qualia roles:

1. Formal role: the basic type distinguishing the meaning of a word;
2. Constitutive role: the relation between an object and its constituent parts;
3. Telic role: the purpose or function of the object, if there is one;
4. Agentive role: the factors involved in the object's origins or *coming into being* (Pustejovsky et al. 2006, 3).

Formal and constitutive qualia roles refer to individual variables of related type and predicate (Pustejovsky 1998, 330–331). The formal role refers to the *type_of* relation, where the lexical item is included in a category and the constitutive role refers to what an object is made of (i.e. *part_of* relation). Depending on their general type and category, concepts tend to activate a certain set of roles. This determines the way concepts are related to each other at the macro- and microstructural level. In this sense, both the agentive and telic roles are mainly typical of events. The agentive role identifies a set of individual events associated with the object, whereas the telic role refers to an event description, which is associated with that object as its function (Pustejovsky et al. 2006, 333).

For instance, a natural physical entity can be described by both *type_of* and *part_of* relations. A "glacier" can thus be a geographic object and have an ablation zone as one of its parts, but it cannot be described in terms of use, purpose or function because it would then become an artefact. In contrast, an instrument is an artefact; as a human-created entity, it has a specific use or function. Broadly speaking, many

general types of environmental instrument are classified according to their function: (1) recording (e.g. "anemograph", "seismograph"); (2) measuring (e.g. "anemometer", "hygrometer"); (3) sampling (e.g. "sediment sampler", "air sampler") and (4) transforming (e.g. "solar panel"). Although qualia roles do not exhaust the semantic content of specialized concepts, they provide a way to systematize meaning.

The meaning definitions of concepts are thus extremely important in terminology. At the micro-semantic level, a definition is the linguistic description of the properties of a concept. According to Antia (2000, 113–115), a definition fixes a concept, describes a concept and also links a concept to others. As is well known, most terminological definitions are composed of a generic or superordinate term and differentiating features (Eck and Meyer 1995, 83–87; Sager 1990, 42). An example of this type of definition is shown in Table 1.

When definitions are well constructed, this means that it is theoretically possible to derive *type_of* hierarchies (Pustejovsky's formal role) for a domain, merely by extracting the generic term in terminological definitions and forming chains of meaning. Table 2 shows a possible definitional hierarchy for "decomposition" in the domain of environmental science. In the definitions in Table 2, each term is defined as a type of the other. The definitions thus become increasingly more specific, thanks to the

Table 1. Definition of "weathering" as a *type_of* "decomposition"

"Weathering"	
Decomposition	**Superordinate term**
of rocks, minerals and soils at or below the Earth's surface	*Differentiating features* referring to affected entities and locations
By the action of atmospheric agents (wind, water, solar radiation, temperature changes), chemical reactions and living organisms	*Differentiating features* referring to agency

Table 2. Definitional hierarchy of "weathering" as a *type_of* "decomposition"

"Decomposition" [environmental science]	
"weathering"	**decomposition** of rocks, minerals and soils at or below the Earth's surface by the action of atmospheric agents (wind, water, solar radiation, temperature changes), chemical reactions and living beings.
"mechanical weathering"	**weathering** involving the breakdown of rocks and minerals by mechanical forces, caused by the action of atmospheric agents, such as wind, water, temperature changes, ice, and solar radiation.
"frost wedge"	**mechanical weathering** in which water freezes in a crack and exerts force on the rock causing it to further rupture.

addition of properties related to (1) the affected entities (rocks, minerals and soils); (2) agent (atmospheric agents, mechanical forces, etc.); (3) location (at or below the Earth's surface) and (4) the process involved (water freezing in a crack).

However, for many reasons, the specification of such hierarchies in definitions is rarely so direct or simple. Firstly, this process is made difficult because the same lexical form can have different meanings within different domains. Table 3 shows how "weathering" is defined in the subject fields of environmental science, architecture and construction.

Table 3. "Weathering" in different specialized domains

"weathering" [environmental science]	**decomposition** of rocks, minerals and soils at or below the Earth's surface by the action of atmospheric agents (wind, water, solar radiation, temperature changes), chemical reactions and living beings.
"weathering" [architecture]	slight **inclination** given to horizontal surfaces, especially in masonry, to prevent water from lodging on them.
"weathering" [construction]	**process** of simulating wear and tear on a model.

Even within the same domain, a concept can be defined in terms of different subordinates. For example, as shown in Table 4, "weathering" can be defined not only as a decomposition process or action, but also as the result of that process.

Table 4. "Weathering" as a type of action and decomposition in environmental science

Concept	Superordinate	Differentiating features
"weathering"	action	of atmospheric agents (wind, water, solar radiation, temperature changes), chemical reactions and living organisms that decomposes rocks, minerals and soils at or below the Earth's surface
"weathering"	decomposition	of rocks, minerals and soils at or below the Earth's surface by the action of atmospheric agents (wind, water, solar radiation, temperature changes), chemical reactions and living beings.

This difference in perspective reflected in terminological definitions is known as "multidimensionality". As exemplified in Bowker (1997), this phenomenon occurs when a concept can be classified in more than one way. A dimension represents one way of classifying a concept and a concept system with one dimension is said to be multidimensional.

"Weathering" is thus a complex event in much the same way as erosion, sedimentation, warming, glaciation, flooding, construction, etc., which are regarded as "dot objects" by Pustejovsky (2005, 4–8) and lexicalize the event/result polysemy.

The event/result polysemy of deverbal nouns is a special case of inherent polysemy (complex type or dot object) since it is dependent on the meaning of the base verb (e.g. "to weather"). Not only are events and objects radically distinct ontological categories, but the result-object type is temporally and causally dependent on the event type since the performance of the event is the pre-condition for the (coming into) existence of the result. In this case, the conceptual modeling in FBT is in consonance with the proposal of Melloni and Jezek (2009), who assert that the polysemy of nominals, such as "construction" (and "weathering"), should be classified as an event (result-) object where the object type is a result, intended as the causal by product of an event.

2.3 External representation

The rest of the definition of a concept reflects external semantic representation and codifies the other concepts related to the concept being defined. One approach to representing such relations is through ontologies, which can be regarded as shared models or conceptualizations of some domain that encode a view that is common to a set of users. A domain-specific ontology, which is composed of both concepts and instances within a certain field, along with their relations and properties, is a medium for the storage and propagation of specialized knowledge. In this respect, FBT proposes a linguistically-based ontology since its conceptual design is based on information extracted from specialized texts and the structure of terminological definitions. The information in the ontology is semi-automatically extracted from texts instead of being elicited in focus groups or through intensive interviews. It is then validated by experts. The reason for not including experts in the extraction phase was that quite often experts do not know how to formulate their knowledge. This creates a large gap between the knowledge modelled in ontologies and texts documenting the same knowledge (Eriksson 2007, 624–625).

In the ontology underlying the conceptual representations generated in EcoLexicon, top-level concepts are "object", "event", "attribute" and "relation". Concepts can be concrete, abstract, simple or complex. In environmental science, abstract concepts include theories, equations and units for measuring physical entities. They are generally used to describe, evaluate and simulate reality. In contrast, physical or concrete concepts are those that occupy space and/or come into existence over a period of time. They include natural entities, geographic landforms, water bodies, constructions and the natural and artificial process events in which they can potentially participate.

This environmental ontology is primarily organized around direct conceptual representations of physical objects and processes (e.g. "alluvial fan", "erosion", "weathering", etc.). This basic set of concepts act as a scaffold and their natural language

descriptions provide the semantic foundation for data querying, integration and inferencing (Samwald et al. 2010, 22–23). Environmental concepts are codified in terms of natural language definitions that are visually represented as a network of both hierarchical and non-hierarchical semantic relations that have been semi-automatically extracted from a multilingual corpus.

For instance, linguistically speaking, "weathering" is a compressed proposition, stating that atmospheric agents, chemical reactions and living organisms decompose rocks, minerals and soils at or below the Earth's surface. As such, the definition of "weathering" reflects three arguments with roles of agent, patient and location, which in turn activate a set of semantic relations. This structure is the definitional template for different types of "weathering" (Table 5).

Table 5. Definitional template for "weathering"

"Weathering"	
Type_of	Decomposition
Affects	rocks, minerals and soils [patient]
Location_of	at or below the Earth's surface [location]
Effected_by	atmospheric agents (wind, water, solar radiation, temperature changes), chemical reactions and living organisms [agent]

The more specific types of "weathering" (i.e. mechanical weathering and frost wedging) are merely a reduction or specification of the information in the definition of the superordinate. In this sense, mechanical weathering only refers to one of the agents mentioned in the definition of "weathering" (i.e. the action of atmospheric agents) and frost wedging further reduces the definition of mechanical weathering by only referring to the action of water (Table 2).

However, the interrelation of "weathering" with other concepts is also reflected in its definition, which codifies semantic relations with concepts such as "minerals", "solar radiation", "organic being", "chemical weathering", etc. This is reflected in the semantic network for "weathering" found in EcoLexicon and shown in Figure 1.

Such a network can be extremely complex since along with hierarchical relations, such as *type_of* and *part_of,* it also includes non-hierarchical conceptual relations, which are typical of processes (i.e. *affects, result_of* and *causes*) (Faber, Mairal, and Magaña 2011, 568). In addition, the definition of the specialized knowledge unit may also include a second more encyclopaedic part which enlarges on the concepts and processes mentioned in the initial definitional statement. For instance, encyclopaedic information about "weathering" could be that weathering can be mechanical or chemical and that it occurs over a long period of time. For all of these reasons, the specification and structure of specialized meaning definitions is a key factor in estab-

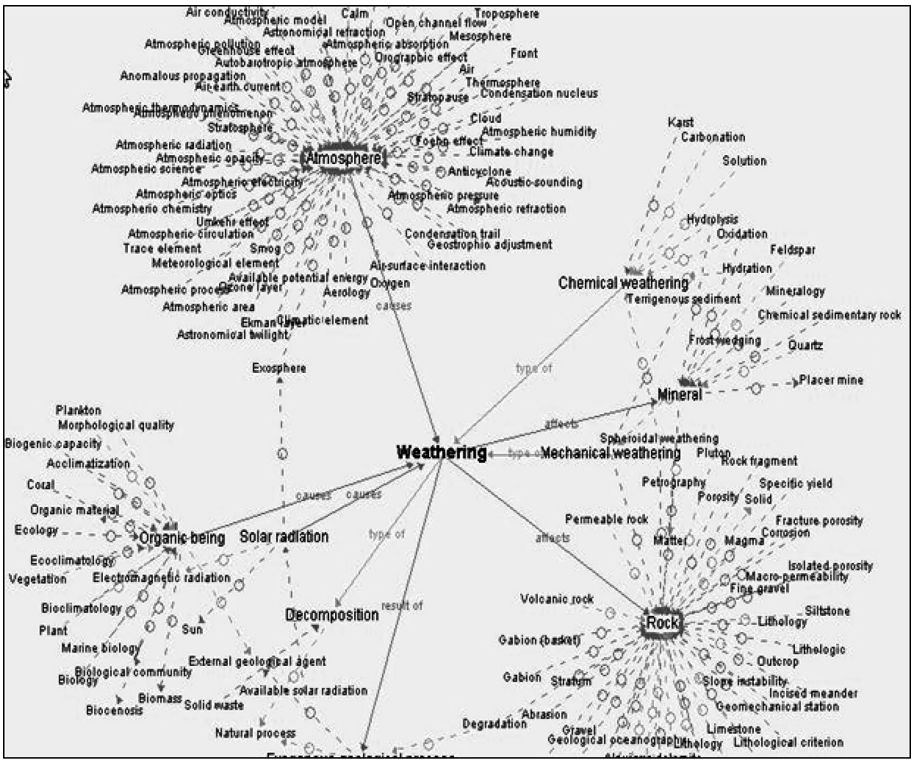

Figure 1. Representation of "weathering" (EcoLexicon)

lishing semantic networks of specialized concepts and thus in the creation of a specialized language semantics.

2.4 Syntactic micro-theory

In Terminology, somewhat less attention has been paid to the syntax of terms in specialized language texts. However, terms have a combinatorial value and distinctive syntactic projections.

The syntactic micro-theory in FBT is event-based. When events are translated into language, they usually take the form of predicate-argument structures. Although the representation of such structures can vary, depending on the linguistic school, it is included in most theories that aspire to be non-language-specific. The nature of an event depends on the predicates that activate the relationships between entities. In this regard, verb predicate classes are based on the degrees of temporality or change that they codify. Our classification of verb predicate types is roughly based on Vendler's (1967) "Theory of Aktionsart", as enriched by Van Valin (2005, 31–50), who augments the four basic classes (state, activity, achievement and accomplishment) by adding

two more classes: "semelfactives" and "active accomplishments". He also distinguishes "causatives" as a parameter cross-cutting the six classes. Although this classification is used in FBT, process is substituted for activity. Table 6 lists the verb classes and gives examples of each.

Table 6. Verb predicate classes (Leon Aráuz, Faber, and Montero Martínez 2012, 122)

Predicate types	Example
State	Atmospheric conditions were favourable.
Process	The wind is blowing.
Semelfactive	Waves hit the cliffs.
Achievement	Waves break in the surf zone.
Accomplishment	The cliff eroded.
Active accomplishment	The ocean flooded shore lagoons.
Causative	The tsunami caused the flooding.

In FBT, each specialized domain can be represented by a general event. In the Environmental Event (Figure 2), general categories of environmental entities are linked by predicates codifying the states, processes, accomplishments, etc. in which the entities can participate (León Aráuz, Faber and Montero Martínez 2012, 116–122). These propositions represent the meanings activated in specialized environmental texts.

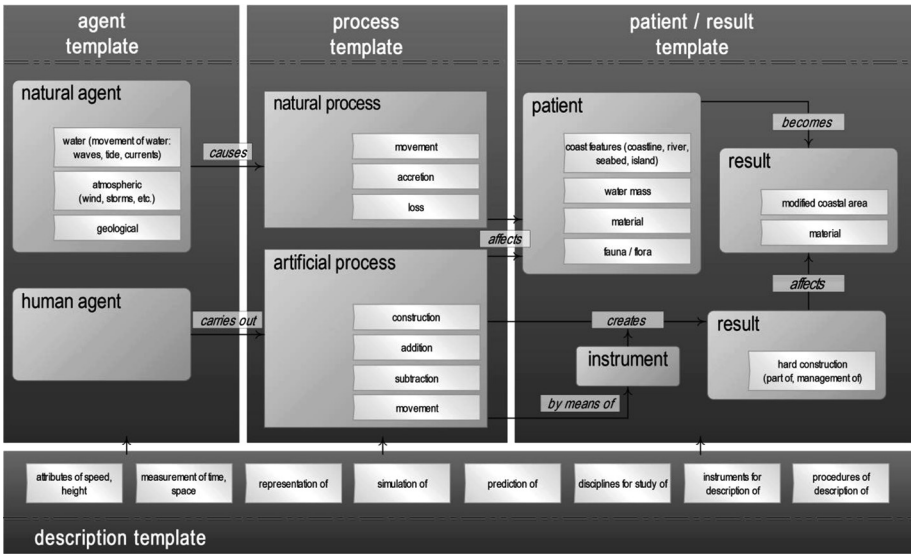

Figure 2. Environmental event (Faber 2012, 118)

The event in Figure 2 is based on general predicates such as "cause", "create", "affect", "carry out", etc. In this regard, the Environmental Event has two types of "agent" that can initiate processes. Such agents can be inanimate (natural forces) or animate (human beings). "Natural agents" such as water movement (e.g. waves, tides and currents) and atmospheric phenomena (e.g. winds and storms) cause "natural processes" such as littoral drift and erosion in a geographic area such as the coast. These processes affect other entities or "patients" (e.g. beaches, sea ports and seabed) which as a "result", may suffer changes (e.g. loss/deterioration/creation of beaches and modifications in seabed composition). "Human agents" can also implement "artificial processes" (e.g. constructions), which can generate or prevent "effects" normally caused by natural processes.

This event is the foundation for the linguistic codification of these relations in specialized texts. FBT maintains that terms and their relations to other terms have a syntax, which can be depicted in graph-based micro-grammars. These micro-grammars not only show how hierarchical and non-hierarchical relations are expressed in different languages, but can also be used to tag a corpus of texts for information retrieval and even measure the prototypicality of causal propositions (León and Faber 2012, 14).

In FBT, micro-grammars based on knowledge patterns are elaborated with NooJ, a development environment used to construct descriptions of natural languages and apply them to large corpora (Silberztein 2003). Accordingly, causal syntactic structures were identified in a 900,000 word corpus. The corpus was classified into four contextual domains of approximately 300,000 words each: Atmospheric Sciences, Coastal Engineering, Oceanography and Soil Sciences. In this way, five micro-grammars have been developed for the following constructions: (1) x causes y; (2) x is caused by y; (3) x is the cause of y; (4) the cause of x is y and (5) x causes y to z. (León and Faber 2012, 13). Of course, the constructions are not limited to *cause*, but also include other terms and phrases with a causative meaning ("produce", "generate", "be due to", etc.). For example, in the construction ⟨`x caused by y`⟩, the first step was to elaborate a core micro-grammar that formalizes the most basic sense of causation (Figure 3).

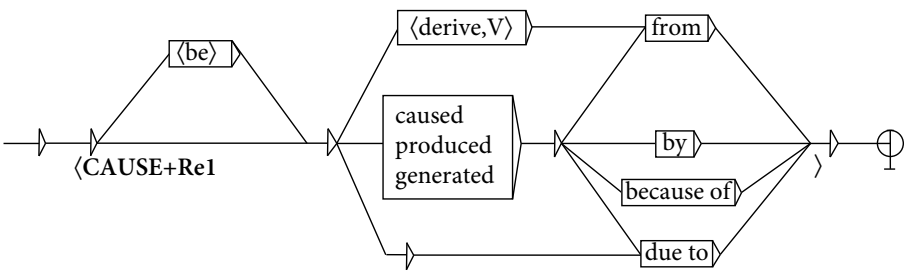

Figure 3. Core grammar of the causal relation (León and Faber 2012, 12–13)

This grammar extracts causal links by following different paths. As shown in Figure 3, the English codification of causation is expressed by the past participle of "cause", "produce" and "generate" (optionally preceded by "to be" in any of its inflected forms), which is followed by one of four constructions ("from", "by", "because of", "due to"). However, causation can also be designated by "derive" in any of its inflected forms, followed by the preposition "from" or by the adjective phrase "due to". When all of the occurrences matching this grammar were located and annotated with the tag ⟨Cause+Rel⟩, 960 candidates were found (Figure 4):

```
                    Flash flooding due to extremely heavy rains
          Most storm-related damage was caused by wind, wind-blown rain and tornadoes
Sustained winds of tropical storm force produced by Rita
The most familiar sea level changes are produced by astronomical tides
            Earthquakes are shock waves caused by abrupt movements of the earth's crust
         Local wind patterns (sometimes caused by structures and urban development)
                     Sediment fluxes generated by incident waves
               Currents are usually due to tides and river flows
                 Internal waves are generated by wind energy
                  Tsunami can also be caused by landslides
              Vapor transfer in soil due to air movement
```

Figure 4. Examples of causal occurrences (León and Faber 2012, 13)

However, not all of the candidates turned out to be valid causal propositions since the causal expression did not always link two specialized terms, such as those cases where x is expressed as "this", "that", etc. This led to the design of a more complex micro-grammar, which reused the annotation ⟨Cause+Rel⟩ as the link between x (effect) and y (cause) (Figure 5).

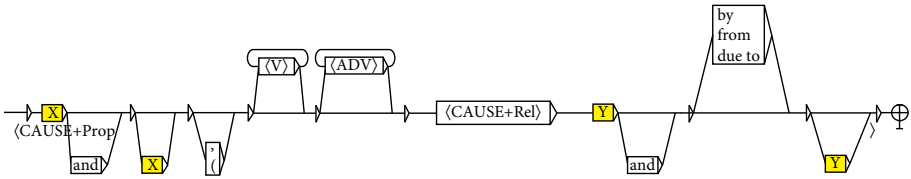

Figure 5. Grammar for causal propositions (León and Faber 2012, 13)

A corpus, classified in contextual domains, can be processed using these causal micro-grammars, as well as new ones for other semantic relations. This is a cyclic process since the application of relational micro-grammars to the most prototypical term pairs in each domain also validates the categorization of the corpus. Furthermore, this makes it possible to identify cases of noise and silence and finally measure the precision and recall of the results with a gold standard. In the future, the disambiguation of polysemic structures will be resolved by adding a semantic component to the grammars. Such semantic features are essential to constrain which entities can be effectively linked through causation (see León and Faber 2012, 10–17 for a more in-depth discussion of micro-grammars).

2.5 Pragmatic micro-theory

In FBT, specialized language pragmatics refers to the situations or contexts in which specialized communication occurs and to the ways that the text sender and receiver deal with them as reflected in text production and understanding. Crucial pragmatic dimensions in specialized communication contexts include (1) the beliefs and expectations of the text sender; (2) the knowledge shared by the text sender and text receivers; (3) the communicative objectives of the oral or written text stemming from the interaction of the participants and (4) the factors that cause receivers to interpret the text in a certain way (Faber and San Martín 2012, 178). The pragmatic micro-theory in FBT consists of a theory of contexts, which can be linguistic, cultural or even graphical. These contexts codify the pragmatic information that should be provided in term entries.

2.5.1 *Linguistic contexts*

The most informative contexts to be included in the term entries of a domain-specific resource are those that link all the information within the term entry to the domain event. According to Fauconnier (1994, xxxviii), information at the referential level is underspecified by linguistic information. Meaning construction thus relies on an elaborate system of backstage cognition to fill in unspecified details. A concept definition should thus describe the most general meaning that is applicable in the widest range of communicative settings. This meaning should help users build a generic mental space by enabling them to combine their background knowledge with the new information in the definition of the concept. This generic space provides information that is common to both the input space of background knowledge and the input space of the definition (Evans and Green 2006, 404). Since an effective context in a specialized knowledge resource is one that helps users to create mental spaces through blending these input spaces, the contexts for a term in the knowledge base must be selected according to one of the following premises:

1. The context is related to the concept through the relations expressed in the definition. By focusing on the relations in the definitional template of a concept and by being able to access contexts that activate those relations, users can construct a more detailed mental space of the concept;
2. The context focuses on a secondary relation (one not expressed in the definitional template). This affords users the possibility of adding new information which enlarges the mental space;
3. The context relates the concept to other concepts in the same domain or to concepts in other domains. This also enlarges the mental space and provides users with the means to create new and related mental spaces (Reimerink, García Quesada, and Montero Martínez 2012, 210).

Decisions regarding the relevance of domain knowledge for linguistic context selection are thus based on the combined analysis of vital relations, knowledge-richness and knowledge patterns:

1. *Vital relations* are links that match two elements or properties in different mental spaces. They are subdivided into outer-space vital relations (time, space, representation, change, etc.) and inner-space vital relations (scaled time, syncopated time, scaled space, syncopated space, uniqueness, etc.), which are compressions of outer-space relations (Evans and Green 2006, 420; Fauconnier and Turner 2002, 89–112);
2. *Knowledge-rich contexts* contain at least one item of domain knowledge that is useful for the conceptual analysis of the search word. Such contexts should indicate at least one conceptual characteristic, whether it is an attribute or relation (Meyer 2001, 279);
3. *Knowledge patterns* refer to explicit domain-independent knowledge patterns, metalinguistic information regarding terms and their conceptual structures. Such linguistic markers help the reader to fully understand the meaning of a concept and the relations of this concept to others. Examples include phrases such as "composed/made of" (part-whole relation), "used/designed for" (cause-effect relation) and "is a kind/sort of" (generic-specific relation) (Barrière 2004, 188–191; Barrière and Agbago 2006, 5).

2.5.2 *Cultural contexts*

Since cultural information also affects the conceptual organization in specialized domains (e.g. Kerremans, Temmerman, and Tummers 2003), this type of context should be reflected in specialized knowledge resources as well as in their underlying ontologies. For example, with regard to environmental concepts, "landscape" is a basic domain of human categorization (Burenhult and Levinson 2007, 136; Majid, Enfield, and Van Staden 2006, 138). It is the backdrop and scenario for human movement and is populated with landmarks for orientation and finding one's way. This basic part of human existence gives rise to both general and specialized concepts, which are not easy to structure hierarchically and map between languages. Despite the fact that the Earth's surface is perceived as continuous and is thus segmented into different types of objects, these divisions and the criteria used for this purpose can differ significantly from culture to culture (Smith and Mark 2003). For example, in the case of landform concepts, Levinson (2008, 257–258) establishes three hypotheses of category formation:

1. Categories are driven by perceptual or cognitive salience. This suggests there should be significant universals in categories like mountain, river, lake or cliff (though this is not always true);

2. Categories are driven by the affordances they offer or the constraints they impose on human activities. This suggests that there should be systematic variation according to subsistence patterns, ecology and the technology of transport;
3. Categories are driven by conceptual templates and cultural beliefs. This suggests greater variation, with universals if any driven e.g. by universals of cognition, cosmology or religious belief.

Interlinguistic analysis reflects that the structure of this category is often not the result of only one, but a mixture of the three, depending on the culture and the language that it reflects. Thus, cultural situatedness also has an impact on semantic networks, where differences exist even between closely related language cultures. For example, the category of geographic landforms (e.g. "estuary", "marshland", "channel", etc.) is constrained by information, directly linked to the nature of the concepts. As Smith and Mark (1999, 247–250) point out, the specificities of geographic objects are the following:

1. Geographic objects are intrinsically tied to their location in space [*located_at*];
2. They are often size-dependent or scale-dependent [*size_of*];
3. 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 stems from the fact that geographic objects are presumably perceived and simulated in a different way from conceptual categories such as "instruments", "atmospheric phenomena", "coastal defence structures" and "marine fauna". Even though within this category, there is greater emphasis on spatial orientation, it is also true that each language has specific terms to designate landforms related to the following: (1) perceptual prominence within the language culture (e.g. "*terral*", a hot dry land-wind blowing from the Spanish peninsula outward in all directions towards the ocean); (2) affordances (e.g. "*albufera*", a freshwater coastal lagoon in Valencia, used for fishing and rice crops) and (3) the space that they occupy within the cosmology and belief system of the cultural community (e.g. "*cenote*", a water-filled limestone sinkhole with religious significance for the Mayans). This type of information must also be taken into account when structuring concepts and trying to establish a common conceptual core for a given set of language cultures.

2.5.3 *Graphical contexts*

Images are also an effective means of describing and representing concepts. The inclusion of different types of visual representation is extremely useful in specialized knowledge fields because images enhance textual comprehension, complement the linguistic information provided in other data fields and generally facilitate knowledge

acquisition. Given the crucial role of images in knowledge representation, graphical material should be selected so as to be consistent with linguistic description, the level of specialization of the text and the recipient's previous subject knowledge (Marsh and White 2003, 652–654). FBT explains how linguistic and graphical information can converge to give the user a better understanding of dynamic concept systems (Prieto and Faber 2012, 229).

In FBT, images are a visual device for the depiction of concepts and their conceptual relations. Accordingly, FBT advocates a multimodal description of specialized concepts in which the information contained in terminographic definitions meshes with the visual information in images for a better understanding of complex and dynamic concept systems (Faber et al. 2007, 39). The role of graphical information in specialized texts implies that images are non-linguistic resources for the representation and transmission of specialized knowledge which direct the reader's attention to a particular aspect of the text. As cognitive support, the image should contain the basic-level categories of the text that it accompanies (Tercedor, López, and Robinson 2005). The types of images to be included in a term entry should be in consonance with the most salient features of the linguistic description of the concept (Faber et al. 2007, 41–49).

In FBT, images that depict concepts are classified in terms of their functions (Anglin, Vaez, and Cunningham 2004, 865–879) or in terms of their relationship with the real-world entity that they represent. The FBT image typology is based on the criteria of iconicity, abstraction and dynamism. Accordingly, illustrations should be selected so that they focus on the semantic features activated in the linguistic description of the concept. Their level of iconicity, abstraction and/or dynamism should be the combination that best portrays the attributes of the concept and the semantic relations activated (Faber et al. 2007, 63; Prieto and Faber 2012, 239).

In this regard, "iconic images" resemble the real-world object represented through the abstraction of conceptual attributes in the illustration. Images may have different degrees of resemblance to the object that they represent. There can also be intratextual iconicity between words and pictures when the verbal text conveys the same message as the picture. Consequently, the most iconic types of picture are natural images, i.e. direct visual perceptions of the world, followed by scaled three-dimensional models, such as a sculpture or a waxwork. Iconic images are especially useful for the representation of non-hierarchical relations, such as *made of*, which link a construction (e.g. groyne, breakwater, etc.) to the material that it is composed of (e.g. concrete, stone, wood, etc.).

"Abstraction" refers to the cognitive effort required for the recognition and representation of the concept (Levie and Lentz 1982; Rieber 1994, 36–57). The degree of abstraction depends on how accurately graphical information represents the essence of specialized concepts insofar as its legibility and intelligibility. For example, the

understanding of conceptual relations such as *located at*, as represented in maps, is facilitated by abstraction.

"Dynamicity" implies the representation of movement and describes the procedural nature of many specialized concepts in scientific and technical domains. However, such a representation need not include explicit movement if it illustrates the sequence of discrete steps that make up the process. For instance, implicit dynamism in *parts-and-steps* images facilitates the comprehension of a dynamic whole, composed of various parts or a sequence of discrete steps. Dynamism is also conferred by the use of symbols, such as arrows (representing movement) and textual information that link the pictures to the real world.

Nevertheless, it is also true that few (if any) images are purely iconic, abstract or dynamic. In FBT, these features are combined to generate eight possible image profiles, based on the presence or absence of these criteria. This profile is an important factor in determining its adequacy for a given representational context (see Prieto and Faber 2012, 242–248 for an in-depth explanation of image profiles for context selection).

3. Conclusion

This chapter has presented an overview of FBT, a cognitive approach to Terminology that explores the notion of "frame" as a framework for the definition and representation of specialized knowledge units. The specification of specialized knowledge frames in FBT is based on a semantic micro-theory, a syntactic micro-theory and a pragmatic micro-theory.

In this regard, the semantics of specialized knowledge units in FBT is reflected in internal and external representations. From an internal perspective, it is represented in the lexical relations and meaning components in terminographic definitions, whose structure is based on Pustejovsky's (1995, 330–331) qualia roles. From an external perspective, it is reflected in an ontology or a specialized domain model shared by a set of users. The FBT ontology is based on information extracted from specialized texts and the structure of terminological definitions. The visual representation of this knowledge structure can be accessed in EcoLexicon, the practical application of FBT.

The syntactic micro-theory in FBT is event-based and takes the form of predicate-argument structures. Accordingly, each specialized domain can be represented by a general event or frame in which categories of entities are linked by predicates designating the states, processes, accomplishments, etc. in which entities can participate. The syntax of terms and their relations can be encoded in graph-based micro-grammars, which schematically depict how semantic relations are encoded in different languages (e.g. causation).

The pragmatic micro-theory in FBT addresses the situations in which specialized communication occurs and the ways that the text sender and receiver deal with them in text production and understanding. In this sense, an analysis of the pragmatic potential of specialized knowledge units, their activation in different types of specialized texts and their comprehension provides insights into category structure as well as the process of specialized communication process.

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