THE SEMANTIC RELATION OF HYPONYMY IN THE TERMINOLOGY USED IN THE DOMAIN OF BIOMEDICAL ENGINEERING

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Abstract

This paper aims at examining the relation of hyponymy in the domain of biomedical engineering, and highlighting its importance in understanding the systemic nature of terminology as well as building hierarchical systems where each concept is defined by the relationship established with other concepts and their place in the conceptual structure of a specialized domain. The analysis of the provided examples is intended to illustrate the way in which hyponymic relations are established as well as the process of property inheritance and specification on each level of the hierarchical system.

Keywords: *terminology, hyponymy, hyponym, hyperonym, hierarchy*

Résumé

Cet article vise à examiner la relation de l'hyponymie dans le domaine du génie biomédical, et à souligner son importance pour comprendre la nature systémique de la terminologie ainsi que pour construire des systèmes hiérarchiques où chaque concept est défini par la relation établie avec d'autres concepts et leur place dans le structure conceptuelle d'un domaine spécialisé. L'analyse des exemples fournis vise à illustrer la manière dont les relations hyponymiques sont établies ainsi que le processus d'héritage et de spécification des propriétés à chaque niveau du système hiérarchique.

Mots-clés: *terminologie, hyponymie, hyponyme, hyperonyme, hiérarchie*

Introduction

Knowing the concept designated by a specific term is not enough to understand how this term is used within the context of a specialized language. Another important factor that should be taken into consideration is the semantic relationship between terms. According to M. Lynne Murphy, "relation" is used to describe co-membership in a definable set as well as to distinguish the types of definitional criteria that define such a set, the term "semantic relations" indicating relations defined by semantic paradigms[1].

As any lexical-semantic system is based on relations, their study is considered extremely important for regulating and systematizing terminology, constructing the

[1]M. Lynne Murphy, *Semantic Relations and the Lexicon*, Cambridge University Press, 2003, p. 8.

hierarchy of concepts in particular fields of knowledge. There is no doubt that the investigation of semantic relations "allows to specify the theoretical understanding of the terminology systemic nature on the semantic level, and also identify patterns of systemic correlation of the expression plan and the content plan of the specific professional terminological system"[2]. One of the most representative semantic relations that would fulfil the purpose of revealing the systemic nature of terminology is hyponymy.

The Concept of Hyponymy

The term "hyponymy" was used for the first time by John Lyons, who argues that it is "the most fundamental paradigmatic semantic relation through which the vocabulary of a language is structured". He states that, although the term is not as traditional as "synonymy" or "antonymy", the notion is a traditional one, and it has long been recognized as one of the constitutive principles of vocabulary organization. The term was intended to replace the one of "inclusion" that he considered ambiguous. He argues that the difference in the point of view from which one may consider "inclusion" corresponds to the difference, in the traditional logic and in certain theories of semantics, between the extension and the intension of a term. The extension of a term is the class of entities to which the term is applicable or refers; the intension of a term is the set of attributes which characterize any entity to which the term is correctly applied[3].

Hyponymy can be defined as a semantic relation based on a hierarchical ordering principle of terms according to their semantic content – assigning a term which designates a specific, precise notion –to another term that designates a more general notion in relation to the first, but it is subsumed to the same class.

According to Angela Bidu-Vrănceanu, this type of semantic relation takes shape of a hierarchic structure of some lexical subunit where the hyperonym is the higher element within a class, whereas the hyponyms are the subordinate ones. Angela Bidu-Vrănceanu and Narcisa Forăscu point out that this relation is the basis of lexicographic and terminographic definitions and contribute to the formulation of the proximate genus and to specific differences because it is a relationship of inclusion or unilateral implication[4]. Along the same line of thinking, M. Lynne Murphy states that hyponymy is a central notion in many models of the lexicon due to its inference-invoking nature, its importance in definition, and its relevance to selectional restrictions in grammar. Inferences, particularly entailments, are strongly associated with the hyponym relation, such that a statement entails an equivalent statement that includes one of its words' hyperonyms. She adds that classical (Aristotelian) definitions also rely on hyponymy.

[2] Larysa Y. Azarova, Ludmila A. Radomska, *Hyper-Hyponymic Relations in Noun-Juxtapositions of the Ukrainian Terminology*, in "Annales Universitatis Mariae Curie-Sklodowska" Vol. XXXI, Lublin, 2013, p. 116.

[3] John Lyons, *Introduction to Theoretical Linguistics*, Cambridge University Press, 1968, p. 453-454.

[4] Simona Nicoleta Staicu, *Hierarchic Structuring Medical Terms according to the Semantic Content*, in "Studii şi cercetări de onomastică şi lexicologie" (SCOL) Anul VI, Nr. 1-2, Craiova, 2013, p. 216.

Such definitions consist of genus and differentiae, that is, a hyperonym and the qualities that distinguish the defined hyponym from the larger class[5].

The hyponymy relation has been referred to in the literature under various names, including IS-A (is-a), a kind-of, taxonymic, superordinate-subordinate, genus-species, and class-subclass relations, and it exhibits different linguistic behaviour when expressed by means of different terms. D. Alan Cruse pointed out that the expression "an X is a kind/type of Y" is more discriminating than "an X is a Y". He called the first relation taxonomy and the second relation simple hyponymy, claiming that taxonomy is not just a logical class inclusion relation – the terms used to represent the classes are important. The expression "a kind/type of" exerts selectional restrictions on the pair of terms. D. Alan Cruse has suggested the existence of a "principle of taxonomic subdivision" that selects only good categories that are internally cohesive, externally distinctive, and maximally informative[6].

Hyponymy establishes a unidirectional hierarchy – in contrast with the bidirectional one in the case of synonymy – as a hyponym can be the hyperonym of another, the next level of classification. The tree can be extended to subsequent levels in a relation of transitivity, until no distinctive features remain. In other words, the meaning of the hyponym inherits the meaning of the hyperonym and adds certain specificity.

According to John Lyons, hyponym/superordinate chains offer the possibility of choosing between more general or more specific meanings, which can be adapted to the specialized register of disciplinary discourse. Howard Jackson and Etienne ZéAmvela claim that the members of a speech community share "encyclopaedic knowledge" which will allow them to adapt to the necessary situation of specificity in disciplinary contexts[7].

Olga Acosta, César Aguilar and Gerardo Sierra state that, from a cognitive point of view, the lexical relation of hyponymy represents a process of categorization, which allows recognizing, differentiating and understating entities according to a set of specific features. Following the works of Eleanor Rosch, Edward Smith and Douglas Medin, Vyvyan Evan and Melanie Green, hyperonyms are associated to basic levels of categorizations where categories carry the most information. In other words, as Gregory L. Murphy points out, the basic level can represent a compromise between the accuracy of classification at a higher superordinate category and the predictive power of a subordinate category.

Studies on cognitive psychology reveal the prevalence of basic levels in natural language. Firstly, basic level terms tend to be monolexemic; in contrast, subordinate

[5] M. Lynne Murphy, *Semantic Relations and the Lexicon*, Cambridge University Press, 2003, p. 217.

[6] Christopher S. G. Khoo, Jin-Cheon Na, *Semantic Relations in Information Science*, in Blaise Cronin (ed.) "Annual Review of Information Science and Technology", Information Today Inc., New Jersey, 2005, p. 174-175.

[7] Concepcion Orna-Montesinos, *Hyponymy Relations in Construction Textbooks: A Corpus-Based Analysis*, in Maria-Lluisa Gea-Valor, Isabel Garcia-Izquierdo, Maria-Jose Esteve (eds.) *Linguistic and Translation Studies in Scientific Communication*, Peter Lang AG, Bern, 2010, p. 95-97.

terms have at least two lexemes, and often include basic level terms. Secondly, the basic level is the most inclusive and the least specific for delineating a mental image. Thus, if we considered a superordinate level, it is difficult to create an image of the category. Despite preponderance of the basic level, superordinate and subordinate levels also have very relevant functions. According to William Croft and D. Alan Cruse, the superordinate level emphasizes functional attributes of the category, also performing a collecting function. Meanwhile, subordinate categories achieve a function of specificity. Given the function of specificity of subordinate categories in specialized domains, they are considered important for building lexicons and taxonomies[8].

Regarding the classification of hyperonym-hyponym pairs, Juan Carlos Gil Berrozpe suggests that they can be studied from different perspectives. As in causality or meronymy, hyponymy can also be refined to provide an enhanced representation of generic-specific relations. In this line, two main proposals have been made as a means to improve the description of hyponymic relations: (i) the specification of hyponymy subtypes supported by George A. Miller and M. Lynne Murphy, and (ii) the establishment of "facets" and/or "microsenses" by D. Alan Cruse.

M. Lynne Murphy states that hyponymy can indeed be decomposed in the same way as other semantic relations, but the number of subtypes and whether they can provide a valid and comprehensive taxonomy of hyponymic relations are unclear. According to George A. Miller, the most commonly accepted distinction is between taxonomic hyponymy ('is-a-kind-of' relation) and functional hyponymy ('is-used-as-a-kind' relation). Moreover, M. Lynne Murphy argues that, whilst taxonomic relations are always analytic, functional relations are vaguer since they are not logically necessary relations.

On the other hand, D. Alan Cruse proposes "facets" as a means to distinguish between different types of hyponymy. "Facets" are dimensions or aspects of a concept that show a high degree of autonomy and distinctness, making it possible to describe that concept from any of those multiple perspectives independently. Another important phenomenon in the specification of hyponymic relations is the existence of "microsenses". A "microsense" is a specific meaning of a concept (e.g. regarding its properties, attributes or functions) which is only activated in a certain context, and which makes it differ from the meaning of the same concept in a different context[9].

The main functions of hyponyms in terminological systems of different fields of science and technology are to systematize the timing and interpretation of values. These functions are implemented in terminology by two methods: generalization, i.e. referring to the generic concept, and specification of features using aspect differences.

[8] Olga Acosta, César Aguilar, Gerardo Sierra, *Using Relational Adjectives for Extracting Hyponyms from Medical Texts*, in Antonio Lieto, Marco Cruciano (eds.) *Proceedings of the First International Workshop on Artificial Intelligence and Cognition* (AIC 2013), CEUR Workshop Proceedings, Torino, 2013, p. 33-36.

[9] Juan Carlos Gil Berrozpe, *Corpus-Based Identification of Hyponymy Subtypes and Knowledge Patterns in the Environmental Domain*, Master Thesis, University of Granada, 2017, p. 11-12.

Except the systematization function, generic-aspect signs in denoted terms by subject (and corresponding concept) are required to get a good definition of a term[10].

Corpus Analysis

For the illustration of the semantic relation of hyponymy in the domain of biomedical engineering, the examples and their definitions were manually extracted from "Medical Sciences Vol. II Encyclopedia of Life Support Systems" edited by B.P. Mansourian, A. Wojtczac and B. McA. Sayers and "Biomaterials: Principles and Applications" by Joon B. Park and Joseph D. Bronzino. The books are divided into sections tackling different aspects and topics within the domain, facilitating the process of establishing a hyponymy relationship among terms and building hierarchical systems. The relation of hyponymy was based on the analysis of genus (hyperonym or superordinate) – differentia (characteristics that vary between cohyponyms) definitions according to the criterion of property inheritance – the inheritance of characteristics between hyperonyms and hyponyms, as used by Juan Carlos Gil Berrozpe and Pamela Faber in their work concerning hyponymy[11].

Ceramic biomaterials

Bioinert ceramics – ***ceramic biomaterials*** that maintain their physical and mechanical properties while in the host, typically used as structural support implants.

- Pyrolytic carbon – a turbostatic carbon ***bioinert ceramic*** formed by heating a hydrocarbon to near its decomposition temperature in the absence of oxygen. Pyrolytic carbon coatings, which are usually alloyed with silicon to lend the material improved stiffness, hardness, and wear resistance, are used extensively as a coating for mechanical heart valves.
- Alumina or aluminium oxide – the most commonly used and most widely studied of the ***bioinert ceramics*** having such advantages as biocompatibility, good mechanical properties and wear properties, historically used as the femoral head of total hip prostheses.
- Zirconia ceramics – another type of ***bioinert ceramics*** commonly used as a medical implant with a strength two to three times higher than that of aluminia[12].

Biodegradable ceramics - ***ceramic biomaterials*** that are designed to degrade over time in the body while being replaced by the growth of native tissue.

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[10]Larysa Y. Azarova, Ludmila A. Radomska, *Hyper-Hyponymic Relations in Noun-Juxtapositions of the Ukrainian Terminology*, in "Annales Universitatis Mariae Curie-Sklodowska" Vol. XXXI, Lublin, 2013, p. 116.

[11] Juan Carlos Gil Berrozpe, Pamela Faber, *Refining Hyponymy in a Terminological Knowledge Base*, in *Proceedings of the 2nd Joint Workshop on Language and Ontology (LangOnto2) & Terminology and Knowledge Structures (TermiKS) at the 10th edition of the Language Resources and Evaluation Conference (LREC 2016)*, Portorož, 2016, p. 11.

[12] Eileen Gentleman, Michael D. Ball, Molly M. Stevens, *Biomaterials*, in Boutros-Pierre Mansourian, Andrzej Wojtczac, Bruce McA. Sayers (eds.) *Medical Sciences* Vol. II *Encyclopedia of Life Support Systems*, EOLSS Publications, Oxford, 2009, p. 49-51.

- Calcium Phosphate – ***biodegradable ceramic*** material that has been used in the form of artificial bone, synthesized and used for manufacturing various forms of implants, as well as for solid or porous coatings on other implants.
- Aluminium-Calcium-Phosphorous Ceramics – ***biodegradable ceramic*** material prepared from stock powders of aluminium oxide, calcium oxide, and phosphorous pentoxide, unique because they provide a multipurpose crystallographic system where one phase of the ceramic on implantation can be more rapidly absorbed than the others.
- Corals – ***biodegradable ceramic*** material naturally produced by marine invertebrates. Used as bone implants, they provide an excellent structure for the ingrowth of bone, and the main component, calcium carbonate, is gradually resorbed by the body
- Tricalcium Phosphate Ceramics – a multicrystalline porous form of β-tricalcium phosphate, a ***biodegradable ceramic*** material that has been used successfully to correct periodontal defects and augment bony contours.
- Zinc-Calcium-Phosphorous Oxide Ceramics – a ***biodegradable ceramic*** material prepared by a thermal mixing of zinc oxide, calcium oxide, and phosphorous pentoxide powders, synthesized to repair bone defects and deliver drugs.
- Zinc-Sulfate-Calcium-Phosphorous Ceramics – a ***biodegradable ceramic*** material prepared from stock powders of zinc sulfate, zinc oxide, calcium oxide, and phosphorous pentoxide. On implantation in bones, the particles set and harden on contact with blood and have been used to repair experimentally induced defects in bones.
- Ferric-Calcium-Phosphorous-Oxide Ceramics –a ***biodegradable ceramic*** material prepared from powders of ferric (III) oxide, calcium oxide, and phosphorous pentoxide, particularly used in patients suffering from anemia and similar diseases.

Bioactive ceramics - ***ceramic biomaterials*** that form a strong bond with adjacent tissue, used a lot in the coating of metal prostheses[13].

The examples provided above build the hierarchical system in the subdomain of biomaterials taking the term of *ceramic biomaterials* as hyperonym and establishing the relations of hyponymy on each subsequent level by adding differentiating properties to the subordinate terms to make their meaning more specific. In fact, the presented hierarchy can be extended in the sense that the term *ceramic biomaterials* is actually a hyponym to the term *biomaterials*, but because of the restraining length of the present paper, it was considered reasonable to exhibit only a branch of the actual hierarchy enough to exemplify the way in which the semantic relation of hyponymy works.

[13] W.G. Billotte, *Ceramic Biomaterials*, in Joon B. Park and Joseph D. Bronzino (eds.) *Biomaterials: Principles and Applications*, CRC Press, Boca Raton, 2002, p. 27-35.

Because of the nature of the source material from which the examples were extracted that is already divided according to the aspect it discusses, not in all definitions the genus or hyperonym was explicitly stated, the organization of the information inherently implying the presence of a classification. Therefore, it was deemed appropriate to add the genus in the definitions that lacked the hyperonym in order to better illustrate the property inheritance between the hyperonym and the hyponym.

Analyzing the conceptual criteria that represent the foundation of establishing hyponymic relations between the terms, we can see that the first level of subordinate terms to the hyperonym *ceramic biomaterials* was chosen on the basis of the physical and mechanical properties and the way in which the ceramic biomaterials behave on the insertion into the human body; hence, we have *bioinert ceramics* that maintain their initial properties, *biodegradable ceramics* designed to degrade in the body and *bioactive ceramics* that form a strong bond with adjacent tissue. Lexically all three hyponyms represent compounds formed from the noun *ceramics* inherited from the superordinate term through the process of conversion of the adjective *ceramic*, and an adjective that expresses the property of each type of ceramic biomaterial. The term *biomaterials* was not transferred from the hyperonym although the prefix *–bio* is still present to reveal the connection of the meaning with the realm of living organisms.

The next level of hierarchy was built on the premises of the chemical composition of each type of *bioinert ceramics* and *biodegradable ceramics*. For the term *bioactive ceramics* no hyponyms were found that would meet the criterion of differentiation of chemical composition; therefore, no subordinate terms were included on the last level. From the lexical point of view, the conceptual criterion of differentiation is expressed through the presence of terms from the domain of chemistry that, for the most part, form the compounds with the term *ceramics* inherited from the hyperonym. That fact proves that biomedical engineering as a domain has an interdisciplinary character combining not only concepts from biology, medicine and engineering, but also from the domain of chemistry.

Conclusions

Using examples from the domain of biomedical engineering, we managed to construct the hierarchy of terms related to ceramic biomaterials, specifying the criteria of establishing hyponymic relations between terms and differentiating properties for each level of the hierarchy, proving the each term holds a certain position within the system and is connected to the hyperonym by inheriting certain properties adding to those other properties that make it more specific. The semantic relation of hyponymy plays a crucial role in the understanding of the systemic nature of terminology by building a hierarchy where each term is defined by its links with superordinate or subordinate terms; therefore, positioning each concept within the wider structure of knowledge from a particular specialized domain.

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