ISKO. CAPÍTULO ESPAÑOL. CONGRESO (7º: 2005: BARCELONA) 296-308

The reference system of relational semantics in knowledge organization systems

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Abstract
The paper describes the relational semantics of knowledge organization system (KOS) and their dependence on a reference system –epistemological position and conception of language and semantics. It starts with characterization of the role and functions of relational semantics in information retrieval systems, with description of types of relational semantics and their understanding in different knowledge fields. Relational semantics is analysed by approach to language: formal and functional, in connection with semantic theories and epistemological positions: empiricism, rationalism, historicism, pragmatism.

Keywords
relational semantics, reference systems, knowledge organization systems, human perception, cognition, language, pragmatism, rationalism, empirism, historicism, functions of the catalogue

1 Introduction

An understanding of semantics is important for construction of KOS of information retrieval systems (IRS), for document representation and for information searching and retrieval. According to E. Svenonius (Svenonius 2001), there are several types of semantics essential in KOS: referential semantics, category semantics and relational semantics. The relationships of hierarchy, synonymy and near-relatedeness expressed by KOS are the most used *relational semantics* in KOS. Relational semantics have several functions. For users it helps to form a query that lets information needs be expressed in the best way by providing terms, which can be used for the selection of the most appropriate term. Visualisation of these relationships is also an important research question to improve information searching by users. The other functions of relational semantics are connected with information processing (both manual [intellectual] and automatic indexing) and information retrieval that is close to the understanding of the text.

Experience has shown that there are diverse ways to express relational semantics for the same terms in KOS. For example (Figure 1), in different directories and subject guides in the Internet the term «libraries» can be found under the following categories (or broader terms): *References* (*Google* <www.google.com>, *Altavista* <www.altavista.com>, *Yahoo* <www.yahoo.com>), *Science and Education* (Delfi <www.delfi.lv>, Tvnet <www.tvnet.lv>), *Education* (Librarian's Index to the Internet <http://lii.org/>, *Generalities* (Bubl <www.bubl.ac.uk>), *Information and libraries* (WWW virtual library <http://vlib.org/>); *Social Sciences: Library and Information science* (The Webliography: Internet Subject Guides from LSU Libraries <http://www.lib.lsu.edu/weblio.html>), *Computers, information & general reference: Library & information science* (Renardus <www.renardus.org>) etc.

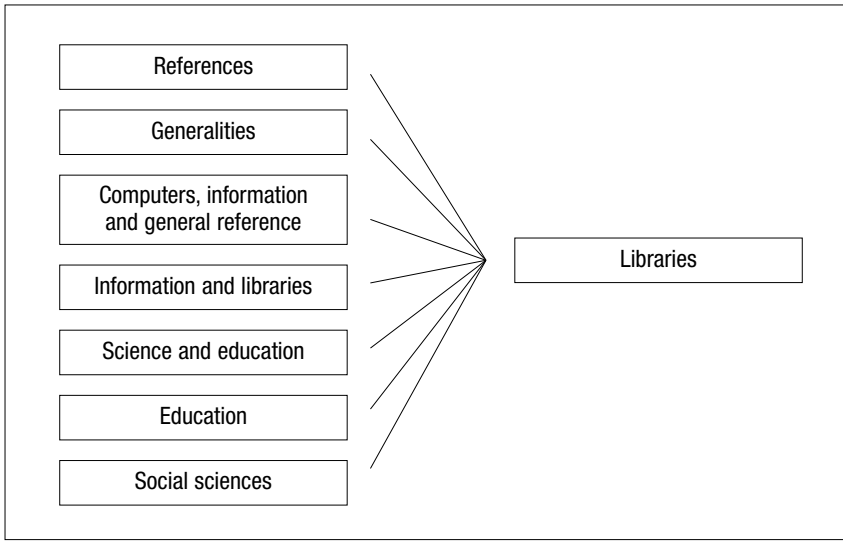

FIGURE 1. Broader terms for the term «Libraries» in different directories and subject guides in the Internet

Broader terms (or main categories) in many cases are similar in their content, but they are not the same. This can be explained by the ambiguity of natural language, but it can also be explained by theories, which are used for categorization (theory-based view of categorization). According to B. Hjørland, semantics and all semantic types depend on a reference system: approach or theory of semantics, and ontological and epistemological position. «All techniques and theories build on some metatheoretical and epistemological assumptions and implicit theories, with which researchers look at computers, texts, questions and interactions» (HJØRLAND 1998).

Therefore, the objectives of this paper are:

1. to characterize the role and functions of relational semantics of KOS and to show the differences of the amount and type of relational semantics in different KOS (classification systems, subject heading lists, taxonomies, thesaurus, topic maps ontologies);
2. to explain the differences in relational semantics by the use of theories about language, semantics and epistemologies;
3. to make conclusions based on the conception of meaning by different semantic theories and by approach to language.

Methodology, based on the approaches to the conception of language (formal and functional approach), semantic theories (logical formalism, linguistic formalism, etc.) and their epistemological positions (rationalism, empiricism, historicism, pragmatism) will be explained by the differences in the identification and definition of relational semantics.

2 Relational semantics in KO and KOS

2.1 Role and functions of relational semantics in KO and KOS

What is relational semantics? There are two kinds of relational semantics: relations between words and their meanings in sentences (syntagmatic relations which are defined as the relation a linguistic unit bears to other units with which it co-occurs in a sequence or context) (Soo-Guan Khoo 1997) and relations between words and their meanings from one semantic field (paradigmatic relations) indicating a similarity in their meanings and possibility to substitute one unit (word) for the other according to different linguistic environments. This paper is concerned with exploration of the last type of relational semantics –paradigmatic relations between linguistic units. The main types of relational semantics controlled by KOS are hierarchy, synonymy and near-relatedeness. Hierarchy is the relationship between terms with broader and narrower and whole-part meanings. Synonymy or equivalence is the relationship between terms with the same or very similar meanings. Near-relatedeness or related-term relationships are defined very vaguely –they include all relations between words (terms) with the exception of synonymy and hierarchy.

The necessity for control of relational semantics can be explained by the main functions of calatalogues defined by C.Cutter and also applicable as requirements for every information retrieval system. Cutter indicated that a catalogue should be able to enable a person to *find* a book, *to show* what a library has and *to help* to choose or to select the book (Taylor 1999).

— *To find a document.* In many cases this means the use of keywords or subjects as retrieval criteria. It is very useful to provide tools for recall, which select all the relevant items described by different words

but meaning the same things (synonymy case). Sometimes it is necessary to refine search results by using more specific or broader terms.

— *To show what documents there are for a definite topic.* This function depends also on information processing –indexing or representation of documents. The control of relational semantics is necessary for an indexer to help in choosing the most appropriate class, subjects or keywords to characterize the meaning of the document and to provide complete recall in case of synonymy. Relational semantics can be used to arrange the retrieval results so that the picture of related documents could help to choose the best one.

— *To help to choose.* Finding depends on the possibility to select the appropriate keywords for a query expression. Synonymy, hierarchy and related-terms relationships can help to formulate a query or to expand a query, particularly in cases when the topic is unfamiliar and vague. Therefore, browsing of the «map of concepts» or the «net of related terms» for users or for information retrieval systems that «try to understand the text: query and document surrogate» have a very important role in improvement of precision and recall.

2.2 Facilities of relational semantics provision

Generally it is possible to provide the control of relational semantics both by manual (intellectual) and automated methods in information retrieval systems. Manual methods are mainly based on human effort, automated – on natural language processing technologies (morphological, lexical, syntactic, semantic analysis of texts). In both cases there are tools that provide the control of relational semantics called knowledge organization systems (KOS) or knowledge representation systems. These systems differ by a multiplicity of relational semantics as well as by the possibility to provide and control it automatically. The most common scale of KOS based on the previous factors is the following: list of words, gazetteers, classification systems, taxonomies, thesaurus, topic maps and ontologies (Figure 2).

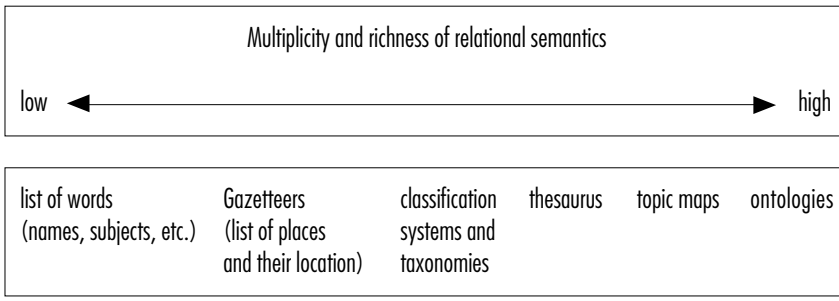

FIGURE 2. Scale of knowledge organization systems by richness of relational semantics

Lists of words and gazetteers are vocabularies usually with control mainly for synonymy (equivalence). Classification systems and taxonomies are characterized as controlled vocabularies mainly with hierarchical relationships (genus-species, whole-part), but often control of other kind of relationships is provided as well. Compared with previous KOS, the task of the thesaurus is to control synonymy, hierarchical relationships and associative relationships or term-relatedness. Topic maps and ontologies are characterized as networks, which, in contrast to tree structure KOS, are extremely flexible and multidimensional. M. A. Riesland admits (RIESLAND 2004) that «topic map associations expand the concept of associative relationships». Topic maps can model not only nouns and noun phrases but also attitudes, emotions, features etc., i.e., they can model real world situations and organize them into topics. The multiplicity and richness of relational semantics of KOS is an important factor also for providing «smart» information retrieval systems, which can «understand» texts and user queries. Soergel etc. indicates that relationships should be more differentiated particularly in ontologies where inferences on the given data are made by software. Therefore, for example, in reengineering a thesaurus to an ontology it is necessary to state not only that terms are in broad or narrow relation, but that one is <*memberOf*> another or <*includesSpecific*> or <*hasComponent*> etc. (SOERGEL 2004).

3 UNDERSTANDING OF RELATIONAL SEMANTICS IN DIFFERENT KNOWLEDGE FIELDS

The need to control relational semantics in KO and KOS, and its role in information retrieval seem to be self-evident. How to provide it qualitatively? Why are there so many different relational semantics for the same words? What are the main criteria for determination of relational semantics? An understanding of relational semantics is necessary to answer these questions.

It is possible to analyse relational semantics from several knowledge fields: linguistics, semiotics, cognitive psychology, language philosophy, etc. The most common way for analyse relational semantics is from linguistics. As mentioned before, relational semantics are named as paradigmatic lexical relations in linguistics. These relations are defined as a culturally determined pattern of association between lexical units that share one or more core semantic components, belong to the same lexical category, fill the same syntactic position in a syntactic construction and have the same semantic function (WHAT 2004).

Similarly to the description above, linguistics eliminates the following paradigmatic lexical relations: synonymy with underlying structure –simple set; generic-specific (hyponymy) relation with underlying structure – tree; scalar property with underlying structure – scale; opposite relations with underlying structure – set of pairs.

Relational semantics as paradigmatic relations are defined also in semiotics. D.Chandler points out that paradigmatic analysis of the text (or sign system) is always connected with seeking what identifies the

various paradigms (or pre-existing sets of signifiers) that underlie the manifest content of texts (or what is absent and why) (CHANDLER 2003). This idea corresponds to the ideas of hermeneutics about the hermeneutical cycle and with the idea about epistemological and ontological positions behind the text, which was introduced in information science by B. Hjørland.

From the view of cognitive psychology and artificial intelligence research, relational semantics corresponds to the models of semantic memory. The main elements of these models are nodes (terms, words or lexical units signifying concepts or objects, processes and situations of reality) and relations (links) between nodes. The models are different, but they can be divided into two broad categories: semantic network models and neural networks models. The main difference between them lies on the focus of the organization of the model and the place of conceptual knowledge. «Unlike semantic network models, which postulate that each node in the network is a concept, neural network models argue that concepts are not stored at any particular node per se, but rather that conceptual knowledge is distributed around all the nodes in the system» (BEST 1992).

Relational semantics is closely related to understanding of meaning or with relations between words, reality and mind. What is a meaning of a word or a text? Does it reflect reality directly or does it show a definite view of world?

3.1 Relational semantics from the approaches of language, semantic theories and epistemological positions

There are two broad classes of semantic theories based by the role of the human in the explanation of meaning. The first part is theories, which analyse meaning as independent from human and reflecting reality directly –words mean by standing for things. As a result – formal, mathematical models were developed to characterize meaning (for example, Possible worlds semantics [S. KRIPKE, R. CARNAP], Situation semantic; B. RUSSEL, G. FREGE, R. MONTAGUE). The second part is theories, which explain meaning as human phenomena. Theories of this part look for a place, where there is a basis for meaning: in human thought (J. LOCKE), in individual speech (D. DAVIDSON, M.A. DUMMET) in result of communication (H. GRICE), in social practices (L. WITGENSTEIN, H. PUTNAM).

The other factor, which characterizes meaning, is connected with the nature of cognition and explains the relations between subject (individual) and object of cognition. There are two broad approaches: monism and pluralism. If we look from the point of view of monism, then the main idea is that subject as a neutral and decontextualised individual reflects reality (like a mirror). Meaning is something that exists objectively, for example, in nature. Looking from the point of view of pluralism, the subject is contextualised (KARPATSCHOF 2000) in society, culture and language, therefore cognition, and as a consequence meaning is a construction of reality and connected with the individual and «theories», which govern the perception of reality.

Based on the understanding of meaning it is possible to show two approaches to language: the formal and the functional approach. The formal approach sees language as an independent sign system (for example, structuralism) with definite components and levels that reflect reality. The functional approach looks at language as a psychological tool, which humans use to reach definite aims arising in activities.

The formal approach to language and appropriate semantic theories correspond to empiricism, rationalism and positivism. The functional approach to language and appropriate semantic theories correspond to pragmatism and historicism, which belong to the humanistic approach and recognize the role of interpretations in cognition and perception of information.

3.1.1 The formal approach to language as a reference system for relational semantics

The basic assumptions of the formal approach to language are the following: 1) the aim of cognition is to find the natural order of the things of reality; 2) methods of getting knowledge are independent of theories and views of the researcher; 3) language reflects reality and objective knowledge about it directly. There are two main epistemological positions which correspond to this approach: empiricism and rationalism, and later – positivism.

— *Empiricism*. According to W.P. Alston (Alston 1998), empiricism stresses the fundamental role of experience. As a doctrine in epistemology it holds that all knowledge is ultimately based on experience and observation. Thus, all knowledge should be verifiable. Empiricism underlines the role of sense organs in cognition. Whatever cannot be verified lacks certainty. The basic method used for obtaining knowledge is induction, i.e., gathering of facts and data on the basis of which generalizations can be drawn.

There are several theories of semantics, which are based on this epistemological position. They hold that the meaning of words, or of our concepts, derives from experience. B. Hjørland mentions in his paper (Hjørland 2005) that R. Carnap's doctrine that the terms and sentences express assertions about the world, which are «reducible» in a clearly specifiable sense to terms and sentences describing the immediate data of experience is one of examples of this position. Empiricism is based on a «bottom-up» strategy in the processing of information: empiricists are searching for simple observations, which any observer can agree on. In philosophy of language and semantics, it corresponds to extensionalism. The classical concept of extension stands for the extent of a certain word or expression. Montague's referential extensionalism and Davidson's verification theory comply most with this approach. Such understanding of meaning implies that meaning is grounded in something outside human users.

Based on this approach, relational semantics can be identified by observations; they are objective and do not depend on the human. Thus, it is possible to use quantitative methods for identification of these relationships by studying texts and word co-occurrence in texts (for example, statistical clustering based on language patterns in the document collection).

— *Rationalism.* Rationalism is the view that rational intuitions are the most important way of acquiring knowledge. The most important knowledge is given a priory. Hjørland writes (HJØRLAND 2005) that the favoured method by rationalism is to reduce any problem to what cannot be questioned: to evident statements. Rationalism tends to use a «top-down» analysis in the processing of information, to look at data from some pre-established categories.

Semantic theories, which correspond to rationalism, believe that signs and meanings are only abstractions established for man to make easier the solving of a definite type of task. Logical formalism stands out as a noteworthy theory. According to logical formalism «we rely on our artificially created mathematical symbols. This position reduces semiotics to a discipline solely constituted by syntax, that is, the rules for producing the signs» (KARPATSCHOF 2000). Wegner argues that «the dream of reducing the world to a pure, clean and objective mathematical model has been shown to be an illusion». Recently Wegner has published proof that interactive computing is an inherently more powerful computational paradigm than purely algorithmic computing (CHALMERS 1999).

Relational semantics based on the rationalism view states that paradigmatic relations exist objectively and externally from the texts. Relational semantics are a result of cognition based on deduction –it is possible to use pre-established categories to inference the relationships, which are absolute and universal. The main task is to find out these objective relationships and to use them in automatic classification or indexing (for example, WordNet). The given approach is rooted also in the classical understanding of categorization, holding that a class, a category embraces elements (documents) with a definite number of inherent features.

3.1.2 The functional approach to language as a reference system for relational semantics

Due to changes in the conception of cognition and the role of the human in cognition and perception of the world, there were changes also in conception of language and its role in communication. The basic assumptions of the functional approach to language are the following: 1) the human is a contextualised person in culture, history and society; 2) cognition is shaped by theories, views, concepts and language, therefore knowledge is relative, and the human is active in the construction of rea-

lity; 3) language, like other tools, is used to reach the definite aim and it reflects a definite view.

There are research projects in several fields which justify the relativity of knowledge and characterize human cognition. Among them are:

1. *Theories in psychology about categorising and perception*. There are many theories about categorisation, but the theory-based view is one of the most influential nowadays. «It focuses on the relationship between concepts and our knowledge of, and theories about, the world.» (Murphy, Medin, Wattenmaker, Lakoff.) The main idea is that properties of objects are not independent and thus not independently assessed in categorization, but are embedded within networks of inter-property relationships, which organize and link them. Our prior theories (stereotypes, informal observations of past experiences) influence what features we perceive in the first place (KNOWLEDGE 1997).

   In J. Gibson's ecological theory of perception the stress is placed on the complementarity of perceiver and environment. The values and meanings of things in the environment arise from the perception of what those things provide or offer as potential actions or uses to the perceiver –in Gibson's terms, their affordances– and not by universally naming and categorising absolute or objective properties (BEST 1992).

2. *Hermeneutics.* In Gadamer's hermeneutics, the meaning of a representation or symbol is open to interpretation. It is not absolute, defined independently of other things and symbols. According to Gadamer, interpretation is most usefully seen as an interaction between the activity, context and preunderstanding (the «horizon») of the reader, and the content, context and background of the information, i.e., the horizon provided by the text. A new word or experience is understood in relation to, and within, language and history.

   Similar opinion can be traced in the texts of feminists, philosophy of science, and social semiotics, and in the theories on the analysis of discourse and other sign systems (including art history).

   Historicism and pragmatism are the most important epistemologies complying with the functional approach to language.

— *Historicism*

   Historicism is an insistence on the historicity of all knowledge and cognition (THORNHILL 1998). As Thornhill shows by citing Heussi and Iggers, historicist thought derives from a critique of the Enlightenment: humanity has no nature, only history; experience and cognition are conditioned solely by history; laws determining human life are not naturally prescribed, but are products of specific historical contexts. The truth-content of cognition is dependent not on categorical logic but upon its situatedness in, and constant attentiveness to, history.

From the semantic point of view the best representative of historicism are the ideas of V. fon Humboldt. He connects language with culture and nation. «Man mainly lives together with objects in a way how language shows them. Language creates interworld, e.g., meaning system, which intermediates man and reality.» Similar ideas can be found in hermeneutics (M. Heideger).

Based on the assumptions of historicism, relational semantics depends on the historical development of a field of knowledge and society overall. To construct KOS means to study how these relationships developed in the history of humankind.

— *Pragmatism*

Pragmatism is a philosophical tradition according to which any knowledge should be evaluated as to its usefulness and applicability so as «to enable us to act more effectively» (Rorty 1998). There is no one world vision, therefore, there is no absolute knowledge; it is relative because man's cognition capacity is influenced by different factors.

This approach lays «the emphasis on society or linguistic community as the producing agent of meaning». Sowa states, «Although the lexicon is an important repository of semantic information, it doesn't contain all the information needed to understand language. Context and background knowledge are also important, since most sentences cannot be understood in isolation» (Sowa 2000). Sowa points out that L. Wittgenstein emphasized that language is not a single unified game, but a collection of as many different games for which one can imagine possible uses (Sowa 2000). Each domain has its own language game, but they all share a common vocabulary and syntax. The meaning of words changes drastically from one domain to the next. As a result, the mapping from words to reality is indirect (Sowa 2000). Thus, in the understanding of language meaning, the stress is laid upon language application in a certain field of activity, where language serves as a psychological tool to promote interaction between subject and object.

Karpatschof defines meaning as the functional value of a sign that makes specific reference possible (Karpatschof 2000). He states that «meaning is an aspect of human activity and the meaning structure is a part of the culture of society. Thus the context of any piece of information carrying meaning is ultimately human activity for which it is a mediator or the cultural system of which it is a part» (Karpatschof 2000).

Based on assumptions of pragmatism as a reference system it could be concluded that relational semantics are relative and definable by analysing discourses –not only texts (as in empiricism), but also the language use in discourses.

4 Conclusions

Based on findings about language, cognition and the role of the human in knowledge discovery, conclusions are the following.

1. There are many tools or KOS which technologies are based on assumptions of empiricism and rationalism. It should be admitted that these tools provide information retrieval at the level of formal or semantic relevance, but they don't provide it at a pertinence level, because relational semantics are considered as independent from the human user. The best solution for these kinds of technologies is to combine them with methods of the functional approach.

2. The functional approach to language shows that relational semantics (paradigmatic relations between words) are relative and it depends on the use of language in different activities and in different «theories».

   For example, considering the differences of the term «libraries» with broader terms (hierarchical relationships) in subject guides and directories of the internet mentioned at the beginning of this paper, the following explanation can be proposed: in the framework of academic studies, the place of the term «libraries» in the subject guide could be understood as a member of the class Social Sciences or Information Science, perceiving the concept «library» as one of the objects of studies by students in the universities and showing all sciences (Internet Subject Guides from LSU Libraries), and focusing on the information use in studies as a human activity. In the context of general information users and their different information needs, libraries could be understood as a place where it is possible to get information, etc. Therefore, the term «libraries» is located in the class (category) References or Generalities or Education and Science (Altavista, Google, Yahoo, etc.) in such a way focusing on the satisfaction of information needs forming in different domains of human activities. So the differences in relational semantics («broader – narrower terms») can be explained by the following factors: activity of information users; the potential information needs of the users formed in activities; the role of the concept in the user's reference system («theory» for perception).

3. As a result, it is not possible to construct a universal KOS for a global information space. To provide tools for multilingual retrieval in this global information space, it will be necessary to work out intermediate languages for mapping different KOS constructed by exploring local discourses and reflecting their relational semantics.

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