Reviews of Concepts in Knowledge Organization

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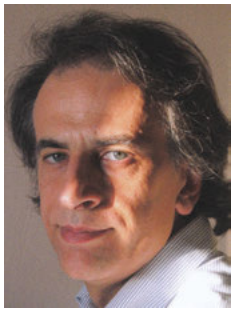
Knowledge Organization System (KOS): An Introductory Critical Account†

Fulvio Mazzocchi

CNR—Institute for the Conservation and Valorization of Cultural Heritage,
Via Salaria km 29,300, I-00015 Monterotondo (RM), Italy,
<fulvio.mazzocchi@cnr.it>



Fulvio Mazzocchi, biologist and philosopher, is a researcher at the CNR—Institute for the Conservation and Valorization of Cultural Heritage (Italy). His research activity is focused on epistemology (e.g., realism vs. constructivism; epistemology of complexity), philosophical issues of scientific research (e.g., the reductionism-holism debate in biology; climate model validation and robustness), and knowledge organization. He has participated in many projects concerning the development of thesauri, such as the General European Multilingual Environmental Thesaurus (GEMET) of the European Environmental Agency.

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Abstract: This contribution discusses the notion of knowledge organization system (KOS), introducing both its broad and narrow meanings. It focuses more in-depth on KOSs as semantic tools, by critically analyzing a number of KOS typologies that have been proposed so far. Theoretical and practical issues are investigated too, focusing on the importance of epistemology and theory of concepts for KOS development. Besides, some remarks are made on how new trends in information organization (e.g., towards an increase of formalization and the employment of data-driven means) could affect the design of future KOSs, pondering whether "interpretation" and context-based evaluations still have a role to play in such an undertaking. A theoretical coda is finally provided, which scrutinizes the notion of "classificatory perspectivism," and whether pluralism in KO research could take a (pragmatically based) integrative fashion.

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1.0 Introduction

Knowledge organization system (KOS)[1] is a generic term used for referring to a wide range of items (e.g., subject headings, thesauri, classification schemes and ontologies), which have been conceived with respect to different purposes, in distinct historical moments. They are characterized by different specific structures and functions, varied ways of relating to technology, and used in a plurality of contexts by diverse communities. However, what they all have in common is that they have been designed to support the organization of knowledge and information in order to make management and retrieval easier. In order to make it accessible and usable (by human or technological agents), knowledge, in fact, has to be organized in some way (Soergel 2009a), something that, given the amount of scientific and cultural production, has become increasingly important throughout the years.

The study and practice of how to organize knowledge contributed to the rise of "knowledge organization" (KO)

(http://www.isko.org/cyclo/knowledge_organization) as a distinct (academic and research) field, today mostly considered as a subarea of (or as linked to) library and information science (LIS). Important contributions for the development of such a field come, at the beginning of the twentieth century, from Cutter (1837–1903), Richardson (1860–1939), Sayers (1881–1960) and, of course, Bliss (1870–1955), who used the term KO in two seminal books, *The Organization of Knowledge and the System of the Sciences* (1929), and *The Organization of Knowledge in Libraries and the Subject-Approach to Books* (1933).

The notion of "knowledge organization" was reprised by Dahlberg in the 1970s: the German term *Wissensordnung* (knowledge ordering) was employed for referring to the conceptual and systematic organization of human knowledge (Dahlberg 1974). In English this term was then translated into "knowledge organization," which has been adopted internationally.

In the view of many KO scholars, such as Broughton et al. (2005) and Hjørland (2008), there are two main items that characterize KO: 1) knowledge organization processes (KOPs), such as abstracting, indexing, cataloging, subject analysis, classifying; and, 2) knowledge organization systems (KOSs), i.e., tools designed for the general purposes described above, which will be analyzed here.

An important issue to be underscored is that, while their basic scope has remained unvaried over time, the environment in which KOSs have to operate has instead drastically changed, and it will continue to change: from the world of physical libraries, for whose purpose grand classification schemes were created, to databases, the digital environment, and the internet. Such a circumstance has solicited a reassessment of KOSs as tools: are they able to address new information needs? And, is a reconsideration of the theoretical and methodological bases on which they are developed necessary?

2.0 What is Meant by KOS?

According to Hjørland (2008), two different aspects, or meanings, of KOS (as well as of KO) should be distinguished: a broad one and a narrower one. The broader understanding, which is discussed in section 3, considers that organization pervades all spheres of society and all cultures (Hjørland 2008, 2016c), and that there is a strict, unavoidable relationship between knowledge in all its forms (including the operational one) and organization, and between both of them and the life of a society. Any type of knowledge, culture, or their representations, should follow some principles of order and so has to do any society in order to exist.

However, the term KOS is mostly used to refer to functional items designed for organizing knowledge and information and making their management and retrieval easier. This corresponds to the narrower meaning, which is also the standard interpretation in a LIS environment. Since they are basically made of terms/concepts and, many of them, semantic relations, KOSs are also depicted as semantic tools (e.g., Hjørland 2007). This account of KOS will be discussed in section 4.

3.0 The Broad Meaning of KOS: An Introductory Analysis

According to the broad reading, the notion of KOS refers, for instance, to encyclopedias, libraries, bibliographic databases, and, even in a more general sense, to conceptual systems, theories, disciplines, cultures, as well as to the social division of labor in society and models of activity and process systems in different domains. In Hjørland's view (2016c), it is important to explore the relationship between the two senses of KOS, because the development of KOSs as tools depends on KOSs as established bodies of knowledge (i.e., disciplinary knowledge).

Hjørland's argument should be understood as part of his more general conception of KO with respect to which he also distinguishes two corresponding meanings:

> In the narrow meaning Knowledge Organization (KO) is about activities such as document description, indexing and classification performed in libraries, bibliographical databases, archives and other kinds of "memory institutions" by librarians, archivists, information specialists, subject specialists, as well as by computer algorithms and laymen … Library and Information **S**cience (LIS) is the central discipline of KO in this narrow sense.
>
> In the broader meaning KO is about the social division of mental labor, i.e. the organization of universities and other institutions for research and higher education, the structure of disciplines and professions, the social organization of media, the production and dissemination of "knowledge" etc. … We may distinguish between the social organization of knowledge on one hand, and on the other hand the intellectual or cognitive organization of knowledge. The broad sense is thus both about how knowledge is socially organized and how reality is organized. The uncovering of structures of reality is done by the single sciences, e.g. chemistry, biology, geography and linguistics. Well known examples are the periodic system in chemistry and biological taxonomy
>
> While *Library and Information Science* (LIS) is the central discipline concerned with KO in the narrow

> sense of the word, other disciplines such as the sociology of knowledge, the single sciences and metaphysics are central disciplines concerned with KO in the broader sense of the word (Hjørland 2008, 86–7).

In his account of the broad meaning of KO, Hjørland (2016c) follows Whitley's (1984) distinction between 1)how knowledge is organized in society (for example, in academic disciplines and in the social division of labor); and, 2)how conceptual knowledge is organized in principles or theories (including, for example, philosophical theories and scientific taxonomies), recognizing, however, that there are reciprocal interactions between these two aspects.

An inquiry about the social aspect, which is covered by disciplines such as sociology of knowledge and social history of knowledge, has been carried, for example, by Edgar Morin, the promulgator of complex thinking, who calls for a substantial reformation of the principles for organizing knowledge. His paradigm of complexity challenges the fragmentary and reductionist stance that dominates, for example, science. One of the key notions of this paradigm is *unitas multiplex*, i.e., the possibility to preserve a distinction among what is connected and to connect without reduction (Morin 1990).

Applying this idea to the organization of knowledge (both in the social and intellectual sense) means to recognize that if any (e.g., scientific) discipline or field is seen as a "closed system," this leads to the fragmentation of knowledge. The development of knowledge should, instead, aim at both preserving diversity—each discipline or field has its own specific features—and ensuring the integration of the different parts into one common framework.

In his works, Morin (1986) also deals with the intellectual organization of knowledge.

He explains how any system of ideas, e.g., a theory, is made of a constellation of concepts arranged in some cohesive way, according to some (e.g., logical) principles and rules of organization. It is also made of parts with different "stability," where a restricted set of foundational assumptions and guiding ideas works as a hardcore, determining the criteria by which everything else is evaluated or justified but not being itself founded or subject to any evaluation or justification. At the same time, each theory or belief system functions as a situated "horizon," something that makes a selection, being capable of shedding light on given aspects of reality, with the exclusion of something else.

There is, of course, a historical development of knowledge, which brings about a process of continuous organization and re-organization of knowledge. With regard to scientific knowledge, Kuhn (1962) described this process as a succession of periods of paradigmatic (or normal) science and periods of revolutions. In his later production, with the theory of kinds and the notion of lexical taxonomy, Kuhn (2000) draws the picture of scientific revolutions in terms of taxonomic changes. Kind terms are, in fact, defined within an integrated conceptual structure, where many concepts are semantically interconnected. Owing to these interconnections, a lexical taxonomy is formed. When a scientific revolution occurs a new lexical taxonomy is generated, due to meaning changes of kind terms and the fact that some of them correspond to new referents (which overlap with those denoted by the old kind terms). Hence, two rival scientific paradigms are associated with different lexical taxonomies and, as a matter of fact, they classify the world in different ways.[2]

In order to make sense in the field of LIS, the distinction between the broad and narrow meanings of KO, as well as their interrelationships, should be clearly elucidated. For example, it should be considered that both the process of building a conceptualization and a KOS involves considering how single terms/concepts enter in relationship with others, and how they are arranged to form a structure. Besides, both the social and the intellectual dynamics described above are, directly or indirectly, relevant for KOS (in the narrow sense) development. For example, for treating topics such as the value of interdisciplinary approaches (see, e.g., Szostak et al. 2016), the historical dimension of knowledge and science with respect to the design of conceptual structures in KOSs (i.e., the latter cannot be developed without considering the former), the persistence over time (since Aristotle) of basic logical and classificatory principles with respect to the development of modern classificatory thinking, and then bibliographic classification systems too.

3.1 What notion of knowledge should be considered?

Another related issue is the distinction between knowledge as a process (how we know) and knowledge as the results (i.e., organized products) of the process of knowing. Whereas it is true that in speaking of knowledge organization items we refer mainly to the latter, the former also matters. We refer to the idea of knowledge, but what is knowledge? This basic epistemological question is far from being trivial, because depending on the way it is answered (something which in turn depends on our philosophical belief) our approach to KO is different.

Believing in the possibility of an objective knowledge, as in classical realism views, or regarding knowledge as limited (because limited are the human cognitive and perceptive means and so are also the technological means

used to improve them) and situated (because culturally biased and depending on theoretically and methodological viewpoints) makes a difference.

The different epistemological preferences influence how the bibliographic world is conceived and KOSs are designed. Therefore it is very important to investigate them, how they are linked to theories of concepts, and how they might lead to assume divergent positions (e.g. universalism vs. contextualism) with respect to KO.

3.2 KOSs, mental patterns, and cultural distinctiveness

A further aspect of KOSs, which is rarely highlighted, is how they relate to the basic human mental patterns, which make use of categorizing and classifying processes in order to cope with the ever-changing multiplicity of the world. Think about how memory works, involving processes of storage and retrieval. It does not passively collect bits of information, but employs mechanisms of selection and organization for archiving (Cardona 1985). As also indicated by pioneer research in semantic networks (Quillian 1968), our "semantic" memory operates through many different types of associative links. There is certainly some connection between human mental (hierarchical and horizontal) pathways and the relations (hierarchical, such as the genus-species relation, and transversal, such as the cause-effect relation) included in KOSs.

On the other hand, it should also be considered that the way mental patterns are "coded" and transformed in meaningful ways of classifying and establishing relations is strongly culturally biased. Think about the differences between Western classificatory thinking, which is based on the philosophy of Plato and Aristotle, and Chinese classificatory thinking. Whereas the former urges us to look for some unitary principles underlying diversity and multiplicity and to follow the precept of universality, the latter searches for meaningful analogies and contextual features (Hall and Ames 1998).

The Western-biased view influences, of course, also how KOSs and their relational structures are developed. As already noticed, the principles of classical logic determine the way classifications and thesauri are built (also see Frické 2016; Mazzocchi 2013; Olson 1999). And it is not a coincidence that bibliographic classification schemes have been developed as grand systems aiming at comprehensiveness, as much as the same occurred in past attempts to classify knowledge (think about Bacon's classification system or the encyclopedic projects of the Enlightenment).

Such issues, too, should be a matter of investigation in pondering the relation between the two aspects of KOS, because, as argued by Hodge (2000, 4), any KOS (as a tool) "imposes a particular view of the world on a collection and the items in it." If such a presumption of the cultural specificity of "classification" is correct, an important question that arises is how the practices and systems developed in a particular cultural setting might ever be compatible with the needs and beliefs of another culture (or also of with the marginalized items of its own culture) (Olson 1999).[3]

The arguments above make it clear that there are multiple dimensions—e.g., a plurality of levels of analysis, theoretical approaches, cultural perspectives, and applicative contexts—involved in the organization of knowledge and then in the development of KOSs as well, which have to be taken into consideration for gaining a wider outlook on the matter.

4.0 KOSs as Semantic Tools and Their Typologies: An Overview

In this section, KOSs as semantic tools are further explored, together with lists and typologies that have been advanced to make an inventory of and classify them.

As reported by Hodge (2000), the term "knowledge organization system" as intended today was coined at the first Networked Knowledge Organization Systems Working Group (NKOS WG), which took place at the ACM Digital Libraries '98 Conference in Pittsburgh. W3C SKOS (Simple Knowledge Organization System) started to use this term seemingly from the beginning of SKOS specification in 2008 W3C Working Draft (Miles and Bechhoferm 2008), although at that time only a limited number of KOS types, e.g., thesauri, classification schemes, subject headings, and taxonomies, were considered.

In point of fact, the list of what could be regarded as a KOS in the narrow sense is wide and, at times, confusing. Among KOSs are listed items with various structures and content, originated in distinct contexts of use for diverse purposes, and expression of different theoretical and methodological approaches. However, focusing on their structure and function, a common core is usually identified, as illustrated despite their differences by the following broad-range definitions:

Hodge (2000, 3):

> The term knowledge organization systems is intended to encompass all types of schemes for organizing information and promoting knowledge management … Knowledge organization systems are used to organize materials for the purpose of retrieval and to manage a collection. A KOS serves as a bridge between the user's information need and the material in the collection. With it, the user should be

> able to identify an object of interest without prior knowledge of its existence. Whether through browsing or direct searching, whether through themes on a Web page or a site search engine, the KOS guides the user through a discovery process. In addition, KOSs allow the organizers to answer questions regarding the scope of a collection and what is needed to round it out.

Zeng (2008, from the abstract):

> These systems model the underlying semantic structure of a domain and provide semantics, navigation, and translation through labels, definitions, typing, relationships, and properties for concepts … Embodied as (Web) services, they facilitate resource discovery and retrieval by acting as semantic road maps, thereby making possible a common orientation for indexers and future users, either human or machine

Soergel (2009b, 3):

> KOS are used by people to find information and make sense of it; KOS must support people in their quest for meaning, they must present meaningful structures of concepts. KOS are also used by computer programs to reason about data; KOS must represent formal knowledge about concepts.… Prototypically, a KOS provides a framework or schema for storing and organizing data, information, knowledge about the world and about thoughts … for understanding, retrieval or discovery, for reasoning, and the many other purposes

Bratková and Kučerová (2014, 8-9):

> A knowledge organization system is a scheme that models a structure (i.e.; elements and mutual relationships) of an organized set of knowledge. Support of the processes of knowledge organization and access to knowledge is the basic function of the knowledge organization system. A concept is the basic structural element of the knowledge organization system. A vocabulary, that is, the formal expression of concepts, forms the core of the physical representation of each knowledge organization system. The vocabulary is utilized to express both the semantics and the syntax of the organized whole, or, as the case may be, the rules defining how a structure is to be used.

4.1 Types and typologies of KOSs

Several different typologies of KOSs have been advanced, usually based on structural items (e.g., degree of complexity and relationships among terms/concepts) and corresponding functions. One of the first (specifically thought for the digital library environment) was by Gail Hodge (2000), who grouped KOSs according to three categories as illustrated in Table 1.

Categories of KOSs	General features of the categories	Specific types of KOSs
LISTS	Linear and less structured systems; emphasis on the lists of terms (frequently provided with definitions)	Authority files Glossaries Dictionaries Gazetteers
CLASSIFICATIONS AND CATEGORIES	Hierarchically structured systems; emphasis on the creation of subject sets	Subject headings Classification schemes Taxonomies Categorization schemes (the last three terms are frequently used interchangeably)
RELATIONSHIP LISTS	Complex and highly structured systems; emphasis on the connections between terms and concepts	Thesauri Semantic networks Ontologies

Table 1. Hodge's (2010) classification of KOSs.

Other candidate lists have been formulated by Bergman (2007), Soergel (2001), Tudhope et al. (2006), Wright (2008), who considers KOSs as a type of knowledge representation resources (KRRs), and many others.

Perhaps one of the most comprehensive typologies has been provided by Souza et al. (2012), who still identify structure as the main criterion for division, although a secondary division is also included, which takes into account numerous application domains and use cases (Figure 1). Four groups are identified: 1) unstructured texts (e.g., abstracts); 2) term and/or concept lists, which corresponds to simple structures (usually alphabetical displays); 3) concept and relationship structures, which includes more elaborated structures with different degrees of relationships among them, from the simpler ones showing loose hierarchies to the more complex and formalized ontologies (thus including in a single group what in Hodge's list is separated into two ones, i.e., classifications and categories

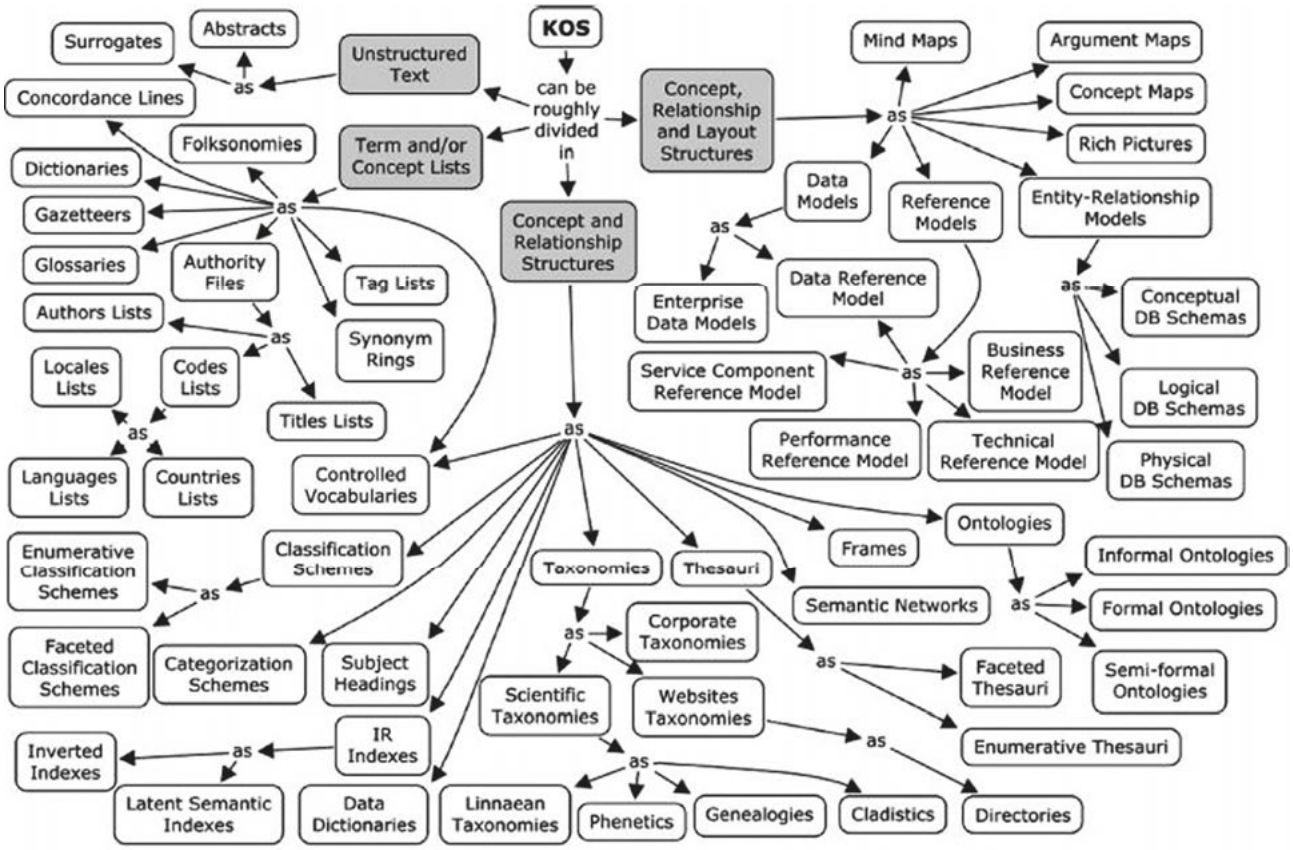

Figure 1. Souza et al.'s (2012) classification of KOSs.

and relationship lists); and, 4) concept, relationship and layout structures, such as mind maps, concept maps, entity-relationhsip models, reference models, data models, or also combination of these types (e.g., data reference model).

According to the rationale used by Souza et al., all the systems that are employed for KO and IR, support knowledge management, and are knowledge representation structures based on terminology, should be regarded as KOSs. In their view, such a rationale also explains the inclusion among KOSs of abstracts, concordance lines and IR indexes, something that is not common, and in contrast, for example, with Hodge's list; on the contrary, standard formats like HTML and SGML are excluded, because they are not regarded as KOSs but only as tools for representing them.

The typologies we have examined so far do not organize KOSs according to a clear progressive line, based for example on their structural complexity, although in some case (as in Hodge's classification) the simpler structures are listed before and vice versa. However, KOSs as discussed here are basically semantic tools. They provide a selection of terms/concepts (usually of a given subject field) and the relations between them. It is then not surprising that the difference in the degree of semantic richness is also employed as a criterion for comparing and classifying different types of KOSs. Many authors refer, in fact, to the idea of a "semantic staircase" (as suggested by Blumauer and Pellegrini 2006), viewing glossaries (or other less structured KOSs) placed at its lower grade and ontologies at its top (Figure 2).

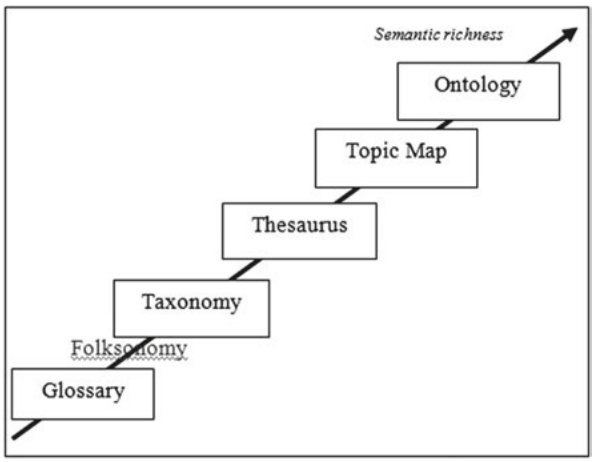

Figure 2. The semantic staircase (Blumauer and Pellegrini 2006), as appears in Olensky (2010, section 2.3.3)

Referring to the idea of semantic staircase, as well as to Hodge's classification, ANSI/NISO Z39.19-2005 (Na-

tional Information Standards Organization [NISO] 2005) and Tudhope et al. (2006), Zeng (2008) developed her own overview of types of KOSs.

As for the other cited schemes, her focus is on both the complexity of their structures and their expected basic functions. The former can be from flat to multidimensional, and generally the higher is the complexity of KOS structure the higher is their ability to carry out various functions; the latter comprise 1) to eliminate ambiguity; 2) to control synonyms or equivalents; 3) to establish semantic relations between terms/concepts (in particular, hierarchical and associative relations); and, 4) to present both relations and properties of concepts in the knowledge models.

Four (although not mutually exclusive) groups are identified and ordered from simpler to more complex structures and functionality, following the figure of the semantic staircase: 1) term lists; 2) metadata-like models; 3) classification and categorization; and, 4) relationship models (Figure 3).

A peculiarity of Zeng's classification is that two groups are separated, namely "term lists" and "metadata-like models," which in Hodge and Souza et al.'s proposals form a single group.[4] What follows is a brief description of the KOSs considered in Zeng's scheme, with the inclusion of some instances of them.

4.1.1 Term Lists

Lists (or pick lists): limited sets of terms arranged in some sequential order (e.g., alphabetical, chronological, or numerical).

Dictionaries: alphabetical lists of terms with their definitions, which usually provide other information such as spelling, morphology, origin, and variant senses for each term.

Glossaries: alphabetical lists of terms with their definitions.

Synonym rings: sets of terms regarded as equivalent for information retrieval (IR) purpose. Basically analogous to synonyms rings are the "synsets" included in WordNet (https://wordnet.princeton.edu/), which group semantically equivalent items.

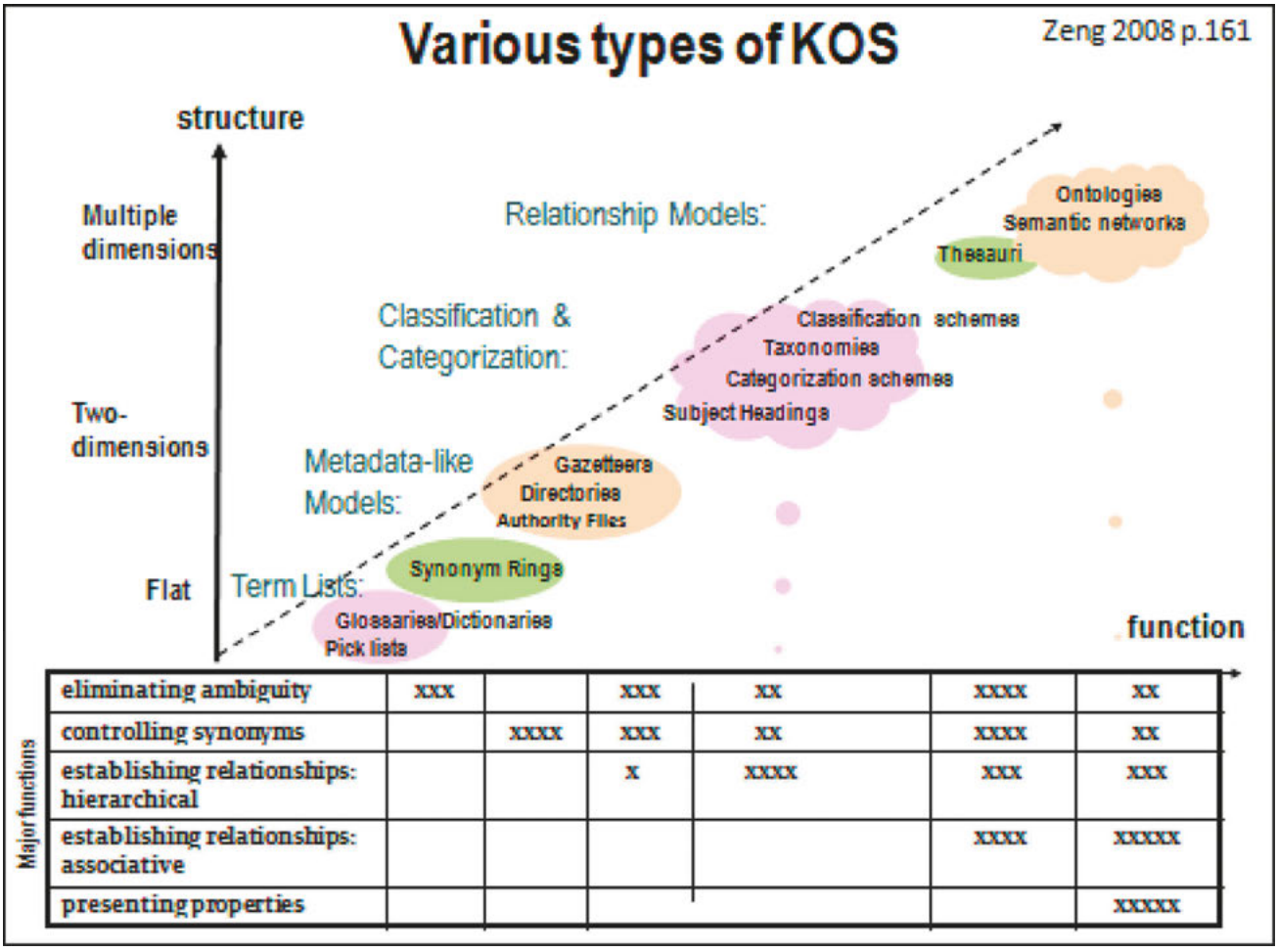

Figure 3. Zeng's (2008) classification of KOSs.

4.1.2 Metadata-like Models

Authority files (also named name authority lists): lists of terms employed for controlling the variant names for an item (or the domain value for a particular field), and where one term is identified as the preferred one. An important international file of name authorities is the Virtual International Authority File (VIAF).

Directories: lists of names with their related contact information.

Gazetteers: organized collections of information concerning geographic items. A well-known gazetteer, although constructed in a thesaurus format, is the Getty Thesaurus of Geographic Names (TGN).

4.1.3 Classification and Categorization

Subject headings (also named subject heading schemes): vocabularies of controlled terms, which represent the subject of items in a collection, and include rules to combine such terms into compound headings. Two important instances, which can be both compared to thesauri with respect to their structure, are the *Library of Congress Subject Headings* (*LCSH*), which has an extensive coverage but a limited hierarchical organization, and the *Medical Subject Headings* (*MeSH*), which is provided with a stronger tree structure.

Categorization schemes: loosely assembled grouping schemes. An instance is the set of subject categories of the Web of Science (WoS).

Taxonomies (the use of the term is, of course, historically associated to biological classifications): any ordered grouping of items based on particular features (see further in section 4.2.2 below).

Classification schemes: hierarchical and faceted arrangements of numerical or alphabetical notations, which are used for representing broad topics and usually conceived as universal systems (i.e., covering all fields of knowledge). Foremost among library classification systems are the *Dewey Decimal System* (*DDC*), first published in 1876, which was originally based on enumerative principles, but over time introduced some aspects of the faceted approach; the *Library of Congress Classification* (*LCC*), first developed in the late nineteenth and early twentieth centuries, which is essentially enumerative; the Universal Decimal Classification (UDC), first published in 1905, which, despite its origin based on the *DDC*, has been developed partly according to faceted principles; the *Colon Classification* (*CC*) (http://www.isko.org/cyclo/colon_classification), first published in 1933, in which Ranganathan introduced the influential idea of faceted classification; and the *Bliss Bibliographic Classification* (*BBC*), originally created by Bliss and published between 1940 and 1953, its second, and totally revised, edition (*BC2*) has been developed in UK since 1977, with the introduction of a new faceted structure.

4.1.4 Relationship Models

Thesauri: controlled and structured vocabularies, which display hierarchical, associative, and equivalence relations among terms/concepts. The first IR thesauri were developed during the 1960s (e.g., *Thesaurus of Armed Services Technical Information Agency (ASTIA) Descriptors* published in 1960, the *Chemical Engineering Thesaurus* published in 1961, and the *Thesaurus of Engineering Terms* published in 1964); thesauri are, however, still very popular, and used, for example, for vocabulary control in many online databases. Other important instances are the *ERIC Thesaurus* and the faceted *Art and Architecture Thesaurus* (*AAT*).

Semantic networks: systems where terms/concepts are modelled like in a network of variable relationship types; they are richer than thesauri in defining categories or semantic types and semantic relations. For example the *UMLS (Unified Medical Language System) Semantic Network*, which deals with biomedical terminology, includes 135 semantic types and fifty-four relations.

Ontologies: according to a widely accepted definition, they are formal, explicit specification of a shared conceptualization (Gruber 1993). Usually they consist of complex relations between entities and include rules and axioms which support logical reasoning. Formal ontologies function as conceptual vocabularies and provide properties and instances. They serve for IR purposes, reuse of knowledge, and automatic deriving of new knowledge.[5] An important instance is the Gene Ontology (GO), which has been developed by the Gene Ontology Consortium, and describes genes and their products.[6]

4.2 Discussion about KOS typologies

The above schemes reflect the common scholarly understanding of KOSs. To such regard at least three issues need to be considered in more depth: 1) their coverage; 2) the terminology used; and, 3) the criteria used for and the scope of comparing different KOSs.

4.2.1 Coverage issues

Concerning the first point, none of these schemes aimed explicitly to achieve full comprehensiveness nor is able to accomplish it. For instance, in contrast with Hodge and Zeng's proposal, Souza et el.'s proposal includes also folksonomies and a reference to the idea of topic maps (although the term is not mentioned as such), but the former does not include other items that may also be considered

as KOSs: for example, web directory structure (Soergel 2009b), bibliometric maps (Hjørland 2007), and IR systems, including search engine retrieval systems making use of algorithms like Google systems (Hjørland 2012).

Consider for example bibliometric maps, which can take different forms, showing relations between journals or authors basing on co-citation data, or also relations between words or keywords based on co-occurrence data. Such maps, which somewhat reflect the social organization of knowledge, could be regarded as a further type of KOS, because, with reference to bibliometric parameters, they display the relations between terms/concepts of a field (e.g., White and McCain 1998), helping to visualize its structure and dynamics (the reciprocal position of terms in the maps reflects somewhat their semantic distance), and can be used to support IR as well.

On the other hand, since they originate in a field (e.g., bibliometrics) that, although with several areas of overlap—it relies, in fact, on the quantitative (statistical) studies of documents, collections of documents, and derived patterns—has developed in parallel with LIS/KO; the inclusion of bibliometric maps in the list calls for a reassessment of what really counts in establishing the range of possible KOSs. The focus should not be, in fact, on whether or not a system has been created within a field traditionally included in LIS/KO, but rather on whether it is possible to develop, through the methods of that field (e.g., bibliometrics or IR), a useful KOS (Broughton et al. 2005), being it a system that displays particular features, both structural (i.e., consisting of terms/concepts and their interrelationships)[7] and functional (e.g., supporting information organization in one or more platforms, such as libraries, databases, and the web).[8]

4.2.2 Terminological issues

With regard to the second point, it should be noted that in dealing with KOSs not only there is a partial agreement on how to classify them but also on the terminology to be used. Many authors have, in fact, highlighted the terminological confusion concerning KOSs (Gilchrist 2003; Pieterse and Kourie 2014; Soergel 2009b; Souza et al. 2012). For several terms concerning KOS types, there is no precise meaning; the same term could have multiple meanings, with many areas of overlap, owing to the fact that is employed by different communities of practitioners in diverse contexts. This is even worsened by the tendency of several authors to create new definitions that disagree with former ones (Noy and McGuinness 2001) or to classify in different ways the same instance of a KOS type (for example, Grabar et al. 2012 reported that *MeSH* is described alternatively as a terminology, a thesaurus, or an ontology and *UMLS* as a metathesaurus, a domain-specific terminology system, or an ontology). It seems a bit paradoxical that there is "a serious lack of vocabulary control in the literature on controlled vocabulary" (Weinberg 1998).[9]

Take for example "taxonomy." It is not clear what constitutes a taxonomy (http://www.isko.org/cyclo/classification#3.4), or what the meaning of the term "taxonomy" is. Gilchrist (2003) pointed out that such a term is used with at least five diverse (but overlapping) meanings to refer to 1) web directories; 2) taxonomies to support automatic indexing; 3) taxonomies created by automatic categorization 4) front end filters; and, 5) corporate taxonomies. It is symptomatic that, as argued by Souza et al. (2012), when compared with thesauri, taxonomies can be seen alternatively as less (Daconta et al. 2005; Guarino 2006; Obrst 2004) or more (Bergman 2007; Smith and Welty 2001) structured.

In several cases, it seems that the same term is used for referring to a set of related items, which, rather than showing features common to all, can be best understood through the Wittgenstein's (1953) notion of family resemblance, i.e., they are similar one to another in many different ways (just as for the members of a family).

This may (partially) apply to the term "thesaurus" too, which have several instances of use, such as Roget's *Thesaurus of English Words and Phrases* (which includes only synonyms and classification categories), standard IR thesauri (which are used to assist indexing and searching), *Thesaurofacet* (which is the combination of a faceted classification and a thesaurus), search or end-user thesauri (which are enhanced with a large amount of entry terms, e.g., synonyms, quasi-synonyms, and linguistic variants, for facilitating expansion of search expressions), metathesauri (which aim at integrating existing thesauri and vocabularies), automatically constructed thesauri (whose relations are established automatically by means of computer algorithms and which usually show a less structured semantic organization as compared to standard thesauri).

Perhaps the term that is used most ambiguously is "ontology," which is borrowed from philosophy and reinterpreted in the framework of artificial intelligence (AI). Such a term is employed both for referring to a specific form of KOS, although differentiated in various types (e.g., top ontologies, general ontologies, and domain ontologies), and as a generic term to designate any type of KO system (e.g., McGuinnes 2003).

In the first sense, ontologies are often compared with thesauri and considered as an extension of them; they usually include more detailed information about concepts, which are represented in a more formal way, a richer relational structure, and a set of inference rules for allowing the knowledge encoded in them to be processed by computer programs.

The second use of the term most likely originated in the framework of the preparation for a discussion panel on ontologies and their definition at the 1999 American Association for AI National Conference. The figure of a spectrum was conceived here as reflecting an "axis of axiomatization," i.e., suitability of systems for logic-based automatic inferencing that depend, above all, on the formality of semantics. Such a figure becomes a model for successive schematizations and elaborations, as for example in Lassila and McGuinness (2001) and McGuinness (2003), and should be related to the above mentioned notion of the semantic staircase too. All types of KOSs are represented as ontologies, although a distinction is made between "lightweight" ontology (e.g., catalogs, glossaries, thesauri) and "heavyweight" ontologies (e.g., formal ontologies), according to their degree of "semantic strength" (Figure 4). A similar characterization is made by Guarino (1998, 2006), who classified ontologies according to their degree of "ontological precision," i.e., the accuracy by which they specify their target conceptualizations, something which in turn depends on the degree of axiomatization and the richness of the relational structure.

Such a loose usage of the term "ontology" seems rather problematic. First, employing the same term for a class and one of its members is somehow incongruous and does not help clarification. Second, it is true that each KOS can be seen as the result of some sort of "ontological modelling" (Souza et al. 2012, 187) or, inversely, that ontologies are basically nothing more than classifications remaking the idea of classification itself in a new context (Soergel 1999). However, by using "ontology" to designate all types of KO systems, i.e., as synonymous of KOS, the risk is to blur the real dissimilarities between them, which depend on their historical development and the particular purposes for which they have been designed for.

Previously, other terms were used with the same (or a very similar) sense that is today attributed to KOS, reflecting their conception as tools for the storage and retrieval of documentary items. For instance, "indexing languages." As shown in Figure 5, indexing languages are usually divided into two types, i.e., classifications and verbal indexing languages, although such a distinction is criticized, as conceptually meaningless, by some scholars (e.g., Lancaster 2003, 20-21), or as missing the point (because the real distinction is between controlled systems and free text systems) by others (Hjørland 2012). "Controlled vocabularies," a term employed in several standards, seems hence to have a more restricted meaning than "indexing languages." However, the opposite is supposed by the following quote (Golub 2011):

> There are two terms related to KOS: controlled vocabularies and indexing languages. Both of these terms belong to KOS but have a different scope and, they can be used with more precision. The term "controlled vocabularies" can be used to de-

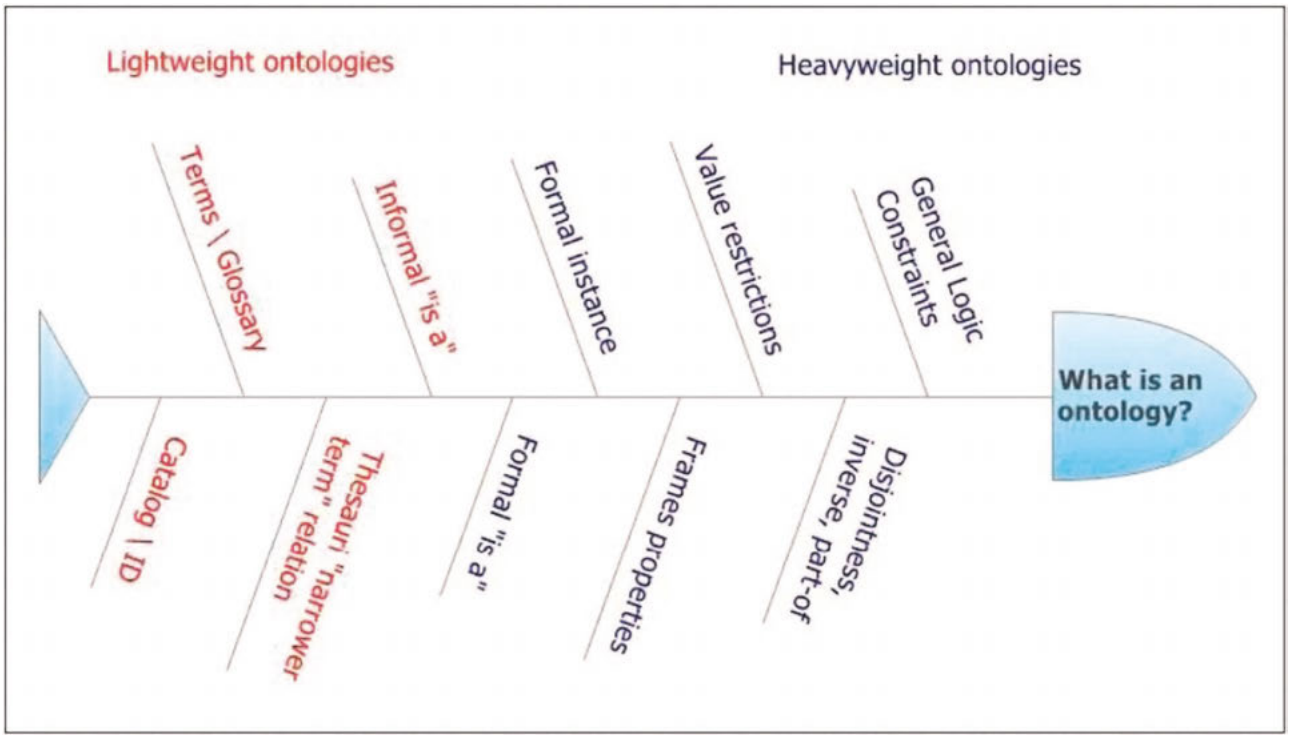

Figure 4. KOS spectrum (adapted from presentation) from Lassila and McGuinness (2001), as appears in Souza et al. (2012).

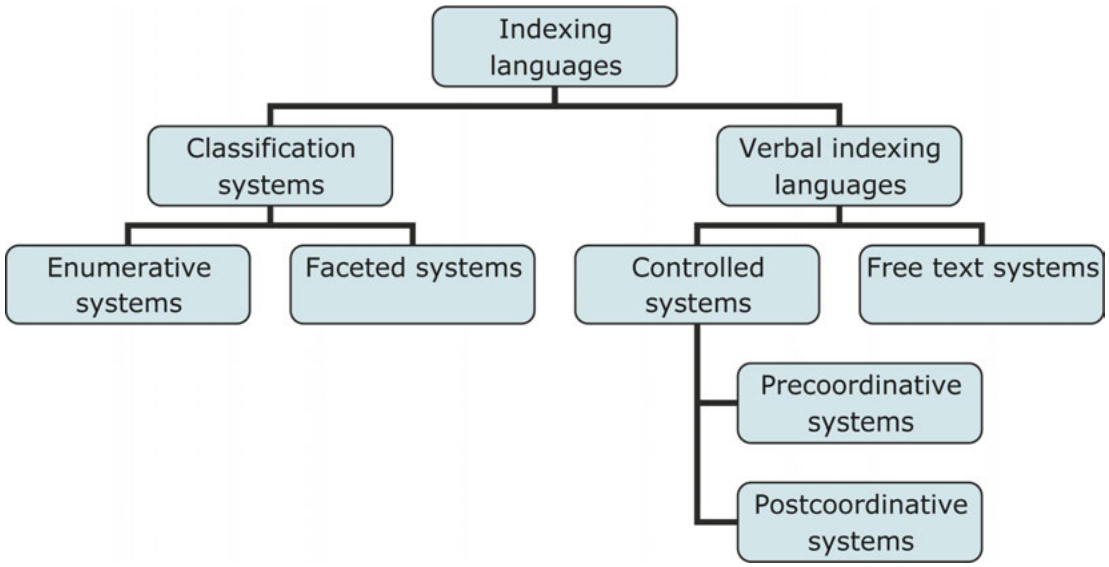

Figure 5. The types of indexing languages (as appears in Hjørland 2012, 304).

> note any controlled set of terms or controlled list of terms used in document description i.e. in descriptive metadata. Indexing languages are a specific kind of controlled vocabularies representing formalized languages designed and used to describe the subject content of documents for the information retrieval purposes.

Another term is "information retrieval languages" (as first coined by Mooers 1951), which is also frequently used in the simplified form "retrieval languages" (Vickery 1973). All these terms are still employed in a LIS/KO environment, and the same occurs for "bibliographic languages" (Svenonius 2000). Most of them refer, although metaphorically, to the notions of "language," something which has today been replaced by the metaphor "system," following the inclination of the NKOS community.

As a matter of fact, one could be tempted to employ Wittgenstein's family resemblance model not only to describe particular types of KOSs but also for accounting KOS as a general notion itself. Are we really sure that, given the remarkable diversity of KOS types and their instances, some common characteristics could be really found? An alternative could also be to employ the prototype model of concepts (Rosch 1978), which is still inspired by the philosophy of Wittgenstein, according to which some members of a category are more prototypical (i.e., better representatives) than others.

4.2.3 Issues regarding criteria for comparison

The third point should be related to the idea of classification spectrum itself, reprised also by other specialists like Daconta et al. (2005) and Obrst (2004), something which is full of theoretical implications.

In their article, Souza et al. (2012) aimed to deconstruct the spectra that have been so far proposed, being unsatisfied with the fact that such spectra originate from comparisons among KOSs based on a single criterion or dimension, i.e., the already mentioned "semantic strength." Such a way of proceeding neglects to consider other important aspects and dimensions by which KOSs could also be evaluated (Souza et al. 2012, 190):

> The spectra of KOS types … tend to make the basis for comparison a single dimension. The visual rhetoric is that of a linear progression, with ontologies as the ultimate form. This stems from the general basis of the spectra being KOS properties for logical reasoning. However, there are many potential applications for KOS and many possible dimensions for comparison. … Focusing on a single dimension obfuscates the underlying similarities and differences between different types and instances of KOS and hinders the selection of an appropriate KOS for a particular purpose.

The visual rhetoric of a linear progression expresses very well a position that, it is no coincidence, originates in a specific community of practitioners and reflects its derivation from the tradition of AI. Such a community is concerned, as already said, with rendering KOSs suitable for logical computer reasoning (see Figure 6) and semantic web applications; formal ontologies have been designed accordingly. However, while such a requisite is certainly important in today's information context, it is not

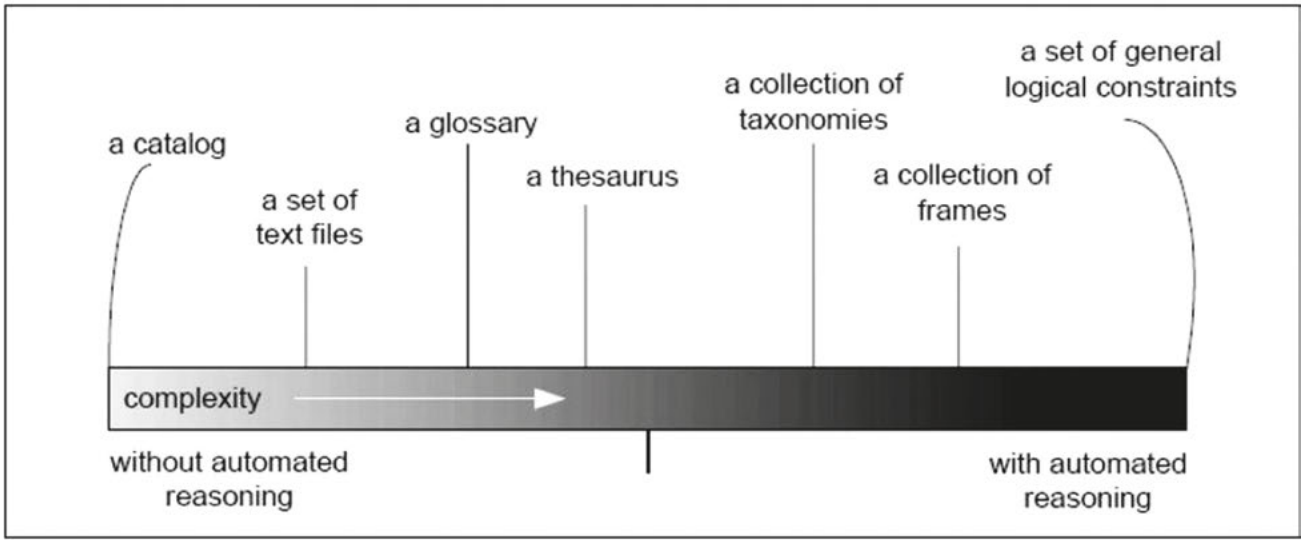

Figure 6. KOS spectrum slightly adapted from Smith and Welty (2001) based on Welty et al. (1999), as appears in Souza et al. (2012).

the only one that matters (also see Almeida et al. 2011 for a critical evaluation of the idea of spectrum). This point will be reprised in the next section.

5.0 Theoretical and Practical Questions

There are several theoretical questions concerning the design and development of KOSs. Some of them regard specifically the bibliographic world and are as such the main object of focus in the LIS environment. Others, while affecting the latter too, originate in a broader setting, and often involve the philosophical underpinnings underlying KO activities. The theoretical investigation on this second aspect has been, however, undertaken with less regularity; there has been not so much engagement with regard to theory of concepts or epistemological issues, something that is rather explicable given that not necessarily the educational background of LIS specialists includes disciplines such as philosophy of language or epistemology. Very likely, when Hjørland (2008, 87) asserts that "KO has mainly been a practical activity without much theory," it is above all to this second aspect that he is referring to. Although recognizing that a number of theoretical advancements have been made (e.g., Cutter's rules and developments in facet analysis) and various outcomes achieved (e.g., standards and guidelines about KOSs), Hjørland puts emphasis on the fact that the overall trend is still rather fragmented, with the coexistence of several schools of thought that only seldom make their philosophical backgrounds explicit, or contrast them with the underpinnings of other schools. What is especially needed, in his view, is that the development of theories and principles about KOSs and KO in the LIS sense is based on theories and principles of KOSs and KO in the broad sense (e.g., Hjørland 2003).

It is not a coincidence that three of the leading contemporary scholars who have most contributed to theoretical advancement in KO urged and were capable, although in different ways and from different theoretical standpoints, to link LIS themes with philosophical arguments and to value interdisciplinary research: 1) Ingetraut Dahlberg, an information scientist and philosopher and, of course, the founder of the ISKO, set the basis for KO to be recognized as a distinct field or science, which is concerned with the order of knowledge (i.e., a metascience); 2) Elaine Svenonius, as described by the title of her most important book dated 2000, contributed to establish the intellectual foundations of knowledge (or, as in her words, information) organization; and, 3) Birger Hjørland, who is today one of the most influential scholar in characterizing and progressing KO, contributed both in terms of specific theoretical formulations (e.g., the domain-analytic approach) and in making explicit and refining the fundamentals of KO (see, e.g., Hjørland 2003). Their positions will be analyzed in the following section.

5.1 Theory of concepts and epistemology in KOS development

As repeatedly said, KOSs can be regarded as semantic tools, i.e., sets of terms/concepts with different degrees of relations among them. Therefore, which notions of concepts and semantic relations are employed have a considerable impact on how KOSs are conceived and designed. Their relevance increases, of course, as the complexity of KOS semantic structures increase too.

Hjørland (2007, 370–1) pointed out that

> The field of KO within IS is thus concerned with the construction, use, and evaluation of semantic tools for IR. This insight brings semantics to the forefront of IS …
> What approaches have been used in the field of KO in the course of its history? How do they relate to semantic theory?… Given that KOS essentially are semantic tools, should different approaches to KO reflect different approaches to semantics?

On the other hand, semantics is strongly interlinked with epistemology. Our approach to KO and in constructing KOSs is always more or less influenced by the epistemological stance adopted.

In their works, Dahlberg, Svenonius and Hjørland have investigated both these issues.

5.1.1 Dahlberg's position

In formulating her ideas for the development of the new science of KO, Dahlberg (e.g., 1993, 2006 and 2009) put concepts at the center of the scene, together with the mapping of conceptual items with objects of reality. The creation of new knowledge has to be paralleled by a constant effort to systematize knowledge. Yet knowledge is contained in knowledge units, i.e., concepts, and then the possibility to arrange it in a systematic order resides in the possibility to construct concepts systems (i.e., knowledge units arranged in some ordered structure). The method to be employed for such a purpose should be based on analyzing the content of the concepts, determining their characteristics or knowledge elements (distinguishing between essential, accidental and individualizing ones) and corresponding categories. The theoretical foundations of Dahlberg's approach to classification should be traced back to Aristotle and the work of, among others, Ranganathan and Wüster (i.e., one of the founders of the modern approach to terminology). By setting the basis for developing concept systems, methods for developing properly any type of KO system are also gained (Dahlberg 2006, 13):

> Using the concept-theoretical methodology, it is possible to construct concept systems relating to given referents from either the real or the abstract realm. Most concept systems are classification systems as well, in the double sense that they represent classes of objects and concepts and determine their respective positions by notations (numbers, codes), which precisely represent their conceptual relationships. Because of their conceptual content, such notations (class numbers) can be used to classify any type of object or topic.

Dahlberg's idea of concepts, while considering them as signs (as occurs in semiotics), follows an essentialist scheme. Her concept triangle (Dahlberg 1978), which resumes and reinterprets the idea of a triadic representation of meaning put forward by mediaeval scholastics[10] and taken in the last century by, among others, Ogden and Richards (1923), is made of three elements: 1) the referent (e.g., a concrete object or an abstract idea); 2) the characteristics or statements about the referent; and, 3) the verbal form or designation. What should be intended for the second element are essential characteristics, i.e., intrinsic and constituting features of the referent, which must be present in all its exemplars and can be detected objectively, i.e., independently from interpretation.

This idea of concept, together with an ontological approach derived from her interpretation of the philosophies of Hartmann and Feibleman, brought Dahlberg to adhere to a universalist view with respect to classification of knowledge (and then KOSs). Such a view is reflected in her aspiration to develop a new universal classification system, namely the *Information Coding Classification* (ICC).

Dahlberg's position, which has its strength in the clarity and coherence of the philosophical arguments, seems however to identify KO with a single particular (philosophical and theoretical) standpoint. However, KO is today populated by theoretical positions finding inspiration in views (such as postmodernism and hermeneutics) that differ with respect to Dahlberg's one, and question, for example, essentialism and universalism (Kleineberg 2015). Besides, the existence of such a plurality of theoretical and methodological approaches is also valued by many as an advantage for KO research (e.g., Smiraglia 2014; Smiraglia and Lee 2012). This same plurality is explicitly acknowledged by Svenonius and Hjørland too.

5.1.2 Svenonius's position

Svenonius explicitly recognizes how philosophy has a strong impact on other disciplines, especially with regard to the theoretical constructs they use. In one of her articles (Svenonius 2004, from the abstract) she explores

> how epistemology, that branch of philosophy concerned with how and what we know, has contributed to the design of knowledge representations embodied in retrieval languages designed for organizing information. Different retrieval languages make different presuppositions about what is meant by knowledge.

In investigating the epistemological foundations of knowledge representations embodied in retrieval languages (to be intended as a synonymous of KOSs), Svenonius considers the semantic theories involved too. Three main orientations are identified.

First, approaches emanating from the Vienna Circle's philosophy of logical positivism (as developed at the beginning of the twentieth century), which assumes that all knowledge is derivable from sensory experience, and follows an operationalist theory of meaning: meaning is empirical and only to an empirical content can an authentic cognitive significance be ascribed. Such assumptions are reflected in the verifiability principle, according to which cognitively meaningful propositions are only those capable of verification, i.e., those whose truth value can be determined such as scientific propositions. Conversely, unscientific (e.g., metaphysical or ethical) discourses that lack an empirical content are not cognitively meaningful. Now, in order for a proposition to be verified, the concepts contained in it have to be defined operationally, which usually means defining them as variables. Some kind of operational definitions are used also in a LIS framework. In Svenonius's view, a well-known, fruitful example is the precision-recall measure, which is used as basis for evaluating the efficiency of a retrieval system (Cleverdon 1962). One of the main limitations of approaches like this is, however, their unwarranted, and often acritical, reliance on quantification and measurements (as if they were "objective" and "neutral"), and the associated tendency to introduce oversimplifications. Svenonius, for instance, highlights the limitations of the precision-recall measure for oversimplifying the subjective notion of relevance and of automatic techniques to identify subjects of documents for being term- rather than concept-based.

Second, approaches still based on an empiricist view of knowledge but referring to the picture theory of meaning, which was put forward by the initiators of modern logic, such as Frege and Russell, and expounded by Wittgenstein in his *Tractatus Logico-Philosophicus* (1961/1921). The meaning of words, whose referents are real-world things, is provided by ostensive definitions, i.e., pointing to such referents, and is relatively fixed (owing to the fixity of reference). According to a strong reading of the theory, propositions are meaningful if and only if they picture (correspond to) a state of affairs, and knowledge rests on the totality of true propositions (to the extent that the latter are accurate pictures of reality).

Recognizing also its influence (especially with respect to the initial stages) in the development of AI, Svenonius draws connections between the picture theory of meaning and a number of theoretical approaches to classification. For example, those inspired by Feibleman's (1954) theory of integrative levels (http://www.isko.org/cyclo/integrative_levels), which assumes that the order of classes in a classification reflects reality, depicted as a hierarchy of organized wholes, and the approach of faceted classification, as far as the latter follows the principles of logical division (http://www.isko.org/cyclo/logical_division) (also see Hjørland 2013).

Not only propositions that picture the world are recognized by empiricism, but also tautological ones, i.e., those that express logical relations among propositions. It is somewhat recalled the distinction made by Hume between propositions that express relations among ideas and those that express matters of fact. Another important and related distinction is the one between *a priori* (or definitional, logically-based) and *a posteriori* relations. An instance of the former is, of course, the genus-species relation (also called inclusion, subsumption or hyponymy), in which, basically reflecting Aristotle's formulation, the genus corresponds to the higher-level class, and different species under the same genus are distinguished as subclasses in virtue of their diverse essential characteristics or *differentia*. The resulting hierarchical or classificatory structures tend to be seen as mirroring the (formal) structure of reality.

Today, the *a priori* vs. *a posteriori* distinction is still a key theoretical issue with respect to the design of KOSs. For example, it has played, since the initial stages (e.g., Bernier 1968), an important role in setting the basis for the development of modern IR thesauri. It is in fact reported as a fundamental principle in international standards (e.g., International Organization for Standardization [ISO] 2011), at times expressed as a distinction between paradigmatic (or context-free and permanent) and syntagmatic (or context-dependent and transient) relations. More generally speaking, only paradigmatic relations should be expressed in the semantics of a KOS, whereas syntagmatic relations should be expressed, when possible and needed, by the syntax (a critical discussion about the *a priori* vs. *a posteriori* distinction has been carried out in Hjørland 2015 and Mazzocchi 2017).

Finally, the philosophy of the second Wittgenstein (1953) and his instrumental theory of meaning, which can be seen, in the development of his thought, as an attempt to overcome the limitations of the picture theory. In fact, this latter theory is afflicted by a number of limitations. By assuming, for example, a universal form of language (as supposed in the *Tractatus)*, the fixity of meaning, and an objectivist view of knowledge, it does not adequately represent the complexity of language and knowledge; it neglects, in fact, to consider the relation between semantics and context, and between knowledge and interpretation, as well as the dynamic aspects of both meaning and knowledge.

The most innovative aspect of the instrumental theory is that the meaning of linguistic expressions is seen as corresponding to their use; such a use is governed by rules embedded in what Wittgenstein calls language games. Since speaking a language is a social action, and being involved in a multiplicity of social practices, language should be seen as a collection of many language games, each with its own rules. In Svenonius's view, the implications of the instrumental theory for KO and the design of KOSs are very significant and concern, for example, the notion of subject (http://www.isko.org/cyclo/subject) (whereby subjects are seen as complex, i.e., represented by networks of concepts rather than single concepts), the notion of class and the design and implementation of semantic relations in KOSs (with the rejection of essentialism and a prioriness of relations), the methods of disambiguation for improving precision (which has to take into account the fact that, following such a view, most words have multiple meanings, i.e., they are polysemic [also see Mazzocchi and Tiberi 2009]) and the strategy for achieving semantic interoperability (which can be seen as one type of language game among many types).

5.1.3 Hjørland's position and related approaches

Hjørland (e.g., 2007) has again and again emphasized the importance of theory of concepts for the design of KOSs, specifying also that if concepts are the basic units of thought and knowledge, then the units of KO are the relations between them. Partially overlapping with Svenonius's account, Hjørland (2003) distinguishes four main orientations in KO (http://www.isko.org/cyclo/classification#4.2c), which follow different theories of concepts as linked with distinct epistemological stances: empiricism, rationalism, historicism, and pragmatism. The empiricist orientation is basically inductive and leads in bibliographic classification to methods based on statistical measures like algorithms for IR. The rationalist orientation is mainly deductive and based on principles of logical division, assumed as universally valid, as occurs in most library classification systems. The historicist orientation is focused on accounting the historical development of knowledge and meaning, as well as the role played by contextual factors. The pragmatic orientation takes into consideration goals and values, pointing for example to the notion of "cultural warrant" (i.e., any classification depends on the assumptions and concerns of the communities involved, thus rejecting the possibility of a universal classification system).

Hjørland's domain-analytic approach (http://www.isko.org/cyclo/domain_analysis) follows a historical-pragmatic orientation. He considers how any project of KO depends on subject knowledge and should take into account the existence (at times even within the same domain) of multiple views or paradigms, approaches, and communities. As a consequence, the same term/concept or object (e.g., a document) might be classified or put into relation with others in many different ways, according to different (e.g., disciplinary) perspectives. Accordingly, any repository of knowledge, information and data (e.g., a database) should be understood as a "merging of different descriptions serving different purposes and based on different epistemologies" (Hjørland 2007, 396). All of this needs to be taken into serious consideration in designing KOSs in order to understand what is really "informative," which depends on the particular circumstance and cannot then be established *a priori*.

Other approaches to KO, which bring further ideas on how to view concepts, can also be put into relation to the domain-analytic approach. Thellefsen and Thellefsen (2004) explored, for example, the relevance of the tradition of pragmatic semiotics (and its understanding of concepts as signs), which was initiated by Peirce, who introduced (among other things) the idea of unlimited semiosis. Any concept represents a "potential knowledge content," but such a potentiality is actualized only whenever the concept is interpreted, something which, in turn, depends on the "pre-understanding" of the community concerned. The meaning communicated by concepts is, thus, "relative to domains of knowledge" (Thellefsen and Thellefsen 2004, 178): on one hand, in order to really grasp the structure and meaning of concepts, the specific characteristics of the particular domain, e.g., the perspectives, goals and interests involved, should be specified; on the other hand, the conceptual structure of a domain comprises its knowledge and reflects its history.

5.2 Which future for KOSs? New and old challenges

A second issue needs to be considered here, which has both theoretical and practical implications. The question could be formulated as follows: since the world in which we live is rapidly changing—e.g., our societies are becoming increasingly complex, globalization is producing never ending transformations at different levels, the amount of collected knowledge and information is increasing exponentially, technological development is changing the organization of our societies—the context in which KOSs are called to work is changing as well—new platforms have been created, e.g., the digital environment and internet, together with new ideas and tools, e.g., the semantic web, Google search engines, big data (also see Ibekwe-SanJuan and Bowker 2017)—and, as a matter of fact, new tools have also been designed. Is it then possible that some of the traditional KOSs are becoming outdated and

need to be replaced by new types of KOSs (or also by some sort of post-KO systems, i.e., not following any classificatory principle at all (see Weinberger 2007)? What about, for example, the historical KOSs that have been designed several decades ago for addressing information needs in a physical library environment (classification schemes and subject headings) and later to facilitate IR in bibliographic databases (thesauri)? Which roles do such systems play in the new setting? In order to handle information organization and searching in the framework of the new medium, i.e., internet, are wholly new "principles" really required or is it rather a deepening of our understanding of the idea of classification itself and how it applies to a constantly changing *milieu* that is required?

A number of interesting debates have been instigated by such issues. For example, the ISKO-UK debate (see Dextre Clarke and Vernau 2016) was concerned with the role of traditional thesauri in contemporary IR, addressing the statement "This house believes that the traditional thesaurus has no place in modern information retrieval." Many believe that the traditional thesaurus format lacks well defined semantics to cope efficiently with today's needs. As said before, richer and highly formalized structures are required to ensure KOS suitability for automatic inferencing and semantic web applications, as well as to enhance the possibilities for IR and interoperability among different KOSs. These features can be found, of course, in formal ontologies, and many have pointed out that thesauri of new generations should include more refined structures and adopt attributes from ontologies (e.g., Fischer 1998; Soergel et al. 2004).

Another debate concerns whether new types of (basically data-driven) systems will supersede the (basically theoretically-driven) traditional KOSs. As a matter of fact, the internet and its search engines are transforming the world of information and how people organize and search for it. Google retrieval systems, for example, are highly successful, yet simple to use (i.e., differently from traditional databases, no information specialists or search skilled end-users are needed), and also show an impressive coverage (Hjørland 2016c), although one may wonder about the excessive amount of information they provide (which hampers the possibility of retrieving information selectively), as well as its quality. Is there, then, a role that KO and classification (as generally understood) have still to play in IR? As argued by (Hjørland 2012, 301),

> Is classification … still needed in the post-Google era? Or are computer algorithms able to do a 100% satisfactory job without the need for classification …? This theoretical challenge constitutes a serious threat to the justification of classification, KO, and LIS as fields of both research and practice.

Ontologies and "Google systems" actually epitomize two distinct types of trends that are currently present in the world of information organization, respectively the logical and the data-driven (inductive-statistical) trend. Despite the differences among them, there is an aspect they share, whose pondering could contribute to better understand the nature of any KOS and then to envision their future evolution too. Although for contrasting reasons, i.e., believing in the power of logic or supposing some sort of neutrality of "data," ontologies and Google systems seem to share, explicitly or not, an underestimation of the role of "interpretation" (here intended in a wide sense) in KOS development or the assumption that it is something that could be or has to be neutralized.

5.2.1 Does an unbiased ontology exist?

Think about ontologies. As mentioned earlier in the discussion about KOS classification spectra, their development reflects today's tendency towards an increase in formalism and standardization, which makes the presumption that the functionality of a KOS is proportional to the extent to which it is formalized and logicized, and that enhancing the degree of semantic strength would have the potential to solve, at least in principle, once and for all problems of inconsistency and ambiguity in information organization.

In this new framework, thesauri as conceived in standards, for example, risk to be regarded as outdated, because they include only a restricted set of semantic relations (hierarchical, associative, and equivalence), which, on the other hand, are often implemented inconsistently (e.g., Mazzocchi et al. 2007). The practice to convert existing thesauri into ontologies, e.g., by formalizing the data and adding inference rules, is animated by the prospect to use them to facilitate automatic inferencing and to create the conditions for interoperability (Pieterse and Kourie 2014).

No doubt the functionality of thesauri could be improved by enriching their relational structure (see, e.g., Dextre Clarke 2001; Hjørland 2016a), in resembling some of the ontologies' features. For instance, the three basic relations could be differentiated into more specific subtypes (such a differentiation would be especially relevant for distinguishing various subclasses of the hierarchical partitive relation and, even more, to better specify the associative relation, which encompasses a heterogeneous assortment of relations).

On the other hand, in speaking about the functionality of a particular KOS, its intended purpose (e.g., suitability for automated applications) has to be specified. In fact, although some attributes might be useful in a variety of situations, there is no feature or function that, in principle, is suitable for all possible contexts. In particular circum-

stances (e.g., "locally oriented" information concerns) or for addressing particular purposes (e.g., enhancing expressiveness),[11] more flexible tools (with respect to ontologies), and relations that are not logically based, may be needed (see, e.g., Mazzocchi 2017)

Furthermore, and most importantly, by seeing things only with the eyes of logic and formalization, we could not grasp the inherent nature of KOSs, which are systems displaying an "organized interpretation of knowledge structures" (Zeng and Chan 2003, 377).There is an intrinsic interpretative character that underlies the construction of any KOS, including ontologies that cannot be considered as neutral representations of a reality "out there."

KOSs are classificatory entities.[12] They are made of terms/concepts and the relations among them, but concepts and relations do not exist in some abstract world. Rather they are embedded in particular cultural, historical, and theoretical settings. There are, and there will always be, different ways of establishing semantic structures, depending for example on different theoretical stances, subject areas, and practical concerns (see, e.g., Hjørland 2007).

5.2.2 Does an unbiased search engine or bibliometric map exist?

A similar argument can be made for search engines. It is true that, through digitalization and other technological advances, massive amounts of data are becoming available so that, by means of more and more refined algorithms, meaningful patterns could be detected from them. Such a circumstance is unprecedented in the history of human culture, and is leading to attribute an increasingly key role to statistical tools, which in some cases, at least on the practical level, could make top-down schemes and generalizations less required (see, e.g., Serres 2015). However, this does not indicate that, as claimed, for example, by big data supporters, data or numbers "speak for themselves," because meaningful patterns are born directly from data via inductive processes and statistical manipulation (see Leonelli 2014 and Mazzocchi 2015 for a critical appraisal), as if classification would not be needed anymore for information organization—just like no theory is needed anymore for scientific research (e.g., Anderson 2008). Even if we only think about how computational tools are designed or the way to look at data to extrapolate regularities or correlation patterns, the fact that these tasks are influenced by some (e.g., theoretically-biased) preconceived notions is evident (Hales 2013):

> Any statistical test or machine learning algorithm expresses a view of what a pattern or regularity is and any data has been collected for a reason based on what is considered appropriate to measure. One algorithm will find one kind of pattern and another will find something else. One data set will evidence some patterns and not others.

Search engines are not neutral tools that "reflect" reality only making information available; rather they should be regarded as "cultural-political" agents that, openly or tacitly, make choices at different levels about what should be findable or meaningful and what should not (Hjørland 2012, 311):

> Search engines may be calibrated to provide different findings or rankings. In order to make such a calibration, we need to have some kind of classification of what should be found.

Similar arguments could be made in several other cases. Especially illustrative is the case of bibliometric maps. One could be tempted to consider them as impartial representations of a particular specialty field, because originating from the application of some algorithms that do not involve any subjective choice or interpretation (Small 1977). As pointed out by Hjørland (2016b), objectivist stances surrounding such an approach make (explicitly or tacitly) the (simplicistic) assumption that just as science provides an accurate (and neutral) "picture" of nature, in the same way bibliometric maps provide an accurate (and neutral) picture of scientific knowledge (e.g., Boyack and Klavans 2010). However, in the construction of any bibliometric map, some biased decisions and acts of interpretation are always involved. For example, even the selection of sources, such as journals on which a particular map is based, is influenced by the views, interests, and preferences of the investigator (also see Sullivan et al. 1977 for a critical appraisal).

Summing up, and reprising the initial pondering about the future of KOSs, it could be argued that many different types of KOSs exist, and novel ones will keep on being created and adjusted, following social and technological development, the existence of a plurality of information needs, and the possibility that new platforms are created. Nevertheless, all KOSs have in common, and will also share in the future, a classificatory nature, something that, in turn, necessarily involves, with respect to their development and usage, an interpretative aspect.

5.3 Making sense of classificatory perspectivism

The recognition of the interpretative aspect in KO and classification represents an important contribution to the theoretical foundation of the field. It motivates why KOSs should be considered as interpretative tools and mediators (between different pre-understandings, per-

spectives, conceptualizations, and languages carried out by the actors involved). A similar view is expressed by the following quote (Fast et al. 2002):

> A controlled vocabulary is a way to insert an interpretive layer of semantics between the term entered by the user and the underlying database to better represent the original intention of the terms of the user.

Nevertheless, as pointed out by Hjørland (2012), if it is true that there are several scholars who have made similar arguments (see, e.g., Fonseca and Martin 2005; Hjørland and Nissen Pedersen 2005; Mai 2004 and 2011), it is also true that the formulation of a "coherent" theoretical position has not yet been achieved.

Borrowing a term used by the philosopher of science Ronald Giere, who has promoted the idea of "scientific perspectivism" (2006),[13] we can refer to such a "hermeneutically oriented" view of KO in terms of a "classificatory perspectivism."

Summarizing what has been said earlier, classificatory perspectivism, at the most basic level, considers that, being KOSs made of terms/concepts, which show given conceptual features, and their interrelationships, which are established based on the evaluation of those features, there are multiple ways to undertake such an evaluation. Multiple criteria, at different levels, can in fact be followed to decide how to relate terms/concepts among them (the key assumption here is, of course, that relations are not *a priori*, universal, ahistorical, and context-free). As a result, there are multiple ways of establishing relations between terms/concepts. This is the underlying situation that is common to all types of KOSs, ontologies, and Google systems included (Hjørland 2012).

Classificatory perspectivism, as any other "virtuous" form of perspectivism, should not, however, be mistaken with flawed forms of it, such as those considering all perspectives as equally good, regardless of their content and purpose. Put it in Giere's words (2006, 13):

> In common parlance, a perspective is often just a point of view in the sense that, on any topic, different people can be expected to have different points of view. This understanding is usually harmless enough in everyday life, but it can be pushed to the absurd extreme that every perspective is regarded as good as any other.

Moreover, it should not be intended in a trivial sense. For example, "there is always a subjective aspect in any classification" is a statement trivially correct but not so informative, if convincing reasons are not given to explain why the possibility of making different choices, as based on different criteria, plays a "constitutive" role in the development of any KOS.

Criteria for making choices could vary by virtue of the fact that different practical considerations (e.g., how to address interoperability vs. expressiveness concerns, global scopes vs. "local" or field-dependent needs) are made. As mentioned before, this is one of the preferred arguments of Hjørland (e.g., 2007 and 2016a), who insists on the need to consider any KOS, together with its relational structure, as a tool to be evaluated with respect to its ability to fulfil the functions that are requested for addressing a particular task. If this is the case, then different purposes or different contexts could require different structures, and it would instead be questionable to prescribe that a KOS should be developed in a uniform way.

Criteria could also differ given that in the development of a KOS diverse theories of concepts could be referred to, for instance, following (either rigorously or inaccurately, either proactively or passively) the indications of standards in which assumptions regarding concepts are incorporated or making a different theoretically motivated choice.

At last, divergences in establishing semantic relations also depend on the fact that in different domains or disciplinary fields, or also according to contrasting paradigms within the same discipline, different conceptual features (or different ways of relating terms) are considered as the most significant.

For instance, the term "insects" could be classified in different ways, e.g., as "arthropods," as "agricultural pests" or as "disease carriers," depending on the standpoint from which it is considered. On the other hand, whereas many relations are relevant nearly for all fields—e.g., the genus-species relation or the agent/process relation (e.g., "hunters" / "hunting"), a subtype of the associative relation—the area-place relation (e.g., "deserts" / "oases"), a subtype of the partitive hierarchical relation, is especially important in the geographical field (Winston et al. 1987).

Although this does not occur frequently among KO scholars, classificatory perspectivism might also be associated, and in a sense reinforced in its motivations, with metaphysical assumptions that concern the underlying structure of reality: does reality, as it is commonly assumed, have a unique structure or it can be better portrayed as being "polymorphous" (or even amorphous), i.e., it has (in some way) more than one structure all together?

The idea of "one and only one structure" would, in fact, be challenged if a multidimensional complexity is ascribed to the world (see, e.g., Dupré 1993), i.e., if the latter is seen as intrinsically nested and entangled, a place where things are interconnected and interrelated to one another in multiple ways and many cross-cutting joints can be

found. There is no argument here regarding our epistemic inability to provide a unique representation, i.e., we are not allowed to have full access to the information that would be needed for making a choice between non-isomorphic representations (also see Votsis 2012). Rather it is the world itself to be considered as having polymorphous features. Consequently, there is no unique way of carving nature at its joints. There could be many different ways to classify and divide it into discrete parts (also see Mazzocchi 2016).

5.4 Pluralism in KO research: towards a pragmatically based integrative approach?

A related and important question is how pluralism is practiced in KO research. As described in this article, different theoretical views are involved, together with different methodologies and approaches (e.g., quantitative vs. qualitative means or basically deductive vs. inductive approaches) and many different types of tools (KOSs). Such a pluralism is surely a resource, because different options could be provided for different information concerns and operative circumstances, as well as that kind of intellectual tension, which may yield productively fertile results. On the other hand, the existence of positions that can be seen as mutually exclusive—think about the different notions of concepts (e.g., as based on essential/context-free vs. context-dependent attributes) or of knowledge itself (e.g., as mirroring an objective reality vs. as culturally/historically/theoretically biased)—risks to create some kind of confusion, especially if they are not made explicit.

The divergent aspects of pluralism need to be balanced by attempts to find some integrative elements, pondering on how to amalgamate conflicting theoretical positions, something that, however, is not an easy task, or focusing on the pragmatic ground.

An attempt like this is discussed, for example, in Mazzocchi (2017). Although recognizing the perspectival (i.e., not *a priori*) nature of all types of relations (something that, of course, reflects a specific theoretical view), it is also supposed that, depending on the conceptual features of the terms involved, different relations show different degrees of "stability" (also see Violi 2001, chapter 7), and that by virtue of this they can play different roles in KO. For example, whereas logically based relations, such as genus-species (e.g., "Arthropoda" / "insects"), are particularly useful for allowing automated applications (which require inheritance properties), and achieving semantic interoperability (which usually involves mapping between the terms/concepts of different KOSs), relations that function more contingently, like "perspective" hierarchies (e.g., "agricultural pests" / "insects or disease carriers" / "insects"), could instead provide contexts that specify the viewpoint from which a given topic/subject is considered, enhancing the expressiveness of the system (Svenonius 2004).

Pluralism is here integrative, because it is acknowledged that the standpoints of both logic and perspectivism (usually seen as conflicting) are significant for KO. They could complement one to another and as such be, at least pragmatically, integrated. Generally speaking, on one hand, without logic it would be difficult to identify common or stable language/conceptual structures. On the other hand, without a hermeneutical attitude, it would be difficult to grasp historical or contextual information.

A comparable position is somewhat echoed also by Svenonius (2004, 585) when she argues that

> Arguably, in the design of a retrieval language, a trade-off exists between the degree to which the language is to be formalized and the degree to which it is to be reflective of language use. It is true that a highly formalized language advances the twin goals of automation and distributed indexing. On the other hand, the greater the expressiveness of a retrieval language, in particular the greater its ability to convey the contextual and relational information needed for disambiguation, collocation, and navigation, the greater validity it has as a knowledge representation.

6.0 Conclusion

A presentation of KOSs has been provided, distinguishing a broad and narrow meaning of the corresponding term. The focus has been especially on the latter, which is used for referring to systems developed with the purpose of aiding the retrieval of information. A number of different typologies or classifications of KOSs have been analyzed, which result from comparing KOSs and tend to employ different criteria and to have different scopes. In this framework, the idea of a classification spectrum (and of a semantic staircase), and the portrayal of KOSs according to a linear progression based on their semantic strength, have been discussed critically. Attention has been drawn on the fact that, in order to have a fuller understanding of them as semantic tools, the theories of concepts and associated epistemologies underlying the design of KOSs should be investigated, not giving for granted the "received view" in this field (e.g., about what semantic relations "are" or "should be"). As argued by some scholars (e.g., Hjørland 2003), in order for such a theoretical engagement to be possible, a rethinking of the educational landscape of LIS/KO specialists would perhaps be necessary. And what seems also especially needed is to make an explicit connection between the broad

meaning and the narrow meaning of KOS, the former corresponding to the social and intellectual organization of knowledge (i.e., how knowledge is organized respectively in society and in conceptual systems like theories and disciplines). Today such an engagement is also essential considering that, for the future developments of KOSs and KO, a balance should be found between technologically-driven and theoretically-driven concerns.

Notes

1. In the present article, the plural form KOSs is used for KO systems, although many references, including quotes in the present text, use KOS in both the singular and the plural sense.
2. In both versions of Kuhn's scheme, there is, underlying any revolutionary change, something that remains unchanged. This is very clear in his later formulation that emphasizes the "local" feature of revolutions (as depending on local changes in the meaning of kind terms). But also in the more holistic formulation developed in *The Structure of Scientific Revolutions,* while not explicitly acknowledged by him, a differentiation can be made between different levels of assumptions with regard to their "stability." For example, Kuhn mentions the scientific revolution bringing from (Newtonian) corpuscular optics to wave optics to contemporary optics, according to which light corresponds to quantum-mechanical entities (photons), which display some characteristics of waves and some of particles. Yet underlying such changes what remains basically stable are the fundamental notions that define what is modern science, as established by Descartes and Galileo (as well as the logical and epistemic principles we have inherited from Greek philosophy).
3. A further related aspect concerns the development of multilingual KOSs. The question here is whether the different linguistic versions of a KOS are able to represent the features and specificity of the languages and cultures involved (with regard to multilingual thesauri see Hudon's pioneering studies [1997], also reprised in De Santis et al. [2012]).
4. As pointed out by an anonymous reviewer, the reasons for such a differentiation are that, first, the items included in the "metadata-like models" group are employed for listing name variations and representing the attributes of some tangible items (e.g., people, organizations, places); second, they also contain further data about these items, such as relationships among them, possible types (e.g., types of places), and special attributes (e.g., geo coordinates of places).
5. "Ontology embraces the classificatory structure used by taxonomies and thesauri. Its unique feature is the presentation of properties for each class within the classificatory structure. With a full taxonomy and exhaustive properties, an ontology functions as both a conceptual vocabulary and a working template which allows for storing, searching, and reasoning that is based on instances and rules" (Zeng 2008, 176).
6. Another important resource to be mentioned here is the *Basel Register of Thesauri, Ontologies & Classifications* (*BARTOC*), which is a large collection of information about different KOSs (e.g., Ledl and Voß 2016).
7. Not necessarily the structure (made up of terms and their interrelationships) of a KOS should be made explicit to users. What indeed counts is the existence of such a structure, something that could be proven in virtue of the fact that, by means of it, a number of retrieval operations are performed (this is the case of Google retrieval systems).
8. Any attempt to compare and classify the multiplicity of types and instances of KOSs is complicated by a number of issues, including the fact that, as pointed out by Souza et al. (2012), what is usually taken into account in these schemes are features pertaining to ideal or conventional types of KOSs. However, such a circumstance risks to obscure the (sometimes significant) dissimilarities that might exist between the specific instances of a KOS, or some hybrid forms that could also exist. For instance, the semantic structure might be more complex in a given instance of a KOS with respect to the instance of another KOS, although the situation is the opposite if the corresponding conventional types are considered.
9. As suggested by an anonymous reviewer, with regard to these issues, standardization activities related to the KOS development should also be considered. In actual fact, the production of international and national standards has concerned only thesauri (e.g., ANSI/NISO Z39.19-2005, BS 8723, ISO 25964). Such a circumstance has favoured, and ruled, the creation and application of a large number of thesauri in many different areas. This availability of thesaurus standards also influenced, at least during the recent several decades, the development of other types of KOSs like subject headings (e.g., *LCSH* and *MeSH*). And the development of SKOS, too, has heavily been based on these same standards (see "Appendix. Correspondences between ISO-2788/5964 and SKOS constructs" in Isaac and Summers 2009). In contrast, international standards about, for example, classifications have not been elaborated, although some efforts in this direction have been made by IFLA. This too has contributed to the terminological and classification confusion regarding the items included in the "classification and categori-

zation" group (i.e., categories, taxonomies, and classifications).

10. This idea is encapsulated in the maxim "Vox significat rem mediantibus conceptibus" ("A word stands for a thing by means of thoughts/concepts").
11. Expressiveness could be portrayed as the ability of representing contextual and many-sided information, e.g., the possible different views about a given topic/subject, which should be made available to users, provided that this is advantageous for them (e.g., Hjørland 2007, 389-90).
12. "Classification" should be intended here in a generic sense, as illustrated for example by the following quotation (Hjørland 2012, 303):

    > "We could say that classification is the interdependent processes of:
    > – defining classes;
    > – determining relationships between classes (such as hierarchical relations, among others), i.e. making a classification system; and
    > – assigning elements (in LIS, documents) to a class in a given classification system.
    >
    > This is equivalent to the interdependent processes of:
    > – defining concepts […];
    > – determining semantic relations between concepts […]; and
    > – determining which elements fall under a given concept (to assign a given "thing" to a concept)"

    If this is the case, then criteria for classifying involve both "criteria for assigning document A to class X" and "criteria by which decisions such as assigning the semantic relation X between the concepts A and B can be made" (Hjørland 2012, 307).
13. The idea of perspectivism is not a novelty in the contemporary age (it was sustained, for example, by Nietzsche). Giere has developed his own version in analogy with vision, highlighting how the appearance of given phenomena (specifically color) can change as the observer's position changes. He makes the point that both scientific observation (as deriving from sensory modalities or with the aid of instruments) and theorizing are perspectival too. More generally speaking, it is human epistemic access to the world that is intrinsically perspectival, although, in Giere's (2006, 14–5) view, it is still possible to associate perspectivism to (a weak form of) realism: "it is perspectival realism that provides us with a genuine alternative to both objectivist realism and social constructivism … Perspectivism makes room for constructivist influences in any scientific investigation. The extent of such influences can be judged only on a case-by-case basis, and then far more easily in retrospect than during the ongoing process of research."

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