Does the Traditional Thesaurus Have a Place in Modern Information Retrieval?

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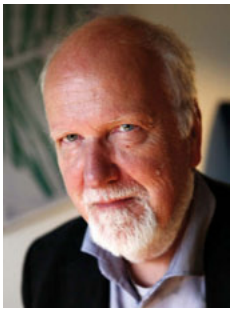

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Hjørland, Birger. 2016. "Does the Traditional Thesaurus Have a Place in Modern Information Retrieval?" *Knowledge Organization* 43 no. 3: 145-159. 82 references.

Abstract: The introduction (1.0) of this article considers the status of the thesaurus within LIS and asks about the future prospect for thesauri. The main following points are: (2.0) Any knowledge organization system (KOS) is today threatened by Google-like systems, and it is therefore important to consider if there still is a need for knowledge organization (KO) in the traditional sense. (3.0) A thesaurus is a somewhat reduced form of KOS compared to, for example, an ontology, and its "bundling" and restricted number of semantic relations has never been justified theoretically or empirically. Which semantic relations are most fruitful for a given task is thus an open question, and different domains may need different kinds of KOS including different sets of relations between terms. (4.0) A KOS is a controlled vocabulary (CV) and should not be considered a "perfect language" (Eco 1995) that is simply able to remove the ambiguity of natural language; rather much ambiguity in language represents a battle between many "voices" (Bakhtin 1981) or "paradigms" (Kuhn 1962). In this perspective, a specific KOS, e.g. a specific thesaurus, is just one "voice" among many voices, and that voice has to demonstrate its authority and utility. It is concluded (5.0) that the traditional thesaurus does not have a place in modern information retrieval, but that more flexible semantic tools based on proper studies of domains will always be important.

Received: 18 January 2016; Revised 20 January 2016; Accepted 23 January 2016

Keywords: thesauri, information retrieval, thesaurus relations, knowledge, semantic

1.0 Introduction

The thesaurus has been—and still is—very important in the self-images of library and information professionals and scientists (LIS). This can be illustrated, for example, by Hahn (2003), who asked: "what has information science contributed to the world?" Among the most important answers she received was the development of a great number of thesauri for many different domains. As a teacher in schools of library and information science, I have also personally experienced the popularity of thesauri. Students like to know that thesauri are recognized as important tools for information retrieval (IR), and that they will learn how to design them and thereby contribute to solving important and appreciated tools for firms and institutions. Marjorie M.K. Hlava is an information professional who claims to have worked with or built over 600 controlled vocabularies, including thesauri (Hlava 2015, 3:129). Such a career is probably a model for many students in LIS.

I feel however, that the popularity of thesaurus construction in education and the profession is too cheap a victory. This concerns both the role of thesauri in modern information retrieval and the qualifications needed in order to develop valuable knowledge organization systems (KOSs) in general. The qualifications needed for selecting and defining concepts and determining their semantic relations presupposes subject knowledge. The qualifications that are needed for contributing to knowledge organization (KO) presuppose knowledge of metasciences (see Hjørland 2016a). Such qualifications are today underrated in both teaching and research.

As indicated by the recent debate in the United Kingdom chapter of the International Society for Knowledge Organization (ISKO-UK 2015), the role of the thesaurus in modern information retrieval seemingly has shrunk from what it once was (although it won the day in the final voting of this debate). Why did the role of thesaurus decrease (if it did), and did the voting in London reflect

the scientific status of the arguments about thesauri? It should be considered that in scientific matters it is not opinion polls that count, but scholarly arguments. Therefore, this article examines the current knowledge regarding the question asked in the title.

The ISKO-UK (2015) debate—and the present article—are about the "traditional" thesaurus. This specification is important because the criticism posed against the traditional thesaurus may be used to improve the thesaurus, to blur the relation to ontologies or to transfer the thesaurus to a new kind of KOS. Dextre Clarke (2016) outlines some important aspects of the history of thesaurus-debate that will not be repeated in the present paper. It should just be mentioned that 1964 is an important year in the history of the modern thesaurus for IR. Among other events, Engineers Joint Council (1964) published *Thesaurus of Engineering Terms,* which served as a model for many later thesauri and became closely connected with the development of standards and thus what we should understand as the traditional thesaurus.

The relations between library science, information science, library and information science, knowledge organization and computer science (among others, see Hjørland 2013b) play a role in this endeavor. I consider KO as a part of LIS and in the rest of the paper refer to it as LIS/KO (although this is not the view of Ingetraut Dahlberg, see further in Kleineberg 2015, 191). Today thesauri are mostly considered part of LIS/KO and they are challenged by research in, first of all, computer science. The issue is, however, more complicated because originally thesauri were developed with "classical databases" (cf. Hjørland 2015b) by information scientists, who did not consider themselves as part of library science. It was only later on that thesauri became an important part of the teaching of knowledge organization in LIS and this association did not necessarily satisfy the inventors. For example, Calvin Mooers, who invented the concept "descriptor" (1950), later wrote (2003, 821):

> In epilogue, the descriptor method is largely a failure because it proved to be beyond the capabilities of the persons who chose to enter the service profession of librarianship in which descriptors were to be used.

Nonetheless, thesauri became an important element in the teaching and research within LIS/KO. Subsequently, an enormous amount of literature about thesauri has been published, but it might be questioned whether much progress has been made. The situation seems to be similar to what Michael Buckland wrote (1991, xiii) about introductions to information science:

> One might have thought that, for so important a field [information science], a general introduction would be easily written and redundant. This is not the case. Each different type of information system (online databases, libraries, etc.) has a massive and largely separate literature. Attention is almost always limited to one type of information system, is restricted by technology, usually to computer-based information systems, or is focused on one function, such as retrieval, disregarding the broader context. What is published is overwhelmingly specialized, technical, "how-to" writing with localized terminology and definitions. Writings on theory are usually very narrowly focused on logic, probability, and physical signals. This diversity has been compounded by confusion arising from inadequate recognition that the word information is used by different people to denote different things.

Most of the literature about thesauri corresponds to Buckland's criticism as narrowly focused, and it is badly in need of a broader interdisciplinary basis in fields such as epistemology, semiotics and studies of scholarly literature, bibliometrics, information retrieval and other fields. The term "reification" (the fallacy of misplaced concreteness) comes to mind, implying that the thesaurus is conceived as a thing (standardized and uniformly applicable in different domains) rather than as a domain-specific tool developed by considering terminological issues and needs in different contexts. Librarians and information specialists learn the meaning of terms such as BT, NT, RT, and they are given examples of the types of semantic relations typically displayed in thesauri. But this knowledge is seldom related to semantic theory, to knowledge about the nature of semantic relations and the theoretical problems connected to questions such as "how do we decide whether A is a kind of B?" Actually, it seems to be a widespread misunderstanding in our community that relations in thesauri are (cf., Hjørland 2015a, 1367) "context-free, definitional, and true in all possible worlds." Misunderstandings of this kind contribute to the cheap popularity of thesauri: the difficult parts of the construction are simply concealed, for example, that semantic relations are theory-dependent (Hjørland 2015c). Our students are not taught the more difficult aspects of thesaurus construction and also LIS/KO-researchers mostly ignore them.[1]

The present article is an attempt to consider foundational issues in LIS by taking thesauri as the point of departure. It is based on the view that the thesaurus and other kinds of KOSs have lost influence due both to alternatives developed mainly in computer science and to a lack of focus on fundamental issues within LIS/KO. Following this introduction, the second section briefly exam-

ines relations between thesauri and those challenging technologies developed in computer science. The third section considers thesauri as one kind of KOS in order to examine whether other forms of KOSs may be considered superior and to challenge the restrictions in the traditional thesauri. The fourth section broadens the issue to all kinds of controlled vocabulary (CV), because it is at this level of generality that the fundamental issues are best described. The conclusion provides an answer to the question in the title of the paper.

2.0 The challenge from search engines and modern IR-research

As already stated, thesauri are developed with the "classical databases" (cf. Hjørland 2015b). These databases differ from modern search engines and related IR-technology in many ways, and the future of thesauri is probably related to the future of classical databases. It is evident that the question "does the traditional thesaurus have a place in modern information retrieval?" can only be answered by considering the challenges from, for example, Google-like systems developed by computer scientists.[2]

The field of information retrieval (IR) was originally founded by information scientists, but has migrated (cf. Bawden 2015) to computer science. Contemporary standard texts about IR include, for example, Baeza-Yates and Ribeiro-Neto (2011), Manning and Raghavan (2008) and Roelleke (2013), in which thesauri are not given much consideration or credit. The dominating approach is probabilistic, statistical and algorithmic and the broad opinion in this field simply seems to be that (Robertson 2008) "statistical approaches won, simply. They were overwhelmingly more successful [compared to other approaches such as thesauri]."

The dominant expectation among computer scientists seems to be that there is no need for classical databases, controlled vocabularies or thesauri.[3] Gerard Salton, for example, wrote (1996, 333):

> Meaning resolution is not at all a thesaurus problem, because the large full-text collections available for analysis operate as an implicit thesaurus. The authors [Hjørland and Albrechtsen] say that "statistical and probabilistic retrieval seem to be blind with regard to the problems of interpretations." In fact, there is no better approach to meaning interpretation than by using the large and small contexts now available with full-text in intelligent ways … Ignoring the completely changed conditions under which information retrieval activities are now taking place, forgetting all the accumulated evidence and test data, and acting as if we were stuck in the nineteenth century with controlled vocabularies, thesaurus control, and all the attendant miseries, will surely not contribute to a proper understanding and appreciation of the modern information science field.

This quotation clearly indicates the challenge thesauri, other CVs and classical databases are confronted with (by Salton these tools were considered "nineteenth century miseries").

It seems obvious that the implications for LIS/KO depend on how we evaluate our options in the light of the challenge from computer science. Has the statistical approach simply made thesauri, controlled vocabularies, research and practice in our field obsolete and superfluous? Or, is there still room for contributions from our field?

Based on Robertson's (2008) claim that statistical approaches work less well when systems are very small, Dextre Clarke (2016, 141) made the suggestion that the use of thesauri is limited to the contexts where statistical methods are not enough, which she suggested might include:

- Small and medium-scale in-house collections;
- Electronic document and records management systems (EDRMS);
- Knowledge-bases used to hold an organization's store of expertise;
- Collections with text in multiple languages;
- Bibliographic databases;
- Heritage collections already indexed with a controlled vocabulary;
- Multimedia resources with little text for the statistics to work on—especially music and still images.

Dextre Clarke did not refer to evidence supporting these suggestions but asked for it. It seems a bit strange that bibliographical databases (corresponding to the "classical databases" previously mentioned) are included in this listing. Such databases are often huge (MEDLINE, for example, contains more than 20 million references, although not in full text). Classical databases are (still) mostly preferred for tasks such as evidence-based medicine but are today also challenged by statistical, probabilistic and algorithmic approaches (cf. Hjørland 2015b[4]). It was exactly for these databases that thesauri were originally developed and have been considered most important. Alternative applications, such as small in-house collections may not be important enough to maintain KO as an active research field and a professional community—and may demand other kinds of thesauri than the traditional kind, discussed here. Therefore, if we exclude bibliographical databases (with or without full text content),

Dextre Clarke's view seems too defensive and resigned, and I prefer to stick to issues on how to retrieve documents in order to identify the ones that are crucial in order to make decisions (decisions that are important enough to support an informational infrastructure such as specialized journals and databases). Thus, the discussion of thesauri in this article is about their future potential in databases such as MEDLINE, PsycINFO and the like. They are currently used in such databases but, as mentioned, are challenged by IR-researchers.

The medical field is a good example of how to connect professional decisions with existing knowledge through KO and IR. What, for example, is the evidence that women older than 50 benefit from regular mammography? In order to answer that question, the best studies have to be retrieved and studied. We may disagree about what "best studies" means,[5] but given a certain consensus of this in the medical community, our task is to make studies corresponding to that consensus findable without too much noise and effort. This may or may not require thesauri, KOSs or other specific tools (this is up to IR evaluation studies to decide). Notice that the approach suggested here is a top-down approach (from what is needed to how it should be represented and identified). This is the opposite of mainstream IR-approaches, which are bottom-up strategies (from matches between terms in queries and in document representations to user needs). The way systems are evaluated is of utmost importance. The top-down strategy suggested here finds the "gold standard" approach used in evidence based research important. It uses highly accepted documents as the gold standard against which retrieval systems should be measured. This is different from mainstream in both information science (user-based evaluation) and computer science (systems-based evaluation).

Robertson (2008) did not just claim that "statistical approaches won, simply. They were overwhelmingly more successful [than other approaches]." He also made room for many other kinds of knowledge; they just have to be combined with the statistical approach (which he considered a necessary but difficult task). This leaves us two options: to challenge the statistical approach or to try to cooperate with it. In both cases, the most important job seems to be to identify the different approaches and explore their relative strength and weaknesses, and, in this way, open the door to make even better retrieval system. I have begun such an analysis (see Hjørland 2013c) but so far only tentatively suggested problematic assumptions in mainstream IR research.[6]

Hjørland (2015b) is an attempt to develop a defense for exact match techniques and human decision-making during searches and for the maintenance of concepts such as "recall devices" and "precision devices." The reader of this article may or may not be persuaded by the arguments, but it should be considered that if no convincing arguments can be developed, the whole field of KO is in a crisis and we all ought to become computer scientists or something else. Therefore, this question is extremely important for KO and LIS, and it is problematic that so few researchers are engaged in it. The issue should not be understood as a dichotomy between computer-based retrieval and human-based retrieval. It is not an argument for human-based retrieval, rather an argument about the relative fruitfulness of different approaches to information retrieval (whether human or machine-based), whether we in KO have anything to contribute to modern IR compared to the existing computer science approaches (as presented by the above mentioned sources). The task is to investigate theoretical assumptions in all forms of IR and to suggest how existing technologies and techniques may be improved. So far I have analyzed the following approaches to KO: user-based and cognitive views, facet-analytical views, bibliometrics and domain-analytic approaches, whereas I have only superficially examined mainstream IR-approaches (see Hjørland 2013c), and other approaches (e.g. standardization) also await future work.

My theoretical view is that criteria of what should be found in searches (criteria of relevance and "information needs") are "scientific criteria," derived from scientific theory and knowledge. This view is opposed to mainstream research in both information science and computer science in which relevance is either seen as individual user-based criteria or as "the systems view of relevance." Relevance is implied by domain-theories and investigations in IR, KO and thesauri should be based on the analysis of theory. For example:

- Which view of art is prioritized by a given search system when searching for "arts?"
- Which (implicit) view of art is dominant in a given library classification system? (cf. Ørom 2003).
- Which view of art is dominant in the *Art and Architecture Thesaurus*?
- Which view of information science is dominant in the *ASIS Thesaurus of Information Science and Librarianship*? (and how does this effect IR in these fields).

These questions are not easy to answer and perhaps even their philosophical basis may be questioned (see Hjørland 2016b "The paradox of atheoretical classification"). Nevertheless, it is my view that considering such philosophical questions is the only way forward if KO is going to improve IR, making it clear why existing KOSs have not been as successful as we may have wished. They may simply have been constructed on the basis of problem-

atic assumptions and methods! The main problematic assumption is that KOSs and retrieval systems can be and should be considered neutral tools.

I agree with Salton (1996, 333) that meanings are mainly developed in primary literatures, only secondarily in thesauri, dictionaries etc., "because the large full-text collections available for analysis operate as an implicit thesaurus." This view is in accordance with the view expressed by Ludwig Wittgenstein ([1953] 1967) that meaning is use: words are defined by their actual use rather than by an abstracted reference to the objects they designate or by the mental representations one might associate with them. Both Salton's remark that full-text collections operate as an implicit thesaurus and Wittgenstein's meaning-is-use theory, are, however, relatively weak analyses.[7] Thomas Kuhn developed what may be a related but stronger theory (see Andersen, Barker and Chen 2006). We need to know much more about meaning distributions and relations in collections of documents. Even if Salton's remark represents a weak analysis, it should not be ignored: Development of KOSs should be based on studies of primary literatures supplemented with logical, philosophical and terminological studies. Salton talked about "using the large and small contexts now available with full-text in intelligent ways." I see a possible role for information specialists utilizing such contexts in intelligent ways and thus contributing to knowledge about terminologies, meaning and semantics, genres etc. that may serve IR whether it is done by humans or by computers (or, more likely, in combinations). Salton worked mostly with a specific approach, known as "the vector space model." Although this model is very strong and influential, it is based on specific assumptions that also have to be challenged, for example, the assumption that document similarity can be measured in an objective way and that the goal of IR is to retrieve "similar" documents.

The utilization of the contexts by information scientists is of course a moving target because technological advance will be able to utilize such findings. Such informational work cannot be understood as external to the scientific process but must be understood as a critical part involved in theoretical struggles in the field. Example: In evidence-based medicine there is a need for indexing the methodologies used (e.g. randomized controlled trials). But such methodologies could also be described by the authors in the full text-documents in ways that allow search systems to retrieve the documents effectively. The need for a specific kind of indexing therefore depends on the degree of standardization of specific genres and the ability of algorithms to utilize the given information. As soon as we are able to make criteria for searching and indexing explicit, they may be incorporated in the scientific norms of writing.

The conclusion of this section is that although algorithmic retrieval systems challenge classical databases and their associated technologies, including thesauri and human controlled searches, the case seems still to be open for the kind of tasks that thesauri were originally meant to support—although those classical systems may need to be developed further and hopefully integrated with full text databases and combined with algorithmic approaches. I am not saying whether this window of opportunity for LIS/KO is extremely small or large, just that I consider it to be open and in line with Robertson's judgment that statistical IR research needs to incorporate other kinds of knowledge.

3.0 The thesaurus as a kind of KOS

A thesaurus can be understood as a kind of knowledge organization system (KOS), or, if we consider different kinds of thesauri (e.g., automatically constructed thesauri, circular thesauri, non-hierarchical thesauri, fuzzy thesauri, indexing thesauri, macro thesauri, meta-thesauri, search thesauri, thesaurofacet and corporate thesauri), then the thesaurus concept can be understood as a family of related KOSs. The concept "KOS" is today a common term in KO, used as a generic term for, among other terms, classification systems, thesauri, taxonomies, ontologies, etc. Figure 1 shows the thesaurus among other KOSs[8] (see the more detailed explanation of the figure in Hjørland 2015c, 108-122).

Hjørland (2007, 369) understood KOSs in a broad and in a narrow sense. In the narrow sense, KOS is a synonym for semantic tools, defined as selections of concepts and an indication of some of their semantic relations.

In the history of library and information science (LIS), the *Universal Decimal Classification* (UDC) system was developed by Paul Otlet and Henri La Fontaine based on the 5th edition of the *Dewey Decimal Classification* (DDC) and first published 1905-1907. This system is mentioned here for two reasons: 1) it represented a KOS developed in LIS based on intimate cooperation with subject specialists. Today, we do not have, to my knowledge, an infrastructure for researching and developing KOSs based on a comparable interdisciplinary cooperation, which I see as a serious problem for LIS/KO; and 2) Systems like UDC became challenged by "mission oriented systems" (of which thesauri may be considered a kind).[9] I consider these two issues important for KOSs: that they be based on proper subject knowledge, and that they are reflecting the needs of a specific domain or can be "mission oriented."[10] While thesauri may, in principle, satisfy these two conditions, the question is whether this is also the case in practice. Does LIS/KO consider subject knowledge sufficiently? Is the theoretical basis of thesaurus development based on theo-

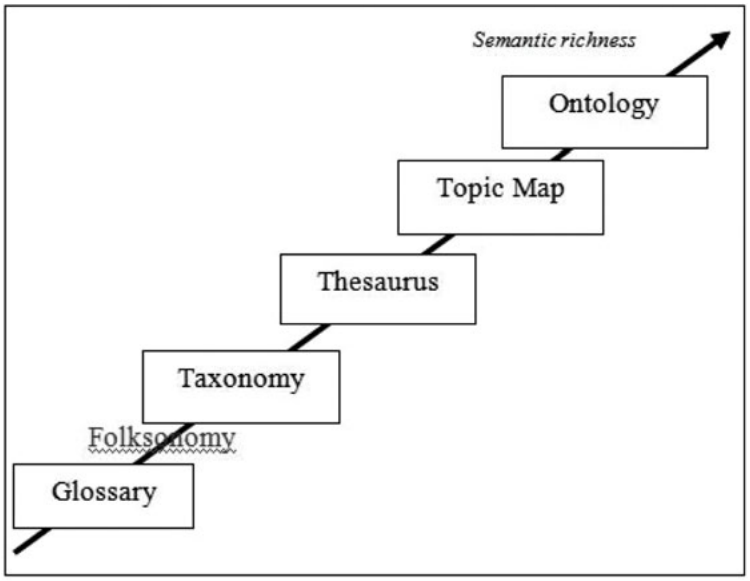

Figure 1. The semantic staircase (after Olensky 2010, section 2.3.3).

ries of knowledge? As far as I can tell, this is not the case in mainstream KO (see for example the criticism in Hjørland 2015a).

As is well known, thesauri display three main relationship types among their concepts: equivalence, hierarchical and associative, to which subtypes and additional relations may be added (Dextre Clarke 2001, 51). This is, however, just a fraction of the possible set of relations (probably an unlimited number of semantic relations exist, cf. Hjørland 2007, 391). The question therefore is: Why is the thesaurus limited to these kinds of relations? Which relations among the unlimited number of relations are useful for information retrieval? Kless et al. (2015) argue that thesauri and ontologies are "two orthogonal kinds of models." However, as discussed in Hjørland (2015c, 108-122), it is difficult to imagine that thesauri would not improve their functionality if they adopted some of the characteristics of ontologies. For example:

– Why should thesauri "bundle" different kinds of semantic relations (Such as different kinds of hierarchical relations or different kinds of associative relations)?
– Why should the generic relation (is-a) be used less consistently in a thesaurus than it is in an ontology?
– Why should relations in thesaurus always be bidirectional (i.e., reciprocal) rather than directed?

Dextre Clarke (2016, 142) addressed the first of these questions:

> People nowadays ask why thesauri do not have rigorously specified relationships in the style of ontologies. A superficial answer is straightforward—little need for them was perceived until the twenty-first century. Until about 20 years ago, the only purpose of the associative links (RT) in a thesaurus was to help the indexer/searcher navigate the thesaurus and think of more terms to use instead of or as well as the ones he/she first thought of…But since the associative links were not used directly in retrieval, designation of the type of RT was not among the features tested in the Cranfield experiments.

This is a purely speculative explanation, however. Either there is or is not a need for more specified relations during retrieval, and if there is such a need, it always existed (but was not recognized by the KO community before ontologies were constructed). If it has always existed, why then has the idea of restricted semantic relations developed in the first place (and why has it never been examined?)? [11] To continue the speculation, one may imagine that the designers have conceived the search as involving just three requirements:

a) to replace non-preferred terms with preferred terms by means of the USE relation
b) to narrow down too broad searches by means of the NT relation and
c) to broaden too narrow searches by means of the BT relation.

This idea of just three requirements supports Dextre Clarke's remark that "the associative links were not used directly in retrieval," but this idea seems problematic. Experienced searchers apply "retrieval devices" and "preci-

sion devices" in creative ways that goes beyond this idea and calls for the use of additional semantic relations, citation relations and more.

The differences between thesauri and ontologies may be justified by the different functions of these two kinds of KOSs. However, I am claiming that, for example, a) the "bundling" of RTs, b) the less consistent use of BT/NT relations and c) the avoidance of directed relations in thesauri have never been properly argued in theoretical or empirical research in information science. Thesauri would probably be improved if they adopted these attributes from ontologies, which are here understood as a kind of KOS in which there are no standardized limitations on the kind of semantic relations used in the construction. (Ontologies have other attributes as well, and I am not arguing that all attributes of ontologies should be used). Because an unlimited number of relations exist, each specific ontology is always based on a selected set of relations considered appropriate for its specific purpose. The traditional thesaurus may thus be considered a special case of ontology as here defined, and the main argument is that this special case should not automatically be preferred or seen as a standard, but that the development of KOSs should be open to different needs in different domains. (See also the arguments for augmentation of thesauri suggested by Tudhope, Alani and Jones 2001). The point is that until research has demonstrated the value of a specific limit on the use of semantic relations, no such limit should be accepted *a priori*. Instead the point of departure should be an open approach to any kind of semantic relations useful for a given task in a given domain.

Dextre Clarke (2001, 51) seems to be open to this view when she writes: "Rules optimized for one application cannot reasonably be expected to apply equally to others. Hence the thesaurus genus can be expected to evolve towards several different species with different styles of relationship as information science and technology advance." She has further stated (Dextre Clarke 2015):

> The main purpose of the relationships in a thesaurus was originally to help human users (both searchers and indexers) explore the indexing vocabulary to find the most appropriate term(s) to express a given concept. After computer-assisted retrieval became generally available, the hierarchical relationships found an additional use in supporting search "explosion" (in which a search could be automatically extended to include all the narrower terms of a given search term) but the main function of the associative relationships has continued to be helping the user to think of terms he/she could choose instead of or as well as his/her original terms(s) (See ISO 25964-1 clause 10.3.1). This function is very different from the inferencing applications and other automated functions that might be expected of an ontology. You refer to "bundling" of semantic relations, by which I guess you mean the thesaural practice of giving many distinct semantic relationships the same "RT" label. This would never do in an ontology, where (for example) the semantics of "apple tree isDamagedBy canker" must be distinguished from "canker isTreatedWith octithilinone" if a computer is to instruct the grower in how to protect his crop. But a knowledgeable human searcher faced with "canker RT apple tree" and "canker RT octithilinone" has no difficulty deciding whether "apple tree" or "octithilinone" is more relevant to his enquiry, and so no need for the type of relationship to be specified.

Before considering the arguments in this quotation it should be mentioned that Kless et al. (2015, 1361) also speak in support of the thesaurus principles, thus, for example:

> Whole-part relationships and associative relationships in thesauri appear to describe a kind of prototypical reality—one that describes the things in their idealized—that is, "common," "usual," or "normal"—form. Sometimes, the associative relationships also appear to express experience or things that are noteworthy in some context, such as "Fertilizers cause soil pollution." Thesauri use the relationships in this way because they (a) allow navigating the concepts of a thesaurus, (b) guide the indexer and searcher in selecting indexing/search terms, or (c) serve other purposes of information retrieval such as automatic search expansion (ISO 25964-1 2011, section 4.1).

Concerning the function of a thesaurus (Dextre Clarke 2015), "to help human users (both searchers and indexers) explore the indexing vocabulary to find the most appropriate term(s) to express a given concept," I have formerly argued (see Hjørland 2011) that the conventional dichotomy between "human IR" and "machine IR" should be relaxed, because both forms are influenced by subjective factors that need to be considered in research. One of the problems in this dichotomy is that we cannot take for granted that there is a future for human searchers if we cannot justify this activity by documenting better research results. Computer scientists also are developing automatically constructed thesauri (e.g. co-occurrence-based automatically constructed thesauri and head-modifier-based automatically constructed thesauri). The arguments for human searchers and the arguments for "classical databases" and traditional thesauri are parts of the same challenge.

It is correct, as stated by Dextre Clarke, that "explosion" (i.e. automatically to retrieve all narrower terms for a given concept) is something between human searching and machine searching, implying that the thesaurus is not just serving pure human IR. Kless et al. (2015) added that thesauri may also serve query expansion, thus relaxing the dichotomy further.[12] Therefore, the goal of research in KO should be to support the development of KOS/semantic tools for both human based retrieval and algorithmic-based retrieval.

Those researchers who will argue that thesauri and ontologies are "two orthogonal kinds of models" make the assumption that humans and machines need different sets of "associatively related" terms for query expansion, which cannot be the case since a given expansion either is fruitful or not fruitful. Alternatively, they assume that the human users know the relevant relations thus making their specification unnecessary. However, we cannot always expect the users to know the implicit relations in "bundled" relations, and the more bundled, the more unclear the relations will be. Also, in the construction of KOS: the more bundled, the greater is the risk that the set of terms listed has been arbitrarily selected without careful consideration.

The "associative relation" in thesauri is in my opinion particularly unfruitful. First, it seems to suggest that there are psychological principles determining when a given term is associated with another, which I consider problematic (it would therefore be much better to term this bundle "other relations"). Second, it represents a bundling of some well-defined relations such as antonyms, cause-effect and relations between terms referring to points in sequences (e.g. bachelor, master). My intuition is that explicating such relations is better than bundling them, but, as already stated, the point is that the form of the traditional thesaurus has never been empirically or theoretically justified, which obviously is not a satisfactory condition for a research-based field. Therefore, I argue that the burden of proof is with the people who defend the present thesaurus standard.

The thesaurus standard ISO 25964-1 (58ff) distinguishes three kinds of hierarchical relations: 1) the generic relationship; 2) the hierarchical whole-part relationship; and 3) the instance relationship. It states (58): "The main function of hierarchical relationships is to help both indexers and searchers choose the appropriate level of specificity. A search can be broadened or narrowed by moving up or down, respectively, in the hierarchy." However, if we consider the concepts "recall devices" and "precision devices" as alternatives to broadening or narrowing as search, I believe this quote is somewhat misleading because also other than hierarchical relationships may be useful as such devices (see also the discussion of recall and precision devices in Hjørland 2015b).

ISO 25964-1 finds that the tags BT/NT are normally adequate to identify also the partitive relationship, but that the following tags may also be used:

BTG= broader term (generic)
NTG= narrower term (generic)
BTP= broader term (partitive)
NTP= narrower term (partitive)
BTI= broader term (instantial)
NTI= narrower term (instantial)

While I find the descriptions in the standard fruitful, I am thinking about the relation between 1) primary research; 2) textbooks; and 3) standards. Much of this fruitful text about, for example, kinds of hierarchy might be considered textbook stuff. The tags above are of course examples of relevant standardizations, but ISO 25964 is silent about when it would be relevant to distinguish these different kinds of hierarchy. In not doing so, and by stating that BT/NT normally are adequate to distinguish hierarchical relations, it introduces something, which afterwards is not recommended. As an example of primary research it can be mentioned that philosophers and scientists consider issues related to partitive relations in the field known as "mereology" (see, for example, Winston, Chaffin and Hermann 1987; Calosi and Graziani 2014 and Alexiev, Isaac and Lindenthal 2015). Winston, Chaffin and Hermann (1987) provided a classification into six types of meronymic relations:

1. component-integral object (pedal-bike).
2. member-collection (ship-fleet),
3. portion-mass (slice-pie),
4. stuff-object (steel-car).
5. feature-activity (paying-shopping), and
6. place-area (Everglades-Florida).

Such additional knowledge about the nature of semantic relations should find its way into textbooks in knowledge organization, just as we in the field should contribute to such research.

Different kinds of relations have different importance in different domains. In technology the component-integral relation is highly important, while the place-area relation is important in geography. The cause-effect relation is important in medicine and in many fields the generic relation is important. Because of this, and because the semantic relations themselves may be relative to different queries, it is problematic to consider a thesaurus as a uniform standard for all fields as opposed to a domain-specific semantic tool.

I'll conclude this section with another important issue (Maniez 1997, 213): "Paradoxically the information lan-

guages [e.g. thesauri] increase the difficulties of cooperation between the different information databases."

Different thesauri tend to develop their individual preferred terminology and thus produce yet another "voice" that the searcher has to relate to. In modern information retrieval, searchers are primarily communicating with the title, abstracts, full-text and citations in documents themselves, thus learning about the genres, terminologies and citation-relations in scholarly communication. IR is a learning process, in which the searcher learns to discriminate between the different "voices" and adjust the search strategy accordingly. In order to contribute, knowledge organization should avoid adding to the difficulties, but should rather help by identifying the existing voices, by providing more descriptive and less prescriptive systems and by justifying the prescriptive choices carefully.

4.0 A basic problem: the challenge for controlled vocabularies

A thesaurus is a kind of controlled vocabulary (CV), and the question is not just whether thesauri are relevant in modern information retrieval, but whether any kind of CV is (cf. the quote by Salton above). There has been a very long controversy about the importance of CV as a tool to improve retrieval based on so-called "natural language" and there is so far no clear conclusion.[13] The reason seems obvious: the answer to the old question is not that either CV or natural language (NL) is always best, but that it depends on context, and the relative quality of each. The quality of a given CV segment depends, among other things, on the qualifications of the person who produced that segment just as the quality of a given natural language segment depends on the qualifications of the person who produced it. It seems absurd to ask the question; which kinds of segments are in general the best? The following insight provided by Elaine Svenonius (2003, 837) is therefore relevant:

> Whether a CV should be constructed in a given situation depends on a number of factors. Some of these are obvious, such as existence of closely related CV, the availability of financial and intellectual resources, and the political promise of support. There are others, however, which are not so obvious, that have to do with the expected effectiveness of a CV. Foremost among these are the nature of the subject discipline involved and the retrieval requirements of potential users of the CV. If a subject discipline is such that its writers tend to give their works noninformative titles, a CV is needed. A CV is needed if the vocabulary of the discipline exhibits very little representational predictability. On the other hand, if the discipline lacks a special terminology or if its vocabulary exhibits a great deal of linguistic indeterminateness, a CV may be less valuable to the extent that control is difficult to impose. It may be less valuable as well in the discipline where the predominant mode of organizing and searching for information is not by subject (in disciplines whose information resources are largely archival).

This quotation is important because it shows how CV-construction has to take careful account of terminological problems in specific domains. Instead of considering "natural language" one thing that CV is the alternative to, Svenonius relativizes the nature of "natural language" (or rather the special language as used in a given domain). The needed terminological control depends on the precision of the special language. It may also depend on the purpose of the thesaurus, which may provide a particular perspective on a domain. For example, in evidence based medicine (EBM), it is important to be able to retrieve documents from the research methods used (according to prevailing norms of producing systematic reviews). To the degree that documents are not retrievable by such norms, a CV might contribute better retrieval (but editors of medical journals could also develop norms for articles, which made research methods searchable by some standardized guidelines. This is the reason why the design of CVs is a moving target). This example explains why it is dangerous to understand CVs and thesauri as based on standardized principles rather than on domain-specific-analyses.

It is important to understand a CV as a kind of interpretation and that the function of the CV depends on the relevance and quality of that interpretation, which is relative to different "information needs." In other words: a CV is not an ideal language (cf., Eco 1995) that just removes unclarity from "natural language." Two terms, A and B, are not inherently synonyms (but may be considered equivalent for given purposes). Semantic relations are not "context-free, definitional, and true in all possible worlds" as it has been claimed (cf. Hjørland 2015a). Any controlled vocabulary should be understood as "a voice" among other voices (Bakhtin 1981). Different "voices" are connected to different interests, perspectives, theories or "paradigms" (Kuhn 1962). Therefore, it is not the formal structure of CVs that is the most important issue to consider, but rather the relevance and quality of the interpretations done in both the construction and application of them.

An important issue is: How do designers of CVs determine the meaning of terms and their semantic relations? Very little has been written about this, and mostly the important philosophical issues have been neglected. Bernd Frohmann (1983) provides an important critique based on

Wittgenstein's philosophy about some assumptions made by Derek Austin and the Classification Research Group. The assumptions that were criticized have a certain similarity with what has been termed "the theory of conceptual analysis" on which the *Routledge Encyclopedia of Philosophy* (Hanna 1998) writes:

> The theory of conceptual analysis holds that concepts—general meanings of linguistic predicates—are the fundamental objects of philosophical inquiry, and that insights into conceptual contents are expressed in necessary 'conceptual truths' (analytic propositions). There are two methods for obtaining these truths:
>
> (1) direct a priori definition of concepts;
>
> (2) indirect 'transcendental' argumentation.
>
> The movement of Conceptual Analysis arose at Cambridge during the first half of the twentieth century, and flourished at Oxford and many American departments of philosophy in the 1950s and early 1960s. In the USA its doctrines came under heavy criticism, and its proponents were not able to respond effectively; by the end of the 1970s the movement was widely regarded as defunct.

Hjørland (2014) made a related analysis and argued that facet analysis is based on rationalism and therefore is insufficient concerning empirical, historicist and pragmatist methods. The question is whether KO is based on this or another "defunct" philosophy? This is not done consciously; of course, most people in knowledge organization probably do not know of the existence of the philosophical theory of conceptual analysis (or the epistemological debates concerning rationalism etc.), but the way they determine semantic relations may well be based on intuitions and, therefore, be in accordance with "conceptual analysis." As long as an alternative method has not been explicated, we may assume that this is the case. My suggested alternative is to consider how things are organized according to current scientific theories (which may be termed "naturalization" of classification and semantics, corresponding to naturalization of epistemology).

KO often ignores scientific and scholarly classification, or KO people may even tend to consider themselves as professional in contrast to the naïve classifications of other researchers, cf. the debate between Hjørland/Nicolaisen (Hjørland and Nicolaisen 2004 and Nicolaisen and Hjørland 2004) and Claire Beghtol (2003, 2004). This is another indication that KO is more influenced by *a priori* principles than by studies of concept developments and semantic relations developed in different scholarly fields.

Another problem is that too few empirical studies about CV are made. The following quote (Liu 2010, 231) is an example of a relevant study, but the point here is that such studies are mainly made outside the KO community:

> This study addresses the value of document representations using controlled indexing languages for different kinds of users. We assessed the potential search effectiveness of MESH terms by reusing queries formulated by users with different levels of subject domain knowledge and search training in an interactive search environment. Our findings support the general conclusion that inclusion of MESH terms in the document representation did not affect the search effectiveness of queries in terms of the precision and recall measures. Adding MESH terms to the search index did not have a positive impact on effectiveness of queries formulated by different kinds of users.

This quote in itself indicates that the relevance of CVs cannot be taken for granted, that their utility in IR may not have a positive impact on IR effectiveness or that the quality of indexing by Medline has to be improves. Such findings are wake-up calls that should be considered with great care.

5.0 Conclusion

A core issue in information science and knowledge organization has always been to make it possible to identify relevant documents and information without too much noise and effort. "Classical databases" with thesauri and controlled vocabularies formed an important contribution to this goal (which today is challenged by search engines and information retrieval research in computer science). In order to evaluate different technologies, it is important to analyze their basic theoretical assumptions and the interests they are serving. The use of classical databases and thesauri is today mainly connected with serious scholarly purposes, such as finding the best evidence for a given medical treatment (see Hjørland 2012). For such purposes, the quality of the retrieval systems is decisive. The classical databases seem so far to outdo the search algorithms (cf. Hjørland 2015b), but the field is moving rapidly. It is important to base the further development of KO and LIS on deep theoretical understanding of terminology, knowledge, scientific paradigms and on the specific conditions in different domains.

The ISKO UK (2015) debate addressed the proposition: "This house believes that the traditional thesaurus has no place in modern information retrieval." My arguments in this article have supported this proposition by arguing that "the traditional thesaurus" is too much a "reification" in need of research connected to terminol-

ogy, knowledge and relevance criteria in different domains. People in KO cannot be experts in thesauri or other kinds of KOS alone but have to understand their role in information searching. There will probably always be a need for high quality KOS, but their design should be based on needs in the domain they are meant to serve.

Google-like retrieval systems become more and more important, while theory and research in LIS tend to seem less and less important (see, for example, the recent debate "Don't Go to Library School: you won't learn anything useful," Bawden 2015; Marcum 2015 and Robinson 2015). I believe that LIS does have relevant things to contribute, but this demands a serious interest in the more theoretical problems that Buckland's quote also called for.

The information in the literature, for example, ISO 25964-1, 2011, is important for information professionals to know and something we can be proud of. What I suggest is that it is not enough, but has to be followed-up by more philosophical and domain-specific knowledge. I would suggest that the design of thesauri be downgraded, and that the evaluation of existing thesauri be upgraded. This may not be easy but important. Besides, more flexible semantic tools such as Topic Maps should be examined; rather than following the restrictions of a standard, we should experiment with more kinds of semantic relations.

Notes

1. David Bawden has contributed to a valuable manual for thesaurus construction (Aitchison, Gilchrist and Bawden 2000), and he has also made theoretical contributions, e.g. suggested the use of quantum concepts and formalisms in the information sciences (Bawden, Robinson and Siddiqui 2015). It is not easy, however, to see any connection between the interest in thesauri and in quantum mechanics; the theoretical contributions seem not to have evolved out of the work with thesauri. Unfortunately, research and practice seems hereby to be separated. Such a lack of research into the specific problems related to thesauri and other KOS seems to be the rule rather than the exception.
2. Google-like systems is a broad category. Google itself is a general-purpose system (as opposed to specialized systems). It has been shown that such general-purpose systems are not adequate for very specific finding information, for example, information about rare diseases. FindZebra is a specialized search engine which has far better retrieval effectiveness for rare diseases (see Dragusin et al. 2013a+b). Another important distinction is between "exact match" systems and "best match" systems. Hjørland (2015) argued that in order to ensure the retrieval of all relevant findings, the exact match systems provide the searcher a better control. It should also be considered that Google itself uses different approaches, including bibliometric approaches, personalization (cf. Pariser 2011) and "Knowledge-Based Trust" (cf. Bradley 2015). The important thing is that a search algorithm is not a neutral thing but is always supporting certain interests and values at the expense of others.
3. There are, however, attempts in both computer science and in LIS/KO to develop thesauri based on algorithmic, statistical principles (see Lykke Nielsen 2004, 72ff, for a bibliography). Schneider (2005) used bibliometric methods to suggest thesaurus terms. His research was based on the assumption that manually developed thesauri can be considered "gold standards" by which automatic approaches may be verified. However, manually constructed thesauri also represent kinds of bias and subjectivity, and, therefore, this assumption may be considered problematic. Also, the idea to introduce an algorithmic thesaurus between user and the documents may be an unnecessary detour. These remarks should not, however, hide the fact that this dissertation is a very important contribution.
4. "Compare the 5S approach with how you usually seek evidence-based information. Is it time to revise your tactics? If, for example, it surprises you that PubMed is so low on the 5S list of resources for finding current best evidence, then this communication will have served a purpose: Resources for finding evidence have evolved in the past few years, and searches can be a lot quicker and more satisfying for answering clinical questions if the features of your quest match those of one of the more advanced services. This is in no way a knock against PubMed, which continues to provide a premier access route to the studies and reviews that form the foundation for all of the other more specialized databases reviewed here." (https://acpjc.acponline.org/Content/145/3/issue/ACPJC-2006-145-3-A08.htm)
5. Goodman (2002) reported a crisis in evidence-based medicine because of disagreements about which studies should be included in the pooled analysis. This disagreement points to important philosophical questions and the abandoning of the idea of pure mechanical or algorithmic selection of studies. This is both bad and good news for information science. It is bad news, because our criteria for indexing and searching becomes less explicit. It is good news, because it may indicate a possible role for human indexers that is hard for algorithmic IR and machine learning to replace. However, this puts even more demands on subject knowledge/domain specificity in LIS/KO.

6. Among these problematic assumptions are 1) that mainstream IR uses measurements of similarity between documents that fail to consider that any two things are similar and dissimilar in a multitude of ways, and that it is necessary to define the perspective according to which things (documents) are considered similar; and 2) that mainstream IR fails to consider documents part of a tradition or "paradigm" and thus may be compared with the status of biological taxonomy before the development of the cladistics paradigm (see Hjørland 2013a+2016).
7. See, for example, Hintikka (1996). *Ludwig Wittgenstein: Half-Truths and One-and-a-Half-Truths.*
8. In this paper, the figure from Olensky (2010) is taken for granted, but it might be worth further investigation. There is a very broad range of, for example, dictionaries, which may contain many more kinds of semantic relations than the figure suggests. When the first edition of "Thesaurus of psychological index terms" was published it was reviewed by Brozek (1975, 718), who concluded: "Unquestionably, the activities aiming to enhance effective communication of psychological concepts should be continued, with the development of a comprehensive, dependable Dictionary of Psychological Terms as a major goal." Brozek thus felt, as did I, that thesaurus needed to be supported by a better understanding of psychological terms. Again, this is an indication that thesaurus development should be connected with terminological studies and other forms of domain analysis.
9. "Perhaps his [Farradane's] important recommendation was that the conference rejects the UDC (Universal Decimal Classification) as a system for organizing scientific information. One may speculate that Farradane's decision influenced Mortimer Taube, the invited guest of the U.S. Library of Congress, who, just two years later in 1950 at the University of Chicago, was the sole advocate of mission-oriented bibliography and service, as opposed to general, traditional library classification." (Lilley and Trice 1989, 18).
10. This "mission-orientated view seems to correspond to the view developed by the "second generation documentation" (cf., Briet 2006). "One of Briet's most important insights was that individual documents may be interpreted in different ways by different people wishing to put them to different uses for different purposes. This variability of interpretation is characteristic of documents even at the level of individual words, and the different decisions made by different translators at the word level can have significant consequences." (Furner 2008, 107). And "Briet's understanding of documentation or information is based on sociological and cultural understandings of user needs, expressed by ways of life and vocabulary. Her notion of the user is not that of individual needs and psychological satisfactions, but rather, institutional and other cultural needs for the performance of tasks and the answering of questions formulated out of social situations and cultural forms." (Day 2006).
11. Since I finished this paper, I found the following statement, which I find supports my point of view: "Terminological investigations into relations between concepts traditionally results in a trichotomy of conceptual relations specified as equivalent, hierarchical and associative. This classification is based on a logical criterion, in line with the pre-constructivist, realist ontology of Wüster's time conception (Budin 2003, 75–76)" (Sambre and Wermuth 2015, 101). In general, terminological studies seem to have the kind of theoretical developments that I have asked for in knowledge organization; see also Cabré Castellví (2003).
12. This author had a bad experience using the explode command back in the 1980s searching for "psychological testing of drug abusers," in which all kinds of "psychological tests" as well as all kinds of "drug abuse" were automatically retrieved. Because of a minor error in the PsycInfo thesaurus, the retrieved set became useless, which was much more serious at that time than it would be today. Probably greater rigor in design principles—related to principles of ontology construction—would have prevented this error
13. For example, see Bogers and Petras (2015, 2):

> 2.1 Natural Language vs. Controlled Vocabularies
> The arguments for natural or controlled language indexing have been enumerated often (Aitchison & Gilchrist 1987; [Dextre] Clarke 2008). Advantages of controlled indexing are synonym and homonym control and the expression of semantic relationships between concepts. The advantages of natural languages are the use of the users' vocabulary and the avoidance indexing errors. CVs have large development costs and often use outdated vocabulary. Natural language can lead to a loss in precision or recall because of vagueness.
>
> 2.2 Searching with Natural Language or Controlled Vocabularies
> While many experiments showed early that natural language performs as well as CVs for searching (Rowley 1994), others claimed that natural language can lead to a performance drop (Lancaster, Connell, Bishop, and Mccowan 1991; Brooks 1993). Notably, the Cranfield experiments showed that individual natural language terms

performed best, but controlled indexing was better than full-text (Cleverdon and Mills 1963). Several studies found that CVs and natural language complement each other (Rajashekar and Croft 1995; Gross and Taylor 2005; Abdou and Savoy 2008), others find users are better served with the natural language (Choi, Hsieh-Yee, and Kules 2007; Liu 2010).

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