

Methodological Challenges in Scheme Versioning and Subject Ontogeny Research

Joseph T. Tennis

Information School, University of Washington, Box 352840, Mary Gates Hall,
Ste 370, Seattle, WA 98195-2840, <jtennis@uw.edu>

Joseph T. Tennis is Associate Professor and Associate Dean of Faculty Affairs at the University of Washington Information School, Adjunct Associate Professor in Linguistics, and a member of the Textual Studies and Museology faculty advisory groups at the University of Washington. He is President of the International Society for Knowledge Organization and immediate past chair of the Dublin Core Metadata Initiative. He is on the *Library Quarterly* and *Knowledge Organization* editorial boards, and a member of the InterPARES Trust research team—a multidisciplinary digital records preservation research project. Tennis works in classification theory, metadata versioning, ethics of knowledge organization, descriptive informatics and authenticity.



Tennis, Joseph T. 2016. "Methodological Challenges in Scheme Versioning and Subject Ontogeny Research." *Knowledge Organization* 43(8): 573-580. 53 references.

Abstract: This paper describes the philosophical and operational challenges to methodology in subject ontogeny research. The observation that indexing languages, comprising thesauri, classification schemes, taxonomies, and ontologies change over time has been a concern of the first order. The need to question the methods and aims of subject ontogeny and scheme change are second order work requiring ontological and epistemic assumptions. Operational concerns for the study of scheme change and subject ontogeny are species of one two-sided issue: isolation quantification. While some foundational issues make the study of the topic difficult, there may be some helpful techniques including phenomenology.

Received 14 October 2016; Revised 8 November 2016; Accepted 10 November 2016

Keywords: subject ontogeny, context, indexing, change, scheme versioning, classification

1.0 Introduction

The observation that indexing languages, comprising thesauri, classification schemes, taxonomies, and ontologies change over time has in the past, been a concern of the first order (Tennis 2015b). That is, the methods brought to bear on studying indexing language change have grown out of attempts at building faithful representations of a universe of knowledge for a particular user group. Those methods include literary warrant comparisons (Hulme 1911-12), facet analysis (Ranganathan 1967; Gnoli 2008), user studies (Fidel 1994), domain analysis (Hjørland 2002; Tennis 2003), cultural and ethical warrant (Beghtol 2002; Olson and Schlegl 2001; Smiraglia 2014), and discussions on the structure and nature of classificatory structures (Broadfield 1946; Olson 2001; Tennis 2016; Parrochia and Neuville 2013; Lee 2011; Dawkins 1976; Frické 2012, *passim*).

In all of these cases, the methodological concerns focus on a faithful representation of the literature so that users can find items in the collection or make sense of the

scope and range of the collection. This is coupled with the concern with creating a parsimonious divide among literatures—that is the differences that make a difference. Effective and efficient access is the desideratum. Even with the ethical and cultural warrant methodologies, there is a pragmatic concern directed toward the goal of the indexing language working effectively and efficiently in order to place appropriate and relevant literature in front of users based on their queries. What is lacking in this approach is a reflection on the complexity of the work of maintaining indexing languages once they are built. Further, it is left to other methods, second-order methods and foundational methods, to focus on the internal consistency of indexing languages through change, as well as the constant investigation into the foundations on which these indexing languages are built (Tennis 2016).

First-order literature looks at the practice of designing and implementing classification schemes. This literature is core to our understanding of classification and shapes the topics of our canonical texts (e.g., Berwick Sayers 1955; Ranganathan 1967; Vickery 1960; Hunter 2002). The

twentieth century saw innovations and advancement in the form of faceted classification and analytico-synthetic classification design methods devised by S. R. Ranganathan and the Classification Research Group (CRG). This is first order because we need to have classification schemes in order to study how best to improve them.

Research presented in second-order literature concerns itself with what to do with classification schemes once they are built. Issues that arise at the second order are how to maintain schemes over time as concepts change and also how we might build crosswalks and switching languages to allow for extant classification schemes to interoperate. These are second-order concerns in classification theory. For example, the work on subject ontogeny and scheme versioning, the subject of this special issue, is concerned with how to preserve the functionality of classification schemes over time, while allowing scheme designers to keep with literary warrant. Likewise, interoperability research attempts the seemingly impossible. It looks into ways that schemes built for a particular purpose can be deployed in service to another context (Dahlberg 1996a, 1996b, 1996c; Panzer and Zeng 2009).

The third category is called foundational literature. It is concerned with defining concepts and terms used in the discipline and are deployed in design, description, and evaluation research in knowledge organization. For example, a fundamental question might be (c.f., Broadfield 1946), what are classes? Other topics relate to the relationship between hierarchical order and socio-political structures like patriarchy (Olson 2007). The authors that contribute to the other orders listed above must deal with foundational and definitional issues in order to do their work. This degree of detail and commitment in definitional work is variable. Some of it is consciously concerned with laying foundations, like Svenonius (1999), Bowker and Star (2001), and Smiraglia (2003). Others look to not only establish our foundations of classification theory, but also look to destabilize us so that we are thinking critically about our assumptions (Furner 2009, Mai 2002).

Indexing language change, so far observed as a constant or an inevitability, has been seen as undesirable and as the kind of labor that is unwanted and perhaps even so challenging as to be avoided—only to be tackled when absolutely necessary (Broadfield 1946). The exception is Ranganathan's faceted approach to classification that allows for the addition of new subjects and new aspects of subjects in its design (1937; 1957; 1967). His technique, like Bliss's and the Classification Research Group's work, made classification schemes hospitable to new subjects, subjects that were combinations of old subjects, and subjects that stand in relation to other subjects and methods (Bliss 1933; Vickery 1960).

However, in order for our indexing languages to persist as highly functioning infrastructure, we must design for other kinds of change. We must account for semantic shifts in classes of literature and semantic shifts between and among the relationships of the classes. This design requirement is consistently pitted against the labor and complexity of second-order work. There remains, based on current understandings of work practice, a balancing act between building for now and building for change (Tennis and Sutton 2008). Research into the ontogeny of subjects and the anatomy of indexing language change (or scheme change) has not only the value of showing us how our structures can be made to adapt, but also lays bare the contours of the necessary complexities we see manifest in our attempts at representing content, subjects, topics and aboutness in our schemes over time. So while we need to question the methods and aims of subject ontogeny and scheme change research (second order work), we also interrogate the bedrock on which our indexing languages are built. We engage, in the case of the latter, in foundational work. In both cases, it seems to me, we must embrace this complexity, at least its presence, and then through research and development identify the most effective and efficient means to serving users in this complex environment.

2.0 Designing indexing languages: methodological concerns of the first order

The primary methodological concern for designers of indexing languages has been keeping the scheme as current as possible from the outset. Editors and designers were and still are preoccupied with drawing terminology from the appropriate source, or warrant. Early discussions of this in the literature called this statistical bibliography or literary warrant (Hulme, 1911-12). Further, these early discussions were focused on the literature of a particular collection or context. Contemporary discussions of this topic call themselves domain analysis (e.g., Hjørland 2002).

In both cases the authors of warrant literature assume a stable view of a context or domain. This is not a view shared by all theorists in this space. Ranganathan assumed that the context or domain would change over time. His work, at least in part, was in support of keeping a scheme for classification intact while representing how the context or domain grew (1937; 1957; 1967). He called it a *continuous infinite universe* (1967, 75 emphasis added). However, growth to Ranganathan was simply the addition of new subjects to the domain. Subjects already present in the context or domain, and represented in the scheme for classification, did not change. Thus, we are led to believe that in Ranganathan's conception, the extension and intension of "civil engineering" in 1933 would be identical to those of "civil

engineering” in 2016 (cf., Tennis 2012a). Contemporary examples of this work in vocabulary development demonstrate a similar understanding of a growing universe of subjects, but with the same assumptions that subjects that are already given in a scheme are stable, effective, and it is efficient to let them stay (cf., Green 2016).

In a brief case study, Tennis identified how this is not necessarily true in every case, at least in disciplinary-based classification schemes (Tennis 2002). Using the topic “eugenics,” Tennis was able to show how the *Dewey Decimal Classification* system redefined the topic based on how it was positioned in the scheme over time. Further investigations into the *DDC* case showed other factors that influenced change in the topic over time (Tennis 2007; 2012b). Not only are there changes in position within the scheme, but editors can also change the words used to describe or contextualize topics, and further they can consciously or unintentionally reference different or shifting warrants in updating schemes (Tennis 2007). This means that stability, while a desirable, is not always guaranteed in long-lived schemes.

Here we arrive at one of the key methodological concerns for second order classification theory and for subject ontogeny research in particular: the nature of the relationship between classes, terms for classes, and the literature classed not at one point in time, but over time. This concern has two prongs. The first is philosophical and concerns itself with the ontological and epistemological questions related to subjects over time. The second is operational. How do we act in designing indexing languages to account for what we understand the nature of subjects to be over time? Coupled with these questions there is one concomitant question that relates to methodology. Namely, how do we perceive time in this context and how does it impact our understanding of the nature of these relationships and how we act on that understanding in designing indexing languages?

In the next section I take up each of these individually, and try to point to both what we know, methodologically, and what work needs to be done.

3.0 Ontological and epistemic concerns

When we study scheme change and track the life of a subject we make ontological and epistemic assumptions. This, in turn, reveals our assumptions about the nature of indexing languages. As mentioned elsewhere (Tennis 2015a,163), we can see two different aspects of the ontology of subjects:

Ontologically, subjects are either real or negotiated. They are either real things or negotiated things. If we believe subjects are real things, we believe that

they persist unchanged through time, that we can name a subject, say, algebra, and have it more or less covered (or be coextensive) with the label. This is complicated by the fact that new concepts emerge and redefine the extension and intension of extant concepts. History and philosophy of science are full of evidence of this, from microbes to atoms. The opposite ontological position is that subjects are negotiated things. If they are negotiated they are not persistent and unchanged.

If we subscribe to the realist camp, we can, perhaps through trial and error, see what the subject is. That we make truth propositions about the nature of the subject by interrogating the relationships between subjects in the indexing language and the real world, with an eye to universals. That is, that this proposition is true in every context for all time (cf., Svenonius 2004). If that is the case, we can observe how our proposition about the subject either comports with reality in all contexts or not. We can then decide how to represent the revised proposition about the subject based on the rules of our representation system. If it is a classification scheme, we might decide to only change the terminology associated with the class or we may need to conduct other kinds of revisions (cf., Tennis 2007; Tennis and Sutton 2008; Tennis 2012a). In all cases the language used to represent the subject is just a label, and the degree to which this label is accurate is the nature of its relationship to the external world in all contexts (cf., Bernier 1968; Wittgenstein [1921] 1998).

The propositional or realist camp requires that we judge our subjects against the world. And when we do this we must rely on some evidence. In the case listed above, we run into a problem with this ontology of subjects. What is the evidence for “civil engineering”? Is it the literature on the topic? Is it the practice? And if it is either or both of these, then it would be difficult to argue that “civil engineering” as a topic has existed without change, is universal, and context independent. That is, the evidence of the history of this subject leads us to believe that it is negotiated. This poses methodological challenges for verifying our propositions of many kinds of subjects.

If we subscribe to the belief that subjects are negotiated things, then we must reflect on the ways they are negotiated. There are at least two ways subjects are negotiated. They are 1) always partial, or 2) known by what they are not (Tennis 2015a, 164):

If a subject is always partial, it means that we believe there is no way the representation of a subject in an indexing language covers every attribute or relation of that concept. The justification for this is variation in translation The second way of con-

sidering a subject negotiated is to know it by what it is not. This is the belief that we can make sense of a subject by considering what it is not, and its relationships with other subjects. This is a pragmatic view, that is, the representation of the concepts is doing some work in some context. And it is only by investigating this context and the work this subject does, that we understand it. And we understand it not as something permanent and unchanging, but as negotiated in a particular context.

In negotiated ontological commitments we only know the subject through context. We might root it in the context of the indexing language, the literature identified by the text of the subject, perhaps the users' conception as manifest in search and successful retrieval, or even through a large macro-social shared conception of what actions we might take based on naming this body of literature by a certain subject's name. We do not identify the subject as a constant entity *per se*. We instead match text strings and the work those text strings do for retrieval, browsing, and sense-making. Often we are not explicitly guided by any particular framework, and our conception of language is predominately pragmatic. That is, we assume language is a tool to do some work (Blair 1990). The measure of that work is itself contextual, depending on user conception, task, domain, and philosophical framework.

In neither case are we guaranteed to know the subject. If we do not know the subject, then we do not know if the subject has changed. What we do know is the context of the subject has changed. We know this through a series of relationships between the subject, other subjects in the indexing language, and the literature that is labeled with those subjects.

From here we are back to Wilson's "sense of position" (1968,72-73). Not unlike the documentalist ontology of documents, (i.e., a document is that which can be described (cf., Briet 1951; 2006)), Wilson not only questions the commonsense assumption that subjects exist, but does so through an analysis of how we identify them. Wilson, using Coates, questions the common assumption that subjects exist (72-73 emphasis original):

How can one account for the persistence of reference to "the subject" of a writing? Coates, for example, defines an "alphabetico-specific subject catalogue" as one in which the headings "state precisely the subjects of each document, chapter, section, paragraph, or other literary unit chosen as the basis for indexing" (Coates 1960); if he found it incredible that writings have single subjects, he would presumably not have given such a definition. Manuals of library practice are full of references to "the

subject" of a writing, and it can scarcely seem incredible to their authors that a writing that *is* one writing will have one subject.

What we see in the scare-quotes is an ontological claim. We are led by Wilson to question the certainty that subjects of documents exist, and to question our ability to identify them (75-92). This is further exacerbated by the nature of our indexing languages as he describes them (103-4):

Suppose I want to find, in ... the Dewey Decimal Classification, whatever writings there are that discuss the history of the use of the stirrup ... It happens that I shall find no position whose description includes specific mention of stirrups; but even if I did find such a position, I would only be at the beginning of my search, if assignment were to only a single position and made on the basis of identification of the unique subject of the items to be located. How do I decide where, or where else, to look for writings containing discussions of the history of the use of the stirrup? I find a position whose description runs: "Harnesses and accessories of livestock and domestic animals" and another with the description: "Harnesses and accessories of horses." ... There are hundreds of available positions ... In making a choice, I employ whatever knowledge I have, not only of the system of classification but of the world, of things, and of scholarship.

In other words, we need a conception of context in order to establish some identity (Furner 2009) between the literature we want (history of the use of the stirrup) and the positions in the classification scheme.

What changes, then, when the indexing language changes? What is the ontological commitment made in identifying the ontogeny of a subject? If we follow the argument above, that we rely on the context to know the subject, we only see relationships change. We see how the syndetic structure of the indexing language changes and we see how scope notes that contextualize the subject change. We see how a label (or term) for the subject changes and we see how the literature used either as warrant or as the set of documents indexed changes.

3.1 Epistemic concerns

The epistemic concerns we have about the methodologies employed in subject ontogeny and scheme versioning research deal with adequate information. If we understand epistemology to be how we know subjects then we are almost always dealing with incomplete and often times inadequate information about change. The asser-

tions we make about the presence or absence of subjects in literature are framed by epistemic assumptions. We assume we can know the presence of subjects by their context. Further that assumption is verified, to a degree, by the actions taken based on those assumptions. That is, we have models of what subjects are, and those are tested in context. Do we retrieve all items about Eugenics from searching on this term? If we take Wilson's case above, we do not. But he is employing a particular model of how we know subjects; that is, through the literature classed or indexed by that term. This empirical argument is linked to the purposes of indexing languages, but is also complicated by error, inter-indexer consistency, various theories of the indexing process, and semantic change (Bade 2002; Lancaster 2003; Mai 2003; Tennis 2012).

The upshot of this situation is the need to test models in relation to the goals of indexing languages, and assess what we know about scheme change from the outcomes of those tests. If context is king in the philosophical assumptions made about subject ontogeny and scheme change and the research that studies it, context is then a primary operational issue for us to consider in our research studies, data collection, and analysis.

4.0 Operationalization concerns

Operational concerns for the study of scheme change and subject ontogeny are species of one two-sided issue: isolation quantification. If we can isolate a single subject we can account for it, and then see it repeat or not over the various editions of the scheme. This basic problem manifests as operational concerns in at least three ways: 1) reification, 2) completeness of set, and 3) comparative work. We will take them in turn below.

4.1 Reification

To reify something is to make something abstract more concrete. When we begin observing subjects, across schemes and through time, and we follow the second ontology of subjects outlined above, we are using context (often incomplete) to create a thing—a particular subject. Once created, we can use it. And we use it to count subjects as present, absent or changed. We do this with little information. In many studies we only have the scheme alone. Many studies fail to account for a broader context or the literature indexed by the subjects studied (Tennis 2002). Where literature is used, it is used often used from a single source (Tennis 2013). If we only know subjects by context, and we are concerned that our information about context is incomplete, then we have more work we can do to verify the reification of subjects and their scope.

4.2 Completeness of set

The corollary to the concern about reification is the question of completeness of set. How do we know we have all of the data points derived from the appropriate context to assert we are dealing with an isolated and quantifiable subject? What happens to our assertions about the life of a subject in a scheme, especially a complex and long-lived scheme, if we are unable to point to all instances of it? We are not likely telling the whole story, and our understanding of the nature of the phenomenon is compromised. This also means we cannot compare across indexing languages.

4.3 Comparative work

With the compromised ability to confidently isolate and quantify subjects we cannot compare the contours of their histories across indexing languages. The implication of this is that it is difficult to design ameliorations to the problem of scheme change because we cannot make robust methodological linkages across studies. Our inconsistency in the process of reification means we are only approximating an operationalization of remains an intuitive phenomenon.

There are potential ameliorations to these problems. The first holds on to the problem space of a single subject and its life through an indexing language and the other backs away from that claim. The first is phenomenology and the latter is population epistemantics.

4.4 Phenomenology

If we take a phenomenological approach to subjects, their ontogeny, and the histories of the schemes that represent them, we are bracketing our reification of subjects (Husserl [1936] 1970). In so doing we are systematically suspending biases and assumptions in order to explain the subject and its life in any given scheme based on its own system of meaning. This does not let us off the hook for inadequate evidence of knowing the subject (our epistemic problem above), but rather amplifies it. We need to systematically account for how we are bracketing, that is how we are including and excluding context in order to establish the (now bracketed) subject in the context of its own system of meaning. Phenomenological bracketing is a common social scientific technique, but one that could be uniquely adapted and deployed in subject ontogeny research. This would begin to highlight the problems of reification and completeness of set as outlined above. Further, we do not need to compromise our ontological position here, because we are not operating on our assumptions of a negotiated and contextualized subject. If we

follow the phenomenological approach we are taking into account the symbolism and the system that we call, in shorthand, subjects in indexing languages.

One can imagine a standard description of a researcher's understanding of subject as a preamble to the exposition of a study of a subject's ontogeny. Along with this we could see differing epistemic and ontological commitments, but if we also saw the method of bracketing subjects, we could work to alleviate the concerns we have about reification, complete set, and comparisons.

4.5 Episemantics

Like epigenetics, which considers genetic effects outside of DNA, episemantics considers semantic effects outside of the indexing language. While only exploratory at this point, the idea of episemantics is to account for meaning as it changes over time outside of the scheme, and relate that to the scheme. Instead of reifying the subject in the context of the scheme alone, and linking those subject to a body of documents, episemantics would establish models for the investigation of particular relationships. These models would be networks of meaning that show how relationships between terms are established. These can then be weighted for popularity, prominence, uniqueness, or any other value. And from there charted to a timeline to see how various models change over time. This would then inform the study of subject ontogeny by providing another context to consider the complex of meaning identification we casually understand to be the emergence, multiplicity, and change of subjects over time.

This is possible only in the contemporary research context. Without mass digitization projects, we would not be able to think of something like episemantics. But with such initiatives now in their mature stages, and other online sources of context available, we might be able to provide robust context for the study of change. This does not solve the ontological problem of subjects in this context, but it does provide us with new way of addressing our epistemic concerns.

5.0 Conclusion and moving forward

If we follow the argument advanced by Wilson and the negotiated view of subjects, we have a problem with the study of subject ontogeny. We are not guaranteed, because there is no established method for isolating a subject, that we are telling the whole story. We are creating something which may or may not be there. This problem jeopardizes the work toward long-term persistence of the functionality of indexing languages simply because we are operating on a commonsense conception of subject. This paper has rehearsed some of the arguments for this. I have also tried

to provide some preliminary ameliorations. We can perhaps work around our foundational problems by bracketing or by looking outside the scheme. In the first case we focus inward on our assumptions and operationalizations of the subject, while redefining the subject not as a natural thing in the world, but as a symbolic thing meaningful to people in the world. The second is to broaden the investigation of semantic change to account for possible models of change, and look for the goodness of fit to describe the phenomenon.

As with many methodologies that deal with meaning, the work in subject ontogeny and scheme versioning does not admit to operationalization easily. Further the nature of indexing languages and their components is still up for debate. Alongside these debates, systems are being design and deployed without the awareness of these discussions. These systems are often a hybrid of controlled vocabularies and natural language. If our goal is effective and efficient retrieval, browsing, and sense-making, then we must meditate on the nature of our tools and the research that informs it. Because while nothing may be permanent, our work should help indexing languages be useful.

References

- Bade, David. 2002. "The Creation and Persistence of Misinformation in Shared Library Catalogs: Language and Subject Knowledge in a Technological Era." Occasional Papers no. 211. Champaign-Urbana, Ill.: Graduate School of Library and Information Science, Univ. of Illinois at Urbana-Champaign.
- Beghtol, Clare. 2002. "A proposed ethical warrant for global knowledge representation and organization systems." *Journal of Documentation* 58: 507-32.
- Bernier, Charles L. 1968. "Indexing and Thesauri." *Special Libraries* 59 no. 2: 98-103.
- Berwick Sayers, W.C. 1955. *A Manual of Classification for Librarians and Bibliographers*, 3rd ed. London: Grafton.
- Blair, David C. 1990. *Language and Representation in Information Retrieval*. Amsterdam: Elsevier.
- Bliss, H. E. 1933. *The Organization of Knowledge and the Subject-Approach to Books*. New York: Wilson.
- Bowker, Geoffrey and Susan Leigh Star. 2001. *Sorting Things Out: Classification and Its Consequences*. Cambridge: MIT.
- Briet, Suzanne. 1951. *Qu'est-ce que la documentation?* Paris: Éditions documentaires, industrielles et techniques.
- Briet, Suzanne. 2006. *What Is Documentation? English Translation of the Classic French Text*, trans. and ed. Ronald E. Day and Laurent Martinet with Hermina G. B. Anghelescu. Lanham, MD: Scarecrow Press, 2006
- Broadfield, A. M. 1946. *Philosophy of Classification*. London: Grafton.

- Dahlberg, Ingetraut. 1996a. "Library Catalogs in the Internet: Switching for Future Subject Access." In *Knowledge Organization and Change: Proceedings of the Fourth International ISKO Conference, 15-18 July 1996, Washington, DC, USA*, ed. Rebecca Green. Advances in Knowledge Organization 5. Frankfurt/Main: INDEKS Verlag, 155-64.
- Dahlberg, Ingetraut. 1996b. "The Compatibility Guidelines—A Re-evaluation." In *Compatibility and Integration of Order Systems: Research Seminar Proceedings of the TIP/ISKO Meeting, Warsaw, 13-15 September, 1995*, ed. I. Dahlberg and K. Siwek. Warsaw Wydawnictwo SBP.
- Dahlberg, Ingetraut. 1996c. "Compatibility and Integration of Order Systems 1960-1995: An Annotated Bibliography." In *Compatibility and Integration of Order Systems: Research Seminar Proceedings of the TIP/ISKO Meeting, Warsaw, 13-15 September, 1995*, ed. I. Dahlberg and K. Siwek. Warsaw Wydawnictwo SBP.
- Dawkins, Richard Bateson. 1976. "Hierarchical Organisation: A Candidate Principle for Ethology." In *Growing points in ethology*, ed. P.P.G. Bateson and R.A. Hinde. Oxford, England: Cambridge University Press, 7-54.
- Fidel, Raya. 1994. "User-Centered Indexing." *Journal of the American Society for Information Science* 45: 572-76.
- Frické, Martin. 2012. *Logic and the Organization of Information*. New York: Springer.
- Furner, Jonathan. 2009. "Interrogating Identity: A Philosophical Approach to an Enduring Issue in Knowledge Organization." *Knowledge Organization* 36: 3-16.
- Gnoli, Claudio. 2008. "Categories and Facets in Integrative Levels." *Axiomathes* 18: 177-92. Doi 10.1007/s10516-007-9022-z
- Green, Rebecca. 2016. "Data-Driven Development of the Dewey Decimal Classification." Presentation at International Conference on Dublin Core and Metadata Applications DC-2016, Copenhagen, Denmark. <http://dcevents.dublincore.org/IntConf/dc-2016/paper/view/435/507>
- Hjørland, Birger. 2002. "Domain Analysis in Information Science. Eleven Approaches—Traditional as well as Innovative." *Journal of Documentation* 58: 422-62.
- Hulme, E.W. 1911-12. "Principles of Book Classification." *Library Association Record* 13: 354-58, 389-94, 440-44; 14: 39-46, 174-81, 447.
- Hunter, Eric J. 2002. *Classification Made Simple*, 2nd ed. Aldershot: Ashgate.
- Husserl, Edmund. (1936) 1970. *The Crisis of European Sciences and Transcendental Philosophy*, trans. David Carr. Evanston: Northwestern University Press.
- Lancaster, F.W.(2003. *Indexing and Abstracting in Theory and Practice*. London: Facet Publishing.
- Lee, Hur-Li. 2011. "Epistemic Foundation of Bibliographic Classification in Early China." *Journal of Documentation* 68: 378-401.
- Mai, Jens-Erik. 2002. "Is Classification Theory Possible? Rethinking Classification Research. In *Challenges in Knowledge Representation and Organization for the 21st Century, Integration of Knowledge Across Boundaries, Proceedings of the 7th International ISKO Conference, 10-13 July 2002, Granada, Spain*, ed. Maria J. Lopez-Huertas. Advances in Knowledge Organization v. 8. Würzburg: Ergon-Verlag, 427-78.
- Mai, Jens-Erik. 2003. "The Future of General Classification." *Cataloging & Classification Quarterly* 37 nos. 1/2: 3-12.
- Olson, Hope A. 2001. "Patriarchal Structures of Subject Access and Subversive Techniques for Change." *Canadian Journal of Information and Library Science* 26 nos. 2/3: 1-29.
- Olson, Hope A. 2007. "How we Construct Subjects: A Feminist Analysis." *Library Trends* 56, no. 2: 509-41.
- Olson, Hope A. and Rose Schlegl. 2001. "Standardization, Objectivity, and User Focus: A Meta-analysis of Subject Access Critiques." *Cataloging & Classification Quarterly* 32 no. 2: 61-80.
- Panzer Michael and Marcia Lei Zeng. 2009. "Modeling Classification Systems in SKOS: Some Challenges and Best-Practice Recommendations." In *DCMI International Conference on Dublin Core Metadata and Metadata Applications*, 3-14.
- Parrochia, Daniel and Pierre Neuville. 2013. *Towards a General Theory of Classifications*. Studies in Universal Logic. Basel: Birkhäuser.
- Ranganathan, S.R. 1937. *Prolegomena to Library Classification*. Madras: Madras Library Association.
- Ranganathan, S.R. 1957. *The Five Lams of Library Science*, 2nd ed. Madras Library Association Publication Series 23. Madras: Madras Library Assn.
- Ranganathan, S.R. 1967. *Prolegomena to Library Classification*, 3rd ed. Bombay: Asia Publishing House.
- Smiraglia, Richard P. 2003. "The History of 'The Work' in the Modern Catalog." *Cataloging and Classification Quarterly* 35 nos. 3/4: 553-67.
- Smiraglia, Richard P. 2014. *Cultural Synergy in Information Institutions*. New York: Springer.
- Svenonius, Elaine. 1999. *The Intellectual Foundation of Information Organization*. Cambridge: MIT.
- Svenonius, Elaine. 2004. "The Epistemological Foundations of Knowledge Representations." *Library Trends* 52 no. 3: 571-87.
- Tennis, Joseph T. 2002. "Subject Ontogeny: Subject Access through Time and the Dimensionality of Classification." In *Challenges in Knowledge Representation and Organization for the 21st Century: Integration of Knowledge across Boundaries: Proceedings of the Seventh International ISKO Conference, 10-13 July 2002 Granada, Spain*, ed. Maria J. López-Huertas and Francisco J. Muñoz-Fernández.

- Advances in knowledge organization 8. Würzburg: Ergon-Verlag, 54-59.
- Tennis, Joseph T. 2003. "Two Axes of Domains for Domain Analysis." *Knowledge Organization* 30: 191-95.
- Tennis. 2007. "Scheme Versioning in the Semantic Web." *Cataloging and Classification Quarterly* 43 nos. 3/4: 85-104.
- Tennis, Joseph T. 2012a. "A Convenient Verisimilitude or Oppressive Internalization?: Characterizing the Ethical Augments Surrounding Hierarchical Structures in Knowledge Organization Systems." *Knowledge Organization* 39: 394-97.
- Tennis, Joseph T. 2012b. "Facets and Fugit Tempus: Considering Time in Faceted Classification Schemes." In *Categories, contexts, and relations in knowledge organization: Proceedings of the Twelfth International ISKO Conference, 6-9 August 2012, Mysore, India*, ed. A. Neelameghan and K.S. Raghavan. Advances in knowledge organization 13. Würzburg: Ergon Verlag, 58-62.
- Tennis, Joseph T. 2013. "Collocative Integrity and Our Many Varied Subjects: What the Metric of Alignment between Classification Scheme and Indexer Tells Us About Langridge's Theory of Indexing." In *Proceedings from North American Symposium on Knowledge Organization, Vol. 4. University of Wisconsin-Milwaukee*. <http://www.iskocus.org/nasko2013-proceedings.php> or <http://journals.lib.washington.edu/index.php/nasko/article/view/14660>
- Tennis, Joseph T. 2015a. "The Memory of What Is: Ontogeny Analysis and its Relationship to Ontological Concerns in Knowledge Organization." In *Ontology for Knowledge Organization*, ed. Richard P. Smiraglia and Hur-Li Lee. Würzburg: Ergon-Verlag, 97-100.
- Tennis, Joseph T. 2015b. "Foundational, First-Order, and Second-Order Classification Theory." *Knowledge Organization* 42: 244-49.
- Tennis, Joseph T. 2016. "Structure of Classification Theory: On Foundational and the Higher Layers of Classification Theory." In *Knowledge Organization for a Sustainable World: Challenges and Perspectives for Cultural, Scientific, and Technological Sharing in a Connected Society. Proceedings of the Fourteenth International ISKO Conference 27-29 September 2016, Rio de Janeiro, Brazil*, ed. José Augusto Chaves Guimarães, Suellen Oliveira Milani and Vera Dodobei. Advances in Knowledge Organization 15. Würzburg: Ergon-Verlag, 84-87.
- Tennis, Joseph T. and Stuart A. Sutton. 2008. "Extending the Simple Knowledge Organization System (SKOS) for Concept Management in Vocabulary Development Applications." *Journal of the American Society for Information Science and Technology* 59: 25-37.
- Vickery, Brian Campbell. 1960. *Faceted classification: A guide to construction and use of special schemes*. London: Aslib.
- Vickery, Brian Campbell. 1966. *Faceted Classification Schemes*. Rutgers Series on Systems for the Intellectual Organization of Information 5. New Brunswick, NJ: GSLS Rutgers.
- Wilson, Patrick. 1968. *Two Kinds of Power: An Essay in Bibliographical Control*. Berkeley: Univ. of California Press.
- Wittgenstein, Ludwig. (1921) 1998. *Tractatus Logico-Philosophicus*, trans. C. K. Ogden. Dover Publications.