This is a preprint of an article accepted for publication in Cataloging & Classification Quarterly.
Wu, S., & Fan, Y. (in press). Music literature indexing: Comparing users' free-text queries and controlled vocabularies. Manuscript will be published in *Cataloging & Classification Quarterly*.

MUSIC LITERATURE INDEXING: COMPARING USERS' FREE-TEXT QUERIES AND CONTROLLED VOCABULARIES

Shuheng Wu
Graduate School of Library and Information Studies, Queens College, 65-30 Kissena Blvd., Queens, NY 11367-1597. E-mail: Shuheng.Wu@qc.cuny.edu

Yun Fan
International Center, R_epertoire International de Litt_erature Musicale (RILM), New York. Email: yfan@rilm.org

ABSTRACT

This study examined the characteristics of users' free-text queries submitted to a music literature database (RILM Abstracts of Music Literature), comparing those queries with the controlled vocabularies used by RILM. Search-log analysis identified 11 categories of user-created search terms, and mapped each user-created search term to RILM's index terms, assessing whether it was a perfect match, a partial match, or no match. Only 30.04% of the user-created search terms did not match RILM's index terms. Most of the partial-matching and non-matching user-created search terms were personal names, work titles, and topical terms. Suggestions are offered to enhance RILM's controlled vocabularies.

Keywords

Music literature indexing, controlled vocabulary, thesaurus, authority file, user queries, RILM Abstracts of Music Literature, search-log analysis.

INTRODUCTION

Subject indexing of music literature (e.g., articles on music history) is often considered to be difficult because of language barriers[1] and the vocabulary problem: people using different words or languages to describe or search the same concepts or information objects.[2] The title of a musical work may be known in multiple languages and the best-known title may not be the original title. Overlap between the various numbering systems for musical works of established Western composers can cause some composers' works to be identified in multiple ways. For example, Beethoven's third symphony is widely known by its nickname "Eroica," while its Library of Congress (LC) uniform title is "Symphonies, no. 3, op. 55, E♭ major." Musicians' names may also have numerous variants. Musical terminology varies in different communities, cultures, and countries. For example, "Americans follow the German nomenclature (translated), while the British use a mixture of Anglicized Latin and French".[3] Musical terms from one tradition or culture are not always translatable to others. For example, the concept of *yinlü* is unique to Chinese music and although related to it, is not equal to the concept of pitch or temperament in Western music. Due to these language barriers and the vocabulary problem, catalogers, indexers, and scholars have not yet agreed upon how to index music literature.[4]

Different user groups (e.g., scholars, performers, teachers, music fans) may search the same music literature using different subject access points (e.g., genre, instrument, composer, level of difficulty) depending on their level of domain knowledge and varying interests. A musical work may have many instantiations (e.g., different scores, recordings, excerpts, and arrangements).[5] This creates challenges for the intellectual control of documents that contain or convey musical works. Downie pointed out the multicultural, multifaceted, multidisciplinary, multirepresentational, and multiexperiential challenges facing music information retrieval.[6]

Similarly, the indexing and retrieval of music literature may share those challenges.

Controlled vocabularies such as the Library of Congress Subject Headings (LCSH) have long been used in libraries, museums, archives, and bibliographic databases to address the vocabulary problem between users and the information systems that they use by translating user search terms into the indexing languages used by the systems. A *controlled vocabulary* can be defined as a controlled list of terms that have been enumerated explicitly, each of which has an unambiguous, non-redundant definition.[7] A controlled vocabulary can be as simple as an authorized list of terms—an authority file—and as complicated as a *thesaurus* consisting of terms arranged in a specific order and structured to display various relationships (e.g., associative, hierarchical) among the terms.[8] The purpose of controlled vocabularies is to improve the recall and precision of an indexing language, addressing the issues of synonyms, homonyms, and polysemes.[9] However, there is a lack of standard controlled vocabularies for music in the library community, and there has been limited work addressing this problem within the musicology community.[10]

There are problems with using controlled vocabularies to index and provide intellectual access to documents. Controlled vocabularies are rigid in their structure, and may not be familiar to users.[11] For example, many of the existing controlled vocabularies in music indexing were designed for trained musicians and scholars without taking into account the needs of general readers and novice listeners.[12] Controlled vocabularies have also been criticized as artificial[13] and biased for gender, age, race, ethnicity, religion, ability, and language.[14] The process of assigning subject index terms from controlled vocabularies to documents is labor-intensive and time-consuming. Inconsistencies exist even among experienced catalogers and indexers.[15] In some situations, providing keyword access to textual documents is a more cost-effective

approach, because controlled vocabularies can require expensive knowledge-engineering work and ongoing maintenance.[16] Some previous studies in information retrieval (e.g., [17], [18]) found that using controlled vocabularies failed to improve recall and precision, but these studies were criticized for their experimental designs.[19] A large body of research has examined whether controlled vocabularies should be replaced by keyword searching, and a review of this line of research can be found in Gross, Taylor, and Joudrey.[20]

One solution suggested for resolving the keyword searching versus controlled vocabulary dilemma is to augment controlled vocabularies with user search terms[21]. Compared with users' search queries, controlled vocabularies are often slow to adopt and reflect the most current terminology in a particular domain. For example, LCSH was criticized for a lack of facets and new genres to describe musical works, partly because the Library of Congress did not receive and catalog many popular music periodicals.[22]

There seems to be a need to identify sources of new knowledge; define methods and mechanisms for harvesting, evaluating, and incorporating new knowledge into controlled vocabularies;[23] and evaluate how closely controlled vocabularies can match users' applied terms and meet their information needs.[24] Monitoring user queries is one of the most effective and inexpensive means of identifying new terminology and highly technical terms which can then be integrated into controlled vocabularies.[25] Prior research has validated both the necessity and the functionality of indexing documents based on users' information needs and their search queries.[26]

This study examined the characteristics of users' free-text or natural language queries created in a music literature database, comparing those queries to the controlled vocabularies used in the database to identify any gaps in the controlled vocabularies. It also examined how to

enhance controlled vocabularies to better serve the user and indexer. This study addressed the following research questions:

1. What are the categories of users' free-text queries in music literature databases?
2. How do users' free-text queries created in music literature databases differ from the controlled vocabularies used by the databases?

The findings may enhance understanding of user queries in music literature databases, inform the design of music related controlled vocabularies, and provide insight into approaches to music literature indexing and retrieval. Design recommendations based on this study could be adopted in diverse settings and produce improved services for multiple stakeholders of music literature, such as librarians, indexers, users, databases, search engines, and publishers.

RELATED LITERATURE

Libraries, museums, and archives have a long history of developing and maintaining knowledge organization (KO) systems (e.g., subject headings, thesauri, classification schemes) to support the retrieval of bibliographic collections, including music literature. In a broader sense, KO is the social organization and division of the "universe of knowledge"; in a narrower sense, KO consists of the activities that librarians, archivists, information specialists, subject specialists, laymen, and computers perform to describe, index, and classify documents in libraries, museums, archives, bibliographic databases, and other kinds of "memory institutions".[27] Hjørland claimed that Library and Information Science (LIS) is a central discipline of KO, dealing with KO processes and systems.[28] The purpose of KO within LIS is to construct, apply, and evaluate KO systems for information retrieval.[29] However, KO cannot be studied independently from other disciplines. The construction, application, and evaluation of KO systems should be connected to a specific discipline or domain and their user communities by

analyzing the user needs, identifying KO systems that can satisfy the user needs, and implementing and maintaining KO systems in a way that can connect disparate communities.[30] Therefore, the development, evaluation, and maintenance of controlled vocabularies for music literature indexing and retrieval cannot be separated from the identification and analysis of user needs.

The leading principle that governs the admission of terms in controlled vocabularies is *literary warrant*, that is, new terms are warranted for inclusion only when they appear in the published literature.[31] A large number of modern controlled vocabularies (e.g., LCSH, Sears List of Subject Headings) follow the principle of literary warrant. However, using literary warrant alone has been proved problematic[32] for disregarding the contextual and subject knowledge as well as the targeted audience.[33] Some scholars in indexing (e.g., Dagobert Soergel) advocate using, in addition to literary warrant, common usage as the principle of selecting terms in controlled vocabularies.[34] The National Information Standards Organization (NISO) recommends utilizing user warrant (users' free-text searches) to enhance the completeness of controlled vocabularies.[35] Selecting common user terms can lead to controlled vocabularies that are more user-friendly and can accommodate users who are unfamiliar with the domain or discipline. This requires recording and paying attention to users' search terms.

Common user terms, user needs, and relationships among the terms can be identified by analyzing search logs[36] or conducting experiments involving end-user searches.[37] For example, Stvilia analyzed the Web server logs of Morphbank to identify users' quality requirements for biodiversity ontologies.[38] Nowick and Mering compared users' free-text queries recorded from a website related to water quality and three controlled vocabularies: LCSH, Water Resources Abstracts Thesaurus, and Aqualine Thesaurus.[39] The comparison examined specificity (broader,

narrower, or related terms), the use of synonyms and acronyms, singular or plural usage, variant spellings or word endings, and whether the word 'water' was included. The search-log analysis found that the total of exact match and near exact match between users' queries and three controlled vocabularies was between 50% and 60%. Compared with controlled vocabularies, users were more likely to use one or two word searches, topical keywords, acronyms, abbreviations, and new terminology.

Gross and Taylor used search terms from the transaction log of an academic library catalog to conduct a series of keyword searches.[40] They found that if the subject headings (LCSH) were removed from the catalog records, user-performed keyword searches would lose 35.9% of the retrievable results. This indicates that subject headings in bibliographic records that match user search terms provide unique subject access to around one third of the search results. Gross, Taylor, and Joudrey replicated Gross and Taylor's study[41] to examine the same keyword searches in the same library catalog but with the addition of automatic enriched metadata (e.g., table of contents, summaries).[42] They still found more than one fourth of the "hits" would be lost in the absence of subject headings (LCSH) in the catalog. Lee collected and content analyzed 1,705 queries from Google Answers' music category to identify user needs expressed and information features in those queries.[43] The content analysis found that the most crucial information needs in Google Answers were known-item searches such as identifying a musical work and/or an artist, locating a recording, and obtaining the lyrics of songs. Lee also identified some features that were heavily used in music information seeking: person-name, title, date, genre, role, lyrics, and place reference.

Besides analyzing search logs, there are a number of previous studies conducting experiments to identify users' information needs for controlled vocabularies. Bates conducted a

laboratory study to compare university students' subject search terms for a set of books with the LCSH assigned by an academic library to those books.[44] Bates's study found that students tended to use either broader or narrower terms than LCSH and to favor the natural order of nouns and adjectives (e.g., "human behavior" but not "behavior, human") when both nouns and adjectives appeared. White used a quasi-experiment to compare the free-text keywords created by scientists and information professionals when describing scientific datasets to four controlled vocabularies used in the sciences: LCSH, Medical Subject Headings (MeSH), National Biological Information Infrastructure Thesaurus (NBII), and Integrated Taxonomic Information System (ITIS).[45] White's experiment found that LCSH had the best coverage for topical terms (i.e., terms describing the aboutness of datasets) among the four controlled vocabularies, while ITIS had the strongest mapping for scientific terms (i.e., terms describing the standardized scientific names of biological species). Wetterstrom conducted a similar experiment to ask 20 users to assign tags to 217 books from the general collection of the National Library of New Zealand, comparing those tags to LCSH according to three categories: match, partial match, and no match.[46] Wetterstrom's experiment found that 75% of the user-generated tags did not match any LCSH entries. Wetterstrom further analyzed the non-matching tags to divide them into different subcategories. He found user-generated tags could complement LCSH by providing additional subject access points in the form of broader or narrower terms, terms in more popular languages, and terms providing different perspectives than those of catalogers. Stvilia, Jörgensen, and Wu conducted an experiment involving users to evaluate whether social metadata from Flickr and the English Wikipedia could enhance two controlled vocabularies—the Thesaurus for Graphical Materials and LCSH—for indexing historical images.[47] They found the social terms did provide added value to supplement and extend expert-created controlled vocabularies in the context of image

indexing and retrieval.

To the best of our knowledge, no previously published studies have examined the search logs of music literature databases or evaluated the quality or usefulness of any controlled vocabularies for music literature indexing and retrieval. This study aimed to address these gaps found in the literature.

STUDY DESIGN

RILM Abstracts of Music Literature (hereafter referred to as RILM) is one of the world's largest music literature databases, indexing writings on all subjects in music and related disciplines. Compared with other major music literature databases such as The Music Index and International Index to Music Periodicals,[48] RILM's disciplinary and language coverage is the most substantial and comprehensive. As of August 2017, RILM had over 950,133 records in 143 languages from 178 countries.[49] For this study we selected RILM to collect and analyze users' search queries, and compared them with the controlled vocabularies used by RILM.

Each publication in RILM is given a set of index strings created by its subject experts. Each index string (e.g., "Froberger, Johann Jacob -- performance practice -- keyboard music -- notation") begins with a headword (in this case the composer's name Johann Jacob Froberger) followed by narrower terms (e.g., "performance practice") that are hierarchically organized, further specifying different aspects of the headword. All the headwords and most of the narrower terms that follow are selected from RILM's thesaurus and authority files, including personal names, institution names, geographic names, and musical work titles). These controlled vocabularies are developed and maintained by RILM's subject experts.

RILM is published on the EBSCO Information Services platform. The search-log data was collected from 7,924 unique user queries submitted to EBSCO against the RILM database

during December 2015, a month when the database had one of the highest numbers of queries during that year. A random sample of 367 queries was drawn from this dataset to conduct a content analysis. The sample size was determined by using the technique mentioned by Powell and Connaway.[50] The unit of analysis is each user search query. An initial coding scheme was developed based on the literature.[51] It consisted of eight categories of user queries: topical term, personal name, corporate body name, geographic name, chronological term, format, musical instrument, and work title. Also included were three types of mapping to RILM's index terms: perfect match, partial match, and no match.[52] User queries classified as "perfect match" are terms that exactly match RILM's index terms in wording, spelling, count, and tense.[53] User queries categorized as "partial match" are terms having spelling, count, or tense differences compared with RILM's index terms[i]. User queries classified as "no match" are terms that do not match RILM's index terms in language, wording, spelling, or meaning.

The two authors independently coded all 367 queries based on the initial coding scheme. The second author is a domain expert in musicology, and provided the subject knowledge to interpret musical terminology. After comparing, discussing, and resolving differences in their independent coding, the two authors collectively formed a new coding scheme that added three more categories of user queries: identifier, document type, and language. The authors then used the new coding scheme to recode all the queries. Despite subtle differences existing, they found no significant discrepancies. They resolved those minor discrepancies through further discussion to obtain agreement.

---

[i] Example 1: user query "Ben Johnson" vs. RILM's index term "Johnson, Benjamin (Ben)"
Example 2: user query "reality tv" vs. RILM's index term "reality television"
Example 3: user query "dramatic voice" vs. RILM's index term "dramatic voices"

FINDINGS

Of all 367 queries in the sample, 28 were omitted from the data analysis, including one invalid query (just a single letter "A") and 27 queries created by directly using the bibliographic metadata (e.g., author, identifier) and index strings created by RILM's subject experts. Therefore, this dataset contains 339 valid user-created queries: 178 (52.51%) are single-word (e.g., "apartheid," "zydeco") or single-concept queries (e.g., "music festivals," "murky bass," "Bach, Johann Bernhard"), while 161 (47.49%) are multi-concept queries (e.g., "army and ww2," "Korea and censorship"). The multi-concept queries were further separated into 350 separate search terms (e.g., ww2, army). In total, this dataset contains 528 separate user-created search terms, including 178 from single-word/concept queries and 350 from multi-concept queries. Each user-created search term was assigned a category from the coding scheme and compared with RILM's index terms to determine whether it was a perfect match, a partial match, or no match.

Categories of User-created Queries

Of the 178 user-created search terms in single-word/concept queries (see Table 1), 67 (37.64%) are personal names, 63 (35.39%) are work titles, 35 (19.66%) are topical terms, four (2.25%) are geographic names, four (2.25%) are corporate body names, three (1.69%) are musical instruments, and two (1.12%) are identifiers (e.g., DOI). There are no single-word/concept queries falling into the categories of chronological term, format, language, and document type.

Of the 350 separate user-created search terms in 161 multi-concept queries (see Table 1), 126 (36.00%) are personal names, 116 (33.14%) are topical terms, 69 (19.71%) are work titles, 12 (3.43%) are geographic names, 10 are musical instruments (2.86%), seven (2.00%) are chronological terms (e.g., "nineteenth century," "civil war"), five (1.43%) are corporate body

names, three (0.86%) are document types (e.g., “doctoral dissertation”), one (0.29%) is a format (i.e., “DVD”), and one (0.29%) is a language. There are no multi-concept queries containing identifiers.

Table 1. Categories of user-created search terms

Category	**Single-word/concept queries**		**Multi-concept queries**	
	Count of terms	**% of the group**	**Count of terms**	**% of the group**
Personal name	67	37.64%	126	36.00%
Work title	63	35.39%	69	19.71%
Topical term	35	19.66%	116	33.14%
Geographic name	4	2.25%	12	3.43%
Corporate body name	4	2.25%	5	1.43%
Musical instrument	3	1.69%	10	2.86%
Identifier	2	1.12%	0	0.00%
Chronological term	0	0.00%	7	2.00%
Format	0	0.00%	1	0.29%
Language	0	0.00%	1	0.29%
Document type	0	0.00%	3	0.86%
Total	178	100%	350	100%

Regardless of single-word, single-concept, or multi-concept queries, of all 528 separate user-created search terms in the dataset, 193 (36.55%) are personal names, 151 (28.60%) are topical terms, 132 (25.00%) are work titles, 16 (3.03%) are geographic names, 13 (2.46%) are musical instruments, nine (1.70%) are corporate body names, seven (1.33%) are chronological terms, three (0.57%) are document types, two (0.38%) are identifiers, one (0.19%) is a format, and one (0.19%) is a language.

Table 2. Subcategories of user-created search terms classified as work title

Subcategory	**Single-word/concept queries**		**Multi-concept queries**	
	Count of terms	**% of the group**	**Count of terms**	**% of the group**
Musical work title	19	30.16%	46	66.67%
Music book title	18	28.57%	8	11.59%
Journal article title	11	17.46%	9	13.04%
Film or music video title	5	7.94%	2	2.90%
Literature work title	3	4.76%	1	1.45%
Journal title	2	3.17%	0	0.00%
Cannot be determined	5	7.94%	3	4.35%
Total	63	100%	69	100%

Since work titles occurred frequently in single-word/concept and multi-concept queries, the authors further analyzed and separated work titles into seven subcategories: musical work title, journal article title, journal title, music book title, film or music video title, literature work

title, and title that cannot be determined. Of the 63 single-word/concept queries that were classified as work title (see Table 2), 19 (30.16%) are musical work titles, 18 (28.57%) are music book titles, 11 (17.46%) are journal articles titles, five (7.94%) are film or music video titles, three (4.76%) are literature work titles, two (3.17%) are journal titles, and five (7.94%) are titles that cannot be determined. Of the 69 separate search terms in multi-concept queries that were classified as work title (see Table 2), 46 (66.67%) are musical work titles, eight (11.59%) are music book titles, nine (13.04%) are journal article titles, two (2.90%) are film or music video titles, one (1.45%) is a literature work title, and three (4.35%) are titles that cannot be determined. There are no multi-concept queries containing journal titles.

Comparison of User-created Queries to RILM's Index Terms

The user-created search queries were compared with RILM's index terms, and classified into three categories: perfect match, partial match, and no match. Of the 178 single-word/concept queries, 22 are field searches for particular titles, authors, and identifiers. Since they were not subject searches, they were excluded from the comparison with RILM's index terms, resulting in 156 user-created search terms from single-word/concept queries for comparison. Of these 156 terms, 39 (25.00%) perfectly matched RILM's index terms, 42 (26.92%) partially matched, and 75 (48.08%) did not match (see Figure 1).

Of the 350 separate user-created search terms in 161 multi-concept queries, 20 are field searches for particular titles, authors, and languages. They were also excluded from the comparison with RILM's index terms because they were not subject searches, and resulted in 330 separate user-created search terms from multi-concept queries for comparison. Of these 330 terms, 127 (38.48%) perfectly matched RILM's index terms, 132 (40.00%) partially matched, and 71 (21.52%) did not match (see Figure 2). Compared to single-word/concept queries, multi-

concept queries contain a much lower percentage of non-matching user-created search terms.

Figure 1. Comparison of user-created search terms from single-word/concept queries to RILM's index terms

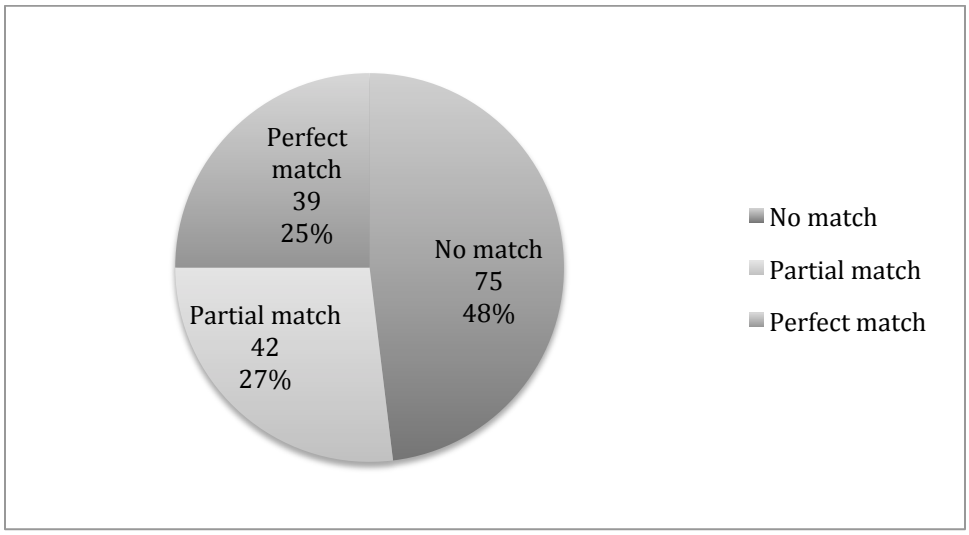
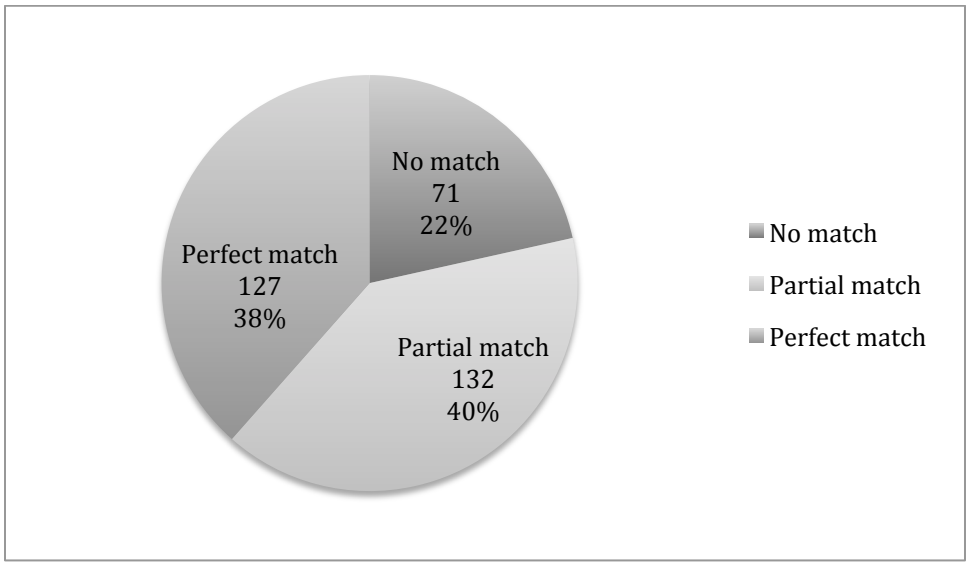


Figure 2. Comparison of user-created search terms from multi-concept queries to RILM's index terms



Of all 486 separate user-created search terms in the dataset that were compared with RILM's index terms, 166 (34.16%) perfectly matched RILM's index terms, 174 (35.80%) partially matched, and 146 (30.04%) did not match.

Comparison of User-created Queries to RILM's Index Terms by Categories

Of the 39 user-created search terms from single-word/concept queries that perfectly matched RILM's index terms, 15 (38.46%) are personal names, 15 (38.46%) are topical terms, five (12.82%) are work titles, two (5.13%) are geographic names, and two (5.13%) are corporate body names (see Table 3). Among the 42 user-created search terms from single-word/concept queries that partially matched RILM's index terms, 22 (52.38%) are personal names, eight (19.05%) are work titles, seven (16.67%) are topical terms, three (7.14%) are musical instruments, one is a geographic name (2.38%), and one (2.38%) is a corporate body name. Of the 75 user-created search terms from single-word/concept queries that did not match RILM's index terms, 40 (53.33%) are work titles, 20 (26.67%) are personal names, 13 (17.33%) are topical terms, one (1.33%) is a geographic name, and one (1.33%) is a corporate body name. All of the three musical instrument terms in single-word/concept queries partially matched RILM's index terms, while most (75.47%) of the work titles did not match.

Among the 127 user-created search terms in multi-concept queries that perfectly matched RILM's index terms, 76 (59.84%) are topical terms, 17 (13.39%) are personal names, 10 (7.87%) are work titles, 10 (7.87%) are geographic names, 10 (7.87%) are musical instruments, one (0.79%) is a chronological term, one (0.79%) is a corporate body name, one (0.79%) is a document type, and one (0.79%) is a format (see Table 4). Of the 132 user-created search terms in multi-concept queries that partially matched RILM's index terms, 83 (62.88%) are personal names, 23 (17.42%) are work titles, 17 (12.88%) are topical terms, six (4.55%) are chronological terms, two (1.52%) are corporate body names, and one (0.76%) is a geographic name. Among the 71 user-created search terms in multi-concept queries that did not match RILM's index terms, 26 (36.62%) are work titles, 23 (32.39%) are topical terms, 17 (23.94%) are personal

names, two (2.82%) are corporate body names, two (2.82%) are document types, and one (1.41%) is a geographic name.

Table 3. User-created search terms from single-word/concept queries mapped to RILM's index terms by categories

Category	Perfect match		Partial match		No match	
	Count of terms	% of the group	Count of terms	% of the group	Count of terms	% of the group
Personal name	15	38.46%	22	52.38%	20	26.67%
Work title	5	12.82%	8	19.05%	40	53.33%
Topical term	15	38.46%	7	16.67%	13	17.33%
Geographic name	2	5.13%	1	2.38%	1	1.33%
Corporate body name	2	5.13%	1	2.38%	1	1.33%
Musical instrument	0	0.00%	3	7.14%	0	0.00%
Total	39	100.00%	42	100.00%	75	100.00%

All of the 10 user-created instrument terms in multi-concept queries perfectly matched RILM's index terms, while only one of the seven user-created chronological terms perfectly matched. Most of the user-created geographic names (83.33%) and topical terms (65.52%) in multi-concept queries perfectly matched RILM's index terms. Not surprisingly, most of the user-created personal names (70.94%) in multi-concept queries partially matched RILM's index terms.

Table 4. User-created search terms from multi-concept queries mapped to RILM's index terms by categories

Category	Perfect match		Partial match		No match	
	Count of terms	% of the group	Count of terms	% of the group	Count of terms	% of the group
Personal name	17	13.39%	83	62.88%	17	23.94%
Work title	10	7.87%	23	17.42%	26	36.62%
Topical term	76	59.84%	17	12.88%	23	32.39%
Corporate body name	1	0.79%	2	1.52%	2	2.82%
Geographic name	10	7.87%	1	0.76%	1	1.41%
Musical instrument	10	7.87%	0	0.00%	0	0.00%
Chronological term	1	0.79%	6	4.55%	0	0.00%
Document type	1	0.79%	0	0.00%	2	2.82%
Format	1	0.79%	0	0.00%	0	0.00%
Total	127	100.00%	132	100.00%	71	100.00%

Analysis of Partial-matching and Non-matching Search Terms

To identify reasons for partial match and no match, the authors analyzed 174 partial-matching and 146 non-matching search terms in the dataset. These terms were compared with RILM's

index terms for specificity (broader, narrower, related, synonymous terms), singular or plural usage, variant spellings or endings, misspellings, phrases in different word order, the use of acronyms or abbreviations, the use of a different language, alternative names or titles, fuller forms of names or titles, new or popular terms, and the use of non-music terms.

Of the 174 partial-matching search terms in the dataset, 105 are personal names, 31 are work titles, 24 are topical terms, six are chronological terms, three are corporate body names, three are musical instruments, and two are geographic names (Table 5). Among the 105 partial-matching personal names, 102 are partial names (92 having only the last name, five missing the middle name, two missing the first name, one missing the prefix, one missing the birth year, and one having the first name abbreviated), two contain misspellings ("eddi prévost" vs. "Prévost, Eddie"), and one is an alternative name ("Le Corbusier" vs. "Jeanneret, Charles-Édouard (Le Corbusier)"). Of the 31 partial-matching work titles, 26 are incomplete titles (e.g., missing the opus number), two are related titles, one is an alternative title ("Symphony No. 4 in E minor Op. 98" vs. "symphonies, no. 4, op. 98"), one contains variant spellings ("Neue Liszt Ausgabe" vs. "Neue Liszt-Ausgabe"), and one includes the use of singular form (e.g., "Silly symphony" vs. "Silly symphonies"). Among the 24 partial-matching topical terms, 11 contain the use of singular form, four are broader terms (e.g., "hand crossing" vs. "hand-crossing technique"), two are narrower terms (e.g., "ethnic villancico" vs. "villancico"), one is a synonymous term ("violoncello" vs. "cello"), three contain variant spellings (e.g., "teacher student relationship" vs. "teacher-student relationship"), two are phrases in different word order (e.g., "sound judgment" vs. "judgment of sound"), and one is an abbreviation ("tv" vs. "television"). One of the six partial-matching chronological terms is an acronym ("ww2" vs. "World War II"); and the other five are partial-matching because controlled vocabularies used abbreviations (e.g., "18th c.,"

"19th c."), while users spelled them out (e.g., "eighteenth century," "nineteenth century"). One of the three partial-matching corporate body names is a partial name, and the other two are alternative names. Two of the three partial-matching instruments are related terms (e.g., "soprano saxophone"), and the other one is a broader term (an instrument family). One of the two partial-matching geographic names is an alternative name ("United States" vs. "United States of America"), and the other one contains a misspelling ("North German").

Table 5. Reasons for partial-matching search terms and suggested solutions

Category	Reason for partial match	# of terms	Suggested solution
Personal name	partial name	102	name suggestion name disambiguation thesaurus-based autocompletion
	misspelling	2	spell-checker
	alternative name	1	inclusion in the authority file
Work title	incomplete title	26	title suggestion title disambiguation thesaurus-based autocompletion adopting LC's uniform titles
	related title	2	ontology
	alternative title	1	inclusion in the authority file
	variant spelling	1	stemming
	singular usage	1	title suggestion
Topical term	singular usage	11	stemming
	broader term	4	inclusion in the thesaurus linking index terms with hierarchical relationship
	narrower term	2	inclusion in the thesaurus linking index terms with hierarchical relationship
	synonymous term	1	inclusion in the thesaurus
	variant spelling	3	stemming
	phrase in different word order	2	inclusion in the thesaurus

	the use of an abbreviation	1	inclusion in the thesaurus
Chronological term	the use of fuller form	5	inclusion in the thesaurus
	the use of an acronym	1	inclusion in the thesaurus
Corporate body name	alternative name	2	inclusion in the authority file
	partial name	1	name suggestion name disambiguation thesaurus-based autocompletion
Musical instrument	related term	2	linking index terms with associative relationship
	broader term	1	linking index terms with hierarchical relationship
Geographic name	alternative name	1	inclusion in the authority file
	misspelling	1	spell-checker

Of the 146 non-matching search terms in the dataset, 66 are work titles, 37 are personal names, 36 are topical terms, three are corporate body names, two are geographic names, and two are document types (see Table 6). Among the 66 non-matching work titles, 64 were not indexed as subject terms in RILM, and two used a different language (i.e., Italian). Of the 37 non-matching personal names, 35 were not indexed as subject terms in RILM, one is a misspelled name, and one is in a different language (in this instance, the user used English, while RILM's controlled vocabularies used Bulgarian). Among the 36 non-matching topical terms, 10 are non-music terms (e.g., "trail," "data element," "business analyst"), six are new or popular terms (e.g., "j horror," "mathematics instruction," "lexical pragmatics"), five are broader terms (e.g., "music," "old," "blue"), three are narrower terms (i.e., "Latino playwrights," "woman of China," "Cuban revolution music"), two are related terms (i.e., "curriculum studies," "popular stage"), four are terms in a different language (i.e., German), three are misspelled terms, and three are invalid terms not making sense in music (i.e., "conservatory music," "tone scale," "organizer web"). One of the two non-matching geographic names is a historical place name (i.e., "Santa

Elena") not indexed in RILM, and the other one is an alternative name ("Britain" vs. "United Kingdom"). None of the three non-matching corporate body names and two non-matching document types were indexed as subject terms in RILM.

Table 6. Reasons for non-matching search terms and suggested solutions

Category	Reason for no match	# of terms	Suggested solution
Work title	not indexed as subject terms in RILM	64	inclusion in the authority file
	the use of a different language	2	inclusion in the authority file
Personal name	not indexed as subject terms in RILM	35	inclusion in the authority file
	misspelling	1	spell-checker
	the use of a different language	1	inclusion in the authority file
Topical term	non-music term	10	ontology
	new or popular term	6	inclusion in the thesaurus
	broader term	5	inclusion in the thesaurus linking index terms with hierarchical relationship
	narrower term	3	inclusion in the thesaurus linking index terms with hierarchical relationship
	related term	2	inclusion in the thesaurus linking index terms with associative relationship
	the use of a different language	4	multilingual thesaurus
	misspelled term	3	spell-checker
	invalid term	3	
Corporate body name	not indexed as subject terms in RILM	3	inclusion in the authority file
Geographic name	historical place name not indexed in RILM	1	inclusion in the authority file
	alternative name	1	inclusion in the authority file
Document type	not indexed as subject terms in RILM	2	

DISCUSSION

Categories of User-created Queries in Music Literature Databases

The first research question concerned the categories of users' free-text queries created in music literature databases. This study identified 11 categories of user-created search terms: personal name, topical term, work title, geographic name, musical instrument, corporate body name, chronological term, document type, identifier, format, and language. A comparison of these categories with those of the user queries created in different information systems or databases in different domains shows some overlap. For example, Lee found the most heavily used features in natural language queries seeking music information in a social Q&A site were person-name, title, date, genre, role, lyrics, and place reference.[54] These features, except for lyrics, can be nicely mapped to the categories of personal name, work title, chronological term, topical term, and geographic name identified in the current study. Since RILM is a music literature database that focuses on indexing scholarly writings about music and rarely indexes musical objects such as music recordings and scores, it is not surprising to find no user queries analyzed in this study searching for lyrics. Nowick and Mering identified nine categories of descriptors used by free-text searchers of a water quality website: keyword, geographic designation, format/genre, title, corporate body, personal name, chemical formula, URL, and date.[55] All of these categories can be mapped to the categories of users' search terms identified in the current study, except for chemical formula and URL. Although the current study did not find any URL as a user search term, it identified other types of identifiers such as DOI and EBSCO's local identifiers. This can be explained by the fact that Nowick and Mering's study analyzed user queries of a water quality website, while the current study examined user queries submitted to a music literature database. White found four categories of subject terms (i.e., spatial, temporal, topical, and scientific terms)

in the free-text keywords created by scientists to describe scientific datasets.[56] Similarly, all of these categories, except for scientific terms, can be mapped to the categories of users' search terms identified in the current study.

The current study found that the most frequently occurring categories of search terms in users' free-text queries were personal names (36.55%), followed by topical terms (28.60%), work titles (25.00%), and geographic names (3.03%). In both single-word/concept and multi-concept queries, these are the four most frequently occurring categories of user-created search terms. Compared with multi-concept queries, work titles were more heavily used than topical terms in single-word/concept queries (see Table 1). RILM's thesaurus contains four types of headword (main index term) used as the first-level index term of each index string: personal name, geographic name, topical term, and instrument. Interestingly, the first three types of headword in RILM's thesaurus can be mapped to three of the four most frequently occurring categories of search terms in RILM's user-created queries. This indicates that RILM's thesaurus nicely represents users' frequent information needs in terms of categories or facets.

Work title is the third most frequently occurring category of search terms in RILM's user-created queries, but work titles are not used in RILM as a type of headword or main index term. Noticeably, work titles are the second most frequently occurring search terms in single-word/concept queries, taking up 35.39% of them (see Table 1). This implies that users are likely to use work titles alone as their search queries. Although user queries contain a variety of work titles (including musical work titles, music book titles, journal and journal article titles, film or music video titles, and literature work titles), the majority are musical work titles (see Table 2). RILM could consider developing musical work titles, especially those that are well known and those without known composers, as a type of headword. In RILM, musical work titles, as index

terms, usually follow the composer's name (as a headword) and a second-level index term indicating the type of composition (i.e., works, directing) in an index string. However, for musical works without known composers (e.g., "Stordalsnibba," "Tall mountains and flowing streams," "Jasmine flower"), titles as index terms usually follow a geographic name (as a headword) and a topical term (second-level index term) in the index strings, for example, "Norway -- traditional music -- Stordalsnibba -- variants" and "China -- traditional music -- guqin music -- Gao shan (Tall mountains) and Liu shui (Flowing streams) -- titles." If these musical work titles were used as headwords with other subdivisions (e.g., melody, form, rhythm and meter, aesthetics) in RILM, it might ease the indexing process, create more parsimonious index strings, and improve the precision for users searching for the literature discussing different aspects of these musical works.

Despite only seven chronological terms in users' multi-concept queries (see Table 1), they were used with topical terms to help restrict the searches (e.g., "female singers AND nineteenth century," "music business AND nineteenth century"). Table 4 shows that only one of these seven chronological terms is a perfect match to RILM's index terms, and the other six are partial match. This may be explained by the fact that chronological terms are not included in RILM's thesaurus. RILM could consider integrating into its thesaurus some significant chronological terms in music history (e.g., 1800-1850, 19th century, Yuan dynasty) to accommodate user needs.

Mapping User-created Queries to RILM's Index Terms

The second research question focused on the difference between user-created queries in music literature databases and the controlled vocabularies used by those databases. Of all the 486 user-created search terms in the dataset that were compared with RILM's index terms, only 30.04%

(146) of them did not match, while 34.16% (166) perfectly matched. Nowick and Mering's search-log analysis found that 40% to 50% of users' queries did not match three controlled vocabularies.[57] Wetterstrom's experiment identified that 75% of the user-generated tags did not match any LCSH.[58] Compared with the findings of those previous studies, RILM's index terms align well with users' search terms. It is apparent that RILM's index terms included in the bibliographic records are useful to searchers. Noticeably, 10 of the 13 user-created instrument terms perfectly matched RILM's thesaurus, and the other three partially matched (see Table 3 and Table 4). None of the user-created instrument terms did not match. This indicates that RILM's thesaurus matches exceedingly well with users' vocabularies on musical instruments. This may also be attributed to RILM's highly hierarchized instrument index terms, which can collocate similar musical instruments under the same instrument family, help users create and revise their queries, and thus improve precision. All the musical instruments in RILM must be preceded by an instrument family headword (e.g., "instruments -- percussion (drum) -- timpani").[59] An instrument's status and the proper instrument family are determined based on the Grove Dictionary of Musical Instruments. Other music literature databases or music-related thesaurus (e.g., LC Medium of Performance Thesaurus) could map their local vocabularies on musical instruments to RILM's thesaurus to better represent users' search terms.

Partial-matching Search Terms to RILM's Index Terms

Most of the partial-matching search terms in single-word/concept queries (52.38%, Table 3) and multi-concept queries (62.88%, Table 4) are personal names. This is mainly due to the use of partial names (e.g., missing first name, middle name, prefix, and/or birth year) as search terms (see Table 5). However, the reasons for users applying partial names as search terms are unknown based only on the search-log data. The authorized form of those personal names in

RILM may be less known, difficult to spell or type (e.g., "Gouvy, Louis Théodore," "Chopin, Frédéric," "Prévost, Eddie," "Kondō, Kōji"), or too complicated (containing birth and/or death years). Users, especially novices, may only be familiar with the last name of composers, musicians, and performers such as Bach, Beethoven, Brahms, Chopin, and Mozart. There are also many musicians sharing the same or similar last names (e.g., Bach, Bache, Mozart, Schubert). RILM could consider incorporating into its system such functionalities as name suggestion, spell-checker, name disambiguation (e.g., using Wikipedia's disambiguation pages),[60] and thesaurus-based (semi)auto-completion to reduce users' cognitive load.[61]

Following personal names, work titles are the next most frequently occurring partial-matching search terms in both single-concept/word queries (19.05%, Table 3) and multi-concept queries (17.42%, Table 4). This is mostly due to the complexity of musical work titles. Western classic musical works without distinctive titles are usually confusing. Their titles may include the form (e.g. symphony, sonata, quartet), key, instrumentation, and opus number or other numbering (e.g. sonata, clarinet, piano, op. 120, no. 2). Publishers often have their own styles of title wording for the same work in various languages. Some works are frequently referred to by their true titles[ii], nicknames, or subtitles. In traditional music, very often one musical work has more than one title or the same name is assigned to different tunes. For example, "Moli hua" (Jasmine flower) is the name of more than six versions of a folk song in China, each of which has a distinctive melody.

RILM has a set of detailed rules for formatting titles of musical works, regulating capitalization, punctuation, the use of opus and catalogue numbers, differentiation of identical titles, etc. Musical works indexed in RILM are formatted following these rules that are not

[ii] True titles are titles given by the composer.

generally known to users. Titles of Western composers' works in RILM also do not always match the uniform titles used by libraries. RILM could consider adopting LC's uniform titles or incorporating them and those commonly used by searchers as alternative titles. Similarly, RILM could consider providing other functionalities, such as title suggestion, spell-checker, title disambiguation (e.g., using Wikidata, LC Authority Files), and thesaurus-based (semi)auto-completion, which would reduce users' cognitive load.[62] Although only two of the 31 partial-matching work titles are related titles (see Table 5), developing an ontology[iii] could link these titles to those in RILM's authority files. In some cases ontologies and thesauri can be applied in a complementary approach. For example, "Star wars: Episode II" is an authorized film title in RILM's authority files, but no other episode of Star Wars is included in the authority files. Building an ontology to relate different episodes of Star Wars to each other can provide users searching for other episodes with an option to know about the literature on Episode II, and some basic information on Star Wars (e.g., the number of episodes).

Topical terms are the third most frequently occurring partial-matching search terms in both single-concept/word queries (16.67%, Table 3) and multi-concept queries (12.88%, Table 4). Unlike partial-matching personal names and work titles, the reasons for partial-matching topical terms are varied, and include the use of abbreviations, singular form, broader terms, narrower terms, synonymous terms, phrases in different word order, and variant spellings (see Table 5). Following the much-many rule, count nouns representing objects in controlled vocabularies are usually in their plural form.[63] NISO specifies an exception to this rule: if there is literary or user warrant for nouns in their singular form in the domain represented by the

[iii] Ontology is a knowledge organization system representing entities, properties of entities, and relationships between entities in a specific domain to provide semantic structure to support indexing, searching, retrieval, and actionable processes. Protégé, NeOn Toolkit, and Vitro are some of popular, open source tools for ontology development and maintenance.

controlled vocabulary, singular usage is acceptable.[64] Singular usage accounts for 11 (45.83%) of the 24 partial-matching topical terms in this study. This indicates that some users, especially those who are unfamiliar with controlled vocabularies, may favor using nouns in the singular form as their search terms. More search-log data may need to be examined to determine whether the singular usage of those topical terms is more popular, and thus acceptable to RILM's thesaurus.[iv] Three partial-matching topical terms are variant spellings. Stemming[v] used by many search engines can help address the subtleties of English spelling, singular usage, and nuances of meaning.[65]

Some of the partial-matching topical terms are broader and narrower terms. Likewise, one of the three partial-matching instrument terms is a broader term. This corresponds to the findings of Bates's study that users may tend to formulate their queries either at a higher or lower level of generality in the hierarchy used by the information systems.[66] Adding those broader and narrower terms to RILM's thesaurus, linking index terms with hierarchical relationships, providing users with access to the thesaurus, and including appropriate cross-references in the thesaurus may help address the problems of using broader and narrower terms.

This study found one alternative personal name, one alternative title, two alternative corporate body names, and one alternative geographic name in those partial-matching search terms. They could be added to RILM's authority files as alternative names and titles, providing users with cross-references to improve recall. This study also found one synonym, one abbreviation, and two phrases in different word order in the partial-matching topical terms. Similarly, they could be added to RILM's thesaurus as synonymous terms to improve recall.

[iv] RIM could consider examining a random sample of the search log on a regular basis (e.g., once a month) to study user-created queries.

[v] Stemming is the process of reducing inflectional forms and derivationally related forms of a word to a common base form to ensure that a search for one of these words in the set will return documents containing other words in the set.

RILM could consider having the database system recognize the synonyms and alternative names and titles, and automatically search the authorized ones for users.

Non-matching Search Terms to RILM's Index Terms

Most of the non-matching search terms in single-word/concept queries and multi-concept queries are work titles and personal names. The main reason for this lack of match is that users conducted keyword searches instead of field searches for particular titles or authors, which were not included in RILM's authority files as index terms (see Table 6). This corresponds to the findings of previous studies that users become more and more accustomed to keyword searches in search engines,[67] and even sophisticated searchers seldom use field or advanced searches.[68]

Similar to partial-matching topical terms, the reasons for non-matching topical terms are varied, including the use of non-music terms, new or popular terms, broader terms, narrower terms, related terms, terms in a different language, misspelled terms, and invalid terms. As indicated above, spell-checker, the inclusion of appropriate cross-references in RILM's thesaurus, linking terms with hierarchical and associative relationships, and making the thesaurus accessible to users could help address the issues of misspellings, broader terms, narrower terms, and related terms.[69] Six new or popular topical terms from the sample in this investigation could be added to RILM's thesaurus for expansion. If these strategies were replicated with larger samples and on a regular basis, the thesaurus might be expanded further. To adopt the most recent terminology in music and related disciplines, RILM could consider enabling users or scholars to suggest additions, changes, and improvements to its controlled vocabularies.[vi]

In terms of the non-matching personal names and work titles in a different language, they could be added to RILM's authority files to serve users of different languages and countries.

[vi] RILM could use an open source, Web-based, collaborative editing tool (e.g., VocBench, TemaTres) as a platform to allow users or community members to suggest additions and revisions to its controlled vocabularies.

Regarding those non-matching topical terms in a different language, RILM could consider developing a multilingual thesaurus to map multilingual terminology, and provide additional subject access points to cultural-related concepts and the literature in non-English languages.[70] For example, the Getty vocabularies have built trusted partnerships with other cultural institutions in different countries[71] to develop multilingual thesauri through large-scale translation projects and small-batch contributions.[72] Adopting a collaborative approach to developing or enhancing multilingual controlled vocabularies with other cultural heritage institutions in different countries, sharing RILM's controlled vocabularies in XML format, and releasing RILM's thesaurus as Linked Open Data could be some options for RILM.

Ten of the 37 topical terms that did not match RILM's index terms are non-music terms. Developing an ontology to relate non-music concepts to RILM's index terms could enrich knowledge representation, provide users with some possible concept expansions, point them to the relevant concepts discussed in music literature, and give them an option to refine their queries using RILM's index terms.

Search-log analysis identified 16 geographic names in the user-created search terms (see Table 1). Only two of them did not match RILM's index terms (see Table 6). Interestingly, one of these non-matching terms is "Santa Elena," the capital of Spanish Florida from 1566 to 1587. This indicates RILM users, especially those searching for historical geographic names, may have the need for cultural music information of a temporal nature. If there are a significant number of such searches, to satisfy this user need, RILM could consider aggregating historical terms to its controlled vocabularies, and associating them with contemporary terms representing the same concepts or entities to create additional access points.[73]

CONCLUSION

This study examined the categories of users' free-text queries submitted to a music literature database, and the mapping between terms from those queries and from the controlled vocabularies used by the database. Data analysis identified 11 categories of user-created search terms in RILM, and further divided the search terms of work titles into seven subcategories. The identified categories and subcategories suggest that RILM could consider developing musical work titles as a type of headword and integrating some significant chronological terms into its thesaurus. Data analysis also mapped each user-created search term within the 11 categories to RILM's index terms, assessing whether it was a perfect match, a partial match, or no match; identifying the reasons for partial match and no match; and providing RILM with some suggested solutions, such as opening the thesaurus to users for additions and revisions, adopting a collaborative approach to develop RILM's controlled vocabularies, and building an ontology or a multilingual thesaurus.

This study has several limitations. Search-log analysis is an unobtrusive research method not requiring any interaction with users, and thus cannot reveal their underlying intentions for the queries or their satisfaction with RILM's index strings. The search-log analysis of this study only examined keyword searches, which could not distinguish whether those title and personal name searches were subject searches or searches for specific titles or authors. Search-log analysis becomes a more powerful tool when combined with other research methods such as interview, observation, and experimentation.[74] Furthermore, this study did not differentiate between initial queries and modified queries submitted by the same user, and thus cannot reveal why and in what context users revised their queries. Previous studies found that casual information seekers and scholars have different needs and requirements for controlled vocabularies.[75] However, the

search-log data cannot provide any demographic information on the users such as the language(s) they use or speak, profession, and education. To address these limitations, future research should include: conducting qualitative interviews with different groups of RILM users (e.g. students, scholars, experts) to learn about their information needs, intentions for the queries, and perceived usefulness of controlled vocabularies; and performing observations on how they create and revise queries and in what context they use controlled vocabularies. Qualitative interviews will also be conducted with indexers or subject experts to identify their perceived quality requirements for controlled vocabularies to index music literature.

NOTES

[1] Elizabeth Kelly, "Music Indexing and Retrieval: Current Problems," *The Indexer* 28, no. 4 (2010): 163-166.

[2] G. W. Furnas, T. K. Landauer, L. M. Gomez, and S. Dumais, "The Vocabulary Problem in Human–System Communication," *Communications of the ACM* 30, no. 11 (1987): 964–971.

[3] Jane A. Myers, "Music: Characteristics for Indexing and Cataloguing," *The Indexer* 19, no. 4 (1995): 271.

[4] Kelly, "Music Indexing and Retrieval."

[5] Richard P. Smiraglia, " Musical Works and Information Retrieval," *Notes* 58, no. 4 (2002): 747-764.

[6] J. Stephen Downie, "Music Information Retrieval," *Annual Review of Information Science & Technology* 37, no. 1 (2003): 295-340.

[7] National Information Standards Organization (NISO), *Guidelines for the Construction, Format, and Management of Monolingual Controlled Vocabularies: An American National Standard*

Developed (Bethesda, MD: NISO Press, 2005).

[8] F. Wilfrid Lancaster, *Indexing and Abstracting in Theory and Practice* (Champaign, IL: University of Illinois, Graduate School of Library and Information Science, 2000).

[9] Elaine Svenonius, "Design of Controlled Vocabularies," in *Encyclopedia of Library & Information Science 2003*, ed. Miriam A. Drake (New York: Marcel Dekker, 2003): 822-838.

[10] Andrew MacFarlane, "Knowledge Oganisation and Its Role in Multimedia Information Retrieval," *Knowledge Organization* 43, no. 3 (2016): 180-183.

[11] Elaine A. Nowick, Daryl Travnicek, Kent Eskridge, and Stephen Stein, "A Comparison of Term Clusters for Tokenized Words Collected from Controlled Vocabularies, User Keyword Searches, and Online Documents," *Library Philosophy and Practice*, 2010 (2010). http://digitalcommons.unl.edu/libphilprac/493/.

[12] Kelly, "Music Indexing and Retrieval."

[13] John Dupre, *The Disorder of Things: Metaphysical Foundations of the Disunity of Science* (Cambridge, MA: Harvard University Press, 1993).

[14] Hope A. Olson and Rose Schlegl, "Standardization, Objectivity, and User Focus: A Meta-analysis of Subject Access Critiques," *Cataloging & Classification Quarterly* 32, no. 2 (2001): 61-80. https://doi.org/10.1300/J104v32n02_06.

[15] Jarmo Saarti, "Consistency of Subject Indexing of Novels by Public Library Professionals and Patrons," *Journal of Documentation* 58, no. 1 (2002): 49-65.

[16] Lois Mai Chan and Athena Salaba, *Cataloging and Classification: An Introduction* (Lanham, MD: Rowman & Littlefield, 2016).

[17] Cyril W. Cleverdon, *The Effect of Variations in Relevance Assessments in Comparative Experimental Tests of Index Languages* (Cranfield, UK: Cranfield Institute of Technology,

1970).

[18] Janet E. Parker, "Preliminary Assessment of the Comparative Efficiencies of an SDI System Using Controlled or Natural Language for Retrieval," *Program* 5, no. 1 (1971): 26-34.

[19] Svenonius, "Design of Controlled Vocabularies."

[20] Tina Gross, Arlene G. Taylor, and Daniel N. Joudrey, "Still a Lot to Lose: The Role of Controlled Vocabulary in Keyword Searching," *Cataloging & Classification Quarterly* 53, no. 1 (2015): 1-39. https://doi.org/10.1080/01639374.2014.917447.

[21] Ibid.

[22] Myers, "Music: Characteristics for Indexing and Cataloguing."

[23] Besiki Stvilia, Corinne Jörgensen, and Shuheng Wu, "Establishing the Value of Socially-Created Metadata to Image Indexing," *Library & Information Science Research* 34, no. 201 (2012): 99-109. https://doi.org/10.1016/j.lisr.2011.07.011.

[24] Hollie White, "Examining Scientific Vocabulary: Mapping Controlled Vocabularies with Free Text Keywords," *Cataloging & Classification Quarterly* 51, no. 6 (2013): 655-674.

[25] Elaine A. Nowick and Margaret Mering, "Comparisons Between Internet Users' Free-Text Queries and Controlled Vocabularies: A Case Study in Water Quality," *Technical Services Quarterly* 21, no. 2 (2003): 15-32. https://doi.org/10.1300/J124v21n02_02.

[26] Dagobert Soergel, *Indexing Languages and Thesauri: Construction and Maintenance* (Los Angeles, CA: Wiley, 1974).

[27] Birger Hjørland, "What is Knowledge Organization (KO)?" *Knowledge Organization* 35, no. 2-3 (2008): 86-87.

[28] Ibid.

[29] Birger Hjørland, "Semantics and Knowledge Organization," *Annual Review of Information*

Science & Technology 41, no. 1 (2007): 367-405.

[30] Gail Hodge, *Systems of Knowledge Organization for Digital Libraries: Beyond Traditional Authority Files* (Washington, DC: Council on Library and Information Resources, 2000).

[31] Edward Wyndham Hulme, "Principles of Book Classification," *Library of Association Record* 13, no. 1911 (1911): 444-449.

[32] Birger Hjørland, "Knowledge Organization (KO)," *Knowledge Organization* 46, no. 6 (2016): 475-484.

[33] Daniel Martínez-Ávila and John M. Budd, "Epistemic Warrant for Categorizational Activities and the Development of Controlled Vocabularies," *Journal of Documentation* 73, no. 4 (2017): 700-715. https://doi.org/10.1108/JD-10-2016-0129.

[34] Dagobert Soergel, *Organizing Information: Principles of Data Base and Retrieval Systems* (Orlando, FL: Academic Press, 1985).

[35] National Information Standards Organization (NISO), "Guidelines for the Construction, Format, and Management of Monolingual Controlled Vocabularies."

[36] Stvilia, Jörgensen, and Wu, "Establishing the Value of Socially-Created Metadata to Image Indexing."

[37] Soergel, "Indexing Languages and Thesauri."

[38] Besiki Stvilia, "A Model for Ontology Quality Evaluation," *First Monday* 12, no. 12-13 (December 2007). http://firstmonday.org/ojs/index.php/fm/article/view/2043.

[39] Nowick and Mering, "Comparisons Between Internet Users' Free-Text Queries and Controlled Vocabularies."

[40] Tina Gross and Arlene G. Taylor, "What Have We Got to Lose? The Effect of Controlled Vocabulary on Keyword Searching Results," *College & Research Libraries* 66, no. 3 (2005):

212-230.

[41] Ibid.

[42] Gross, Taylor, and Joudrey, "Still a Lot to Lose."

[43] Jin Ha Lee, "Analysis of User Needs and Information Features in Natural Language Queries Seeking Music Information," *Journal of the American Society for Information Science & Technology* 61, no. 5 (2010): 1025-1045. https://doi.org/10.1002/asi.21302.

[44] Marcia J. Bates, "System Meets User: Problems in Matching Subject Search Terms," *Information Processing & Management* 13, no. 6 (1979): 367-375.

[45] White, "Examining Scientific Vocabulary."

[46] Mikael Wetterstrom, "The Complementarity of Tags and LCSH: A Tagging Experiment and Investigation into Added Valued in a New Zealand Library Context," *The New Zealand Library & Information Management Journal* 50, no. 4 (2008): 292-306.

[47] Stvilia, Jörgensen, and Wu, "Establishing the Value of Socially-Created Metadata to Image Indexing."

[48] Martin D. Jenkins, "A Descriptive Study of Subject Indexing and Abstracting in International Index to Music, RILM Abstracts of Music Literature, and The Music Index Online," *Notes* 57, no. 4 (2001): 834-863.

[49] Répertoire International de Littérature Musicale (RILM), "RILM Abstracts of Music Literature," 2017, http://rilm.org/abstracts/.

[50] Ronald R. Powell and Lynn Silipigni Connaway, *Basic Research Methods for Librarians* (Westport, CT: Libraries Unlimited, 2004).

[51] Nowick and Mering, "Comparisons Between Internet Users' Free-Text Queries and Controlled Vocabularies."

[52] Wetterstrom, "The Complementarity of Tags and LCSH."

[53] White, "Examining Scientific Vocabulary."

[54] Lee, "Analysis of User Needs and Information Features."

[55] Nowick and Mering, "Comparisons Between Internet Users' Free-Text Queries and Controlled Vocabularies."

[56] White, "Examining Scientific Vocabulary."

[57] Nowick and Mering, "Comparisons Between Internet Users' Free-Text Queries and Controlled Vocabularies."

[58] Wetterstrom, "The Complementarity of Tags and LCSH."

[59] RILM, "Indexing of Instruments," 2017, http://wiki.rilm.org/.

[60] Xianpei Han and Jun Zhao, "Name Entity Disambiguation by Leveraging Wikipedia Semantic Knowledge," in *Proceedings of the 18th ACM Conference on Information & Knowledge Management* (New York, NY: ACM, 2009): 215-244.

[61] Douglas Tudhope and Ceri Binding, "Still Quite Popular After All Those Years--The Continued Relevance of the Information Retrieval Thesaurus," *Knowledge Organization* 43, no. 3 (2016): 174-179.

[62] Ibid.

[63] Svenonius, "Design of Controlled Vocabularies."

[64] NISO, "Guidelines for the Construction, Format, and Management of Monolingual Controlled Vocabularies."

[65] Nowick and Mering, "Comparisons Between Internet Users' Free-Text Queries and Controlled Vocabularies."

[66] Bates, "System Meets User."

[67] Online Computer Library Center (OCLC), "*Online Catalogs: What Users and Librarians Want: An OCLC Report"* (Dublin, Ohio: OCLC, 2009). https://www.oclc.org/content/dam/oclc/reports/onlinecatalogs/fullreport.pdf.

[68] Bernard J. Jansen, Amanda Spink, and Tefko Saracevic, "Failure Analysis in Query Construction: Data and Analysis from a Large Sample of Web Queries," in *ACM Conference on Digital Libraries* (New York, NY: Association for Computing Machinery, 1998): 289-290.

[69] Nowick and Mering, "Comparisons Between Internet Users' Free-Text Queries and Controlled Vocabularies."

[70] Tudhope and Binding, "Still Quite Popular After All Those Years."

[71] Murtha Baca and Melissa Gill, "Encoding Multilingual Knowledge Systems in the Digital Age: The Getty Vocabularies," *Knowledge Organization* 42, no. 4 (2015): 232-243.

[72] Shu-jiun Chen, Marcia Lei Zeng, and Hsueh-hua Chen, "Alignments of Conceptual Structures in Controlled Vocabularies in the Domain of Chinese Art: A Discussion of Issues and Patterns," *International Journal of Digital Libraries* 17, no. 1 (2016): 23-38.

[73] Baca and Gill, "Encoding Multilingual Knowledge Systems in the Digital Age."

[74] Bernard J. Jansen, "Search Log Analysis: What It Is, What's Been Done, How to Do It," *Library & Information Science Research* 28, no. 3 (2006): 407-432.

[75] Tina Gross, Arlene G. Taylor, and Daniel N. Joudrey, "Still a Lot to Lose: The Role of Controlled Vocabulary in Keyword Searching," *Cataloging & Classification Quarterly* 53, no. 1 (2015): 1-39. https://doi.org/10.1080/01639374.2014.917447.