TOWARDS ORGANIZING AND RETRIEVING CLASSICAL MUSIC BASED ON FUNCTIONAL REQUIREMENTS FOR BIBLIOGRAPHIC RECORDS (FRBR)

By

Sung-Min Kim

B.L.I.S., Daegu University, Korea, 2000

M.L.I.S, University of Pittsburgh, USA, 2004

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This dissertation was presented

by

Sung-Min Kim

It was defended on

April 23, 2015

and approved by

James D “Kip” Currier, PhD, Assistant Professor

Jung Sun Oh, PhD, Assistant Professor

Yin Zhang, PhD, Professor, School of Library and Information Science, Kent State University

Dissertation Director: Daqing He, PhD, Associate Professor

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Music is one of the most popular categories in general public's Web search. Compared to other types of information retrieval, music search requires a different approach. This is due to the fact that music information includes many unique elements such as composers, performers, instruments, and various media formats, which could make it difficult for the users to realize that there may be related or even duplicated music information available in a different format. Therefore, the methods of organization and presentation for music information become significant in the field of Music Information Retrieval (MIR).

Functional Requirements for Bibliographic Records (FRBR) is considered an effective model for representing the relationships between musical works and organizing the information of musical works. The goals of this dissertation are twofold. First, I adopted FRBR as a model to represent classical music and propose additional attributes and relationships through user studies to enrich music information for users. Second, I examined, through user studies, how the FRBR model improves MIR compared to existing keyword-based retrieval methods.

In order to achieve these two goals, three phases of studies are designed. The first phase examined users' perspectives toward FRBR representation and elicited their views on the importance of certain attributes and relationships in describing bibliographic records of classical music work. Phase 2 involved a content analysis of Web users' questions regarding classical music information obtained from Yahoo! Answers, which aimed to further understand Web users' information needs for classical music information and to examine whether the FRBR-

based classical music representation is adequate for satisfying those needs. The third phase examined users' retrieval performance and perceptions with FRBR-based music retrieval in comparison with FRBR-like search method using objective and subjective measures that are based on usability characteristics.

This study has two primary contributions. First, it proposed an extended FRBR-based classical music representation model, CMFRBR, which was derived through interaction with music experts, information experts, and general music seekers. Second, it examines user experiences and system performance of classical music information retrieval using CMFRBR based search system compared to FRBR-like music retrieval system on the Web in multiple dimensions.

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1 INTRODUCTION

1.1 Motivation of the Study

The explosive increase of Web and digital resources causes users to spend a significant amount of time searching, browsing, and filtering information on the Web. In digital library environments, researchers endeavor to save users' time and labor by providing effective and friendly functions such as recommending keywords, linking relationships of search results, and providing relevance ranking. There are several categories (e.g., image, local, commerce, music, etc.) people would like to search on the Web, and the music is one of the most popular topic in Web search from the general public (Beitzel, Jensen, Chowdhury, Grossman, & Frieder, 2004; Song, Ma, Wang, & Wang, 2013). This study particularly focuses on the music field because searching for music requires a different approach in comparison to other types of information retrieval. Not only it is difficult to fully grasp the many unique elements that describe music information such as composers, performance date, performers, conductors, featured instruments, and various media formats, it is also difficult for users to realize that related or even duplicate sound-recording information may be available in different media formats. In addition, most music information lacks the relationships from musical work level to performance and physical music objects such sound recordings, book, music score and so forth. Researchers have been working on resolving these problems for decades (Dickey, 2008).

Music information retrieval (MIR) has been a flourishing area in information retrieval. Currently, many musicologists, computer scientists, and even library and information scientists are primarily concerned with content-based music retrieval that focuses on music similarity of audio data that examines similar patterns of rhythm, pitch, and melodies (Casey et al., 2008). This general trend of music information retrieval especially benefits music experts, such as musicians and musical scholars, in discovering relevant music resources. However, non-expert users are not as interested in these approaches as professional users. Novice users search music information mainly with text by using metadata and keywords (Bosma, Veltkamp, & Wiering, 2006; Kim & Belkin, 2002).

In order to develop effective music database systems in both library and Web environments, it is necessary to create an appropriate organization system and metadata schema for music resources. Traditional cataloging systems provide catalog records based on item descriptions like books, films, digital objects and sound recordings in their collections. Library patrons can find adequate information about an item but would not find background information or historical creation information for a work. Especially for music, catalog records provide limited information about the work and limited performance information. Old cataloging rules and systems such as MARC (Machine Readable Cataloging), ISBD (International Standard Bibliographic Description), and AACR2 (Anglo American Cataloging Rules 2) have limitations in describing multi-layered bibliographic records that are crucial for defining the relationships of music information. Hemmasi (2002) describes the above weakness in MARC as a digitized representation of music.

Through the efforts of many library researchers, the new cataloging standard, Resource Description and Access (RDA), was launched on April 1st, 2013 at the Library of Congress of

United States of America (Library of Congress, 2012) and the British Library of United Kingdom[1]. These cataloging rules can describe the relationships between metadata information elements of classical music more systemically by applying the FRBR (Functional Requirements for Bibliographic Records) as their conceptual model.

Many FRBR-related studies and projects have been conducted in the past decade. For examples, in the early stage of music FRBR, many library projects concentrated on the migration from old music cataloging records to FRBR-based records, known as FRBRization (Yee, 2005), and several projects have done this successfully in the last few years (Ayres, 2005; Chang, Tsai, Dunsire, & Hopkinson, 2013; Hardesty, Harris, Coogan, & Notess, 2012). Following these FRBRization projects, several studies have been conducted which focused on FRBR as a conceptual model of RDA (Picco & Ortiz Repiso, 2012; Riva & Oliver, 2012; Taniguchi, 2012). Among prior FRBR-related studies, only a small number of them have included user evaluation and FRBR user task study from the past decade (Hider & Liu, 2013; Pisanski & Zumer, 2010a, 2010b, 2012; Zhang & Salaba, 2012).

In terms of classical music, thousands of famous pieces of classical music have been performed and published in various formats, which complicates the relationships of music information. The complex relationship structure of classical music makes it difficult to represent in general music information representation. It is expected that the complex structure of classical music should represent related musical works and their information. Le Boeuf (2005b) suggested that FRBR is an effective model for representing these relationships among musical works and organizing the information of musical works, including classical music. Many library projects

[1] British Library announces implementation of RDA, Available at: http://www.bl.uk/bibliographic/catstandards.html#rda

such as the Variations project from Indiana University[2] and Music Australia (now Trove)[3] are providing FRBR-based music bibliographic records. Although music FRBR has been examined as a potential solution for improving music information retrieval, there are few Web-based music databases that partially implement some aspects of a FRBR model (without claiming to have implemented a FRBR model) to organize and present music information (e.g. MusicBrainz[4]).

1.2 Focus of the Study

Motivated by previous research and discussions of the FRBR model mainly in the library cataloging settings (Ayres, 2005; Hardesty et al., 2012; McGill, 2011; Riley, 2008), there is potential benefit in adopting the FRBR model for Web-based information representation (Pisanski, Pisanski, & Žumer, 2013). In addition, classical music bibliographic records need new methods to represent and organize their complex relationships and detailed information. This study focused on the ways in which FRBR attributes and relationship descriptions enhance the usability for finding classical music bibliographic information in a Web environment.

The purposes of this dissertation are threefold. First, I adopted FRBR as an entity relationship model to represent classical music and proposed additional attributes and relationships to supplement this model. The newly added components were selected based on the original FRBR model through consultation studies in which I received feedback from various

[2] http://variations.indiana.edu/index.html

[3] http://trove.nla.gov.au/general/australian-music-in-trove

[4] http://wiki.musicbrainz.org/FRBR

groups to enrich classical music information and relationship descriptions for classical music seekers.

Second, I investigated general public's classical music bibliographic information seeking patterns in a social Q&A site, Yahoo! Answers to see if the FRBR model could provide good resources for users' classical music information needs.

Third, I examined through a user experiment how the FRBR model-based classical music search system improves music information retrieval compared to the existing keyword-based retrieval methods (IMSLP as the baseline method) on the Web.

This dissertation proposes an extended FRBR-based classical music bibliographic records representation, called CMFRBR (Classical Music bibliographical records based on the FRBR model). CMFRBR was derived through interaction with music experts, information experts, and general music seekers in Phase 1, which identified the important attributes and relationships of classical music description in FRBR model. Proposed CMFRBR's classical music representation examined the usefulness of attributes in each entity and the effectiveness of the relationships between entities. Additionally, this study examined user experiences and system performance of music information retrieval using the CMFRBR-based information retrieval system, called FIRM, compared to music information retrieval on the Web (IMSLP) in multiple dimensions. The task sets in the experiment were sampled from Yahoo! Answers in Phase 2.

1.3 Research Design

This section presents the research plan and procedure of this study. This dissertation examines the users' information needs in seeking for classical music, and how classical music information

should be represented in a FRBR-based bibliographic system. The study adopts both a qualitative and quantitative methodology in order to analyze effectiveness and usefulness of the FRBR model in enhancing the usability of information retrieval of classical music. To do so, users' search performance and perception were measured in various ways.

1.3.1 Research Questions

In order to identify the usefulness of FRBR-based classical music representation, I propose two research questions. The research questions addressed in this study are:

- RQ 1: How can classical music information be represented in a FRBR-based bibliographic system?
    - RQ 1.1: What are the important features (attributes and relationship between entities) of FRBR to represent classical music?
    - RQ 1.2: Do users experience FIRM's attributes and relationships among entities as a useful and positive aid in satisfying their information needs? Moreover, does FIRM give users a better user experience when compared to IMSLP?
- RQ 2. Can FRBR-based classical music representation provide better help for users to find music?
    - RQ 2.1: What is the general public's information need (i.e., entities, attributes, and relationship) of classical music on the Web?
    - RQ 2.2: What change in FRBR-based classical music representation should be made to help the general public on the Web find classical music information?

- RQ 2.3: Can the attributes and the relationships of the CMFRBR representation in FIRM provide the users with a superior objective and subjective experience when searching for classical music information compared to IMSLP?
- RQ 2.4: Which internal factors (independent variables: language, music knowledge, and search skills) influence the users' search performance and subjective experience?

RQ 1.1 is answered in Phase 1 (Chapter 3) and RQs 2.1 and 2.2 have been resolved in Phase 2 (Chapter 4). Finally, the remaining research questions have been examined in Phase 3 (Chapter 5).

1.3.2 Research Plan

This study follows the various steps of the research plan, summarized in Table 1.1.

Table 1.1 Research Plan

	Objectives	Methodology	Research Questions
Phase 1	• Music experts' view on FRBR entities, attributes, and relationships • Finding important attributes and relationships in FRBR in cataloging system	• Consulting with music domain experts • User survey	• RQ 1.1
Phase 2	• Finding users' information needs of classical music on the Web	• Analysis of web users' questions from Yahoo! Answers	• RQ 2.1 • RQ 2.2
Phase 3	• Effectiveness and usefulness of FRBR-based classical music representation in finding music resources	• User survey • User experiment • Interview	• RQ 1.2 • RQ 2.3 • RQ 2.4

Phase 1 (Chapter 3) consisted of two parts: 1) a consultation study with music domain experts and 2) a user survey. The first study was a consultation with four music school students from Carnegie Mellon University and the University of Pittsburgh. The participants reviewed all the attributes of each entity and relationships FRBR model proposed and they were asked to determine the FRBR's important attributes and relationship descriptions fit to classical music representation. From this study, additional attributes and relationships were proposed.

The goals of the user survey in Phase 1 were to examine users' perspectives toward FRBR representation and to determine the important attributes and relationships to describe bibliographic records of musical work. It was found that the FRBR model is suitable for classical music representation because the model contains many features to support classical music information and relationships. After the survey, attributes in each entity and the relationships between entities were ranked based on their responses. The top ranked attributes (i.e., title of work and expression, instrument of expression, name and biography of person), and relationships of classical music in FRBR were adopted to Phase 3, which examined the usability of FRBR-based classical music search that provides the attributes information and relationships between entities.

In Phase 2 (Chapter 4), a qualitative method was chosen to analyze users' questions about classical music information sampled from Yahoo! Answers, one of the most popular Social Q&A sites. The study investigated 500 questions in the classical music category in Yahoo! Answers to examine whether general web users seek to find bibliographic information of classical music. Based on the data analysis, it is revealed that a number of questions are related to bibliographical information of classical music, which can be answered with the FRBR's attributes and relationship descriptions. The findings demonstrate that FRBR-based classical music

representation can be feasible for Web-based music search systems. Phase 2 answered RQs 2.1 and 2.2. To extend the study from the findings of the Phase 2, it is necessary to examine how FRBR-based classical music representation can help users find useful information compared to the general classical music information provider on the Web.

Phase 3 (Chapter 5) assessed whether CMFRBR (Classic Music representation based on the FRBR model) can help provide useful information in practice through a user experiment. The question sets for the user experiment were adapted from the sampled questions in in Yahoo! Answers. The experiment was designed as a comparative study and conducted in FIRM, the CMFRBR-based classical music information system, and plain text-based classical music library website, called IMSLP[5] (International Music Score Library Project) to evaluate the efficiency, effectiveness, and user experience. The results analysis of the study indicated that FIRM is a suitable system to provide proper bibliographic records and relationship descriptions for general music seekers. This phase answered RQs 1.2, 2.3, and 2.4. The main research questions were solved in multiple phases. The relationships between phases and research questions are shown in Figure 1.1.

[5] http://imslp.org/

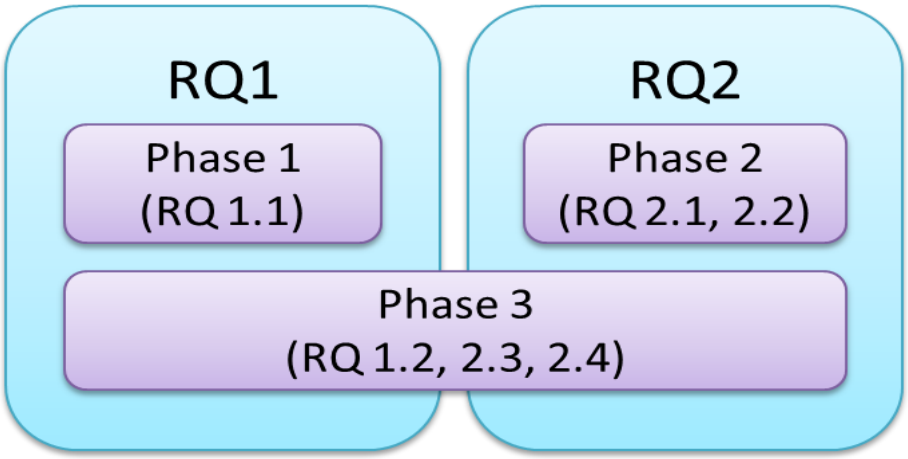


Figure 1.1 Phases and Research Questions

In terms of the relationships among the phases, Phase 1 contributes to the rest of phases by providing the attributes and relationships for the CMFRBR model. All the code categories in Phase 2 were created based on the lists of attributes and relationships for CMFRBR from Phase 1. In addition, Phase 3 adopted all the relationships and attributes from Phase 1 in order to build the classical music collection. Phase 3 also borrowed the questions from Phase 2 in order to organize six task sets which ask for bibliographic information of classical music from real questions from the general public. Figure 1.2 illustrates the relationships among the phases.

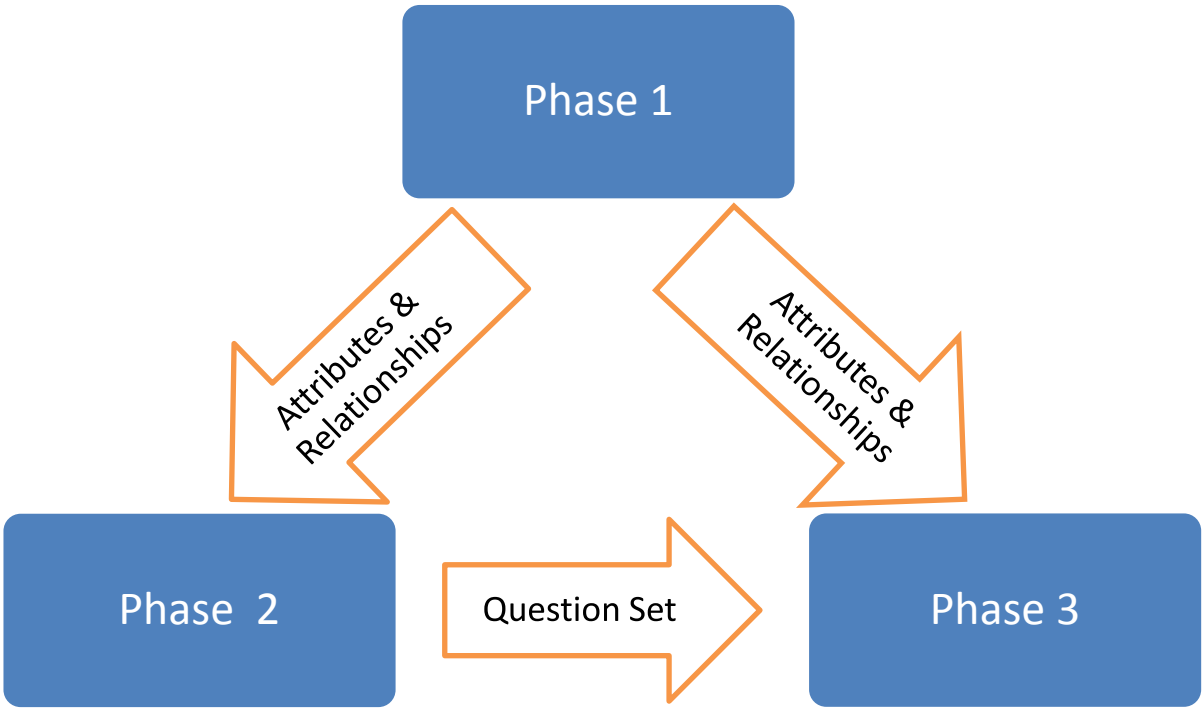


Figure 1.2 Relationships Among Phases

1.4 Terminology

This section provides concise definitions for the key terminologies in this study, including the components of Functional Requirements for Bibliographic Records (FRBR), and Music Information Retrieval (MIR).

1.4.1 Functional Requirements for Bibliographic Records (FRBR)

1.4.1.1 Work

IFLA (International Federation of Library Associations and Institutions) Study Group on the Functional Requirements for Bibliographic Records defined work as *"*a distinct intellectual or artistic creation. It is an abstract entity; there is no single material object one can point to as the work*"* (1998). The definition of musical work is "an intellectual sonic conception. Musical work takes documentary form in a variety of instantiations" (Richard P Smiraglia, 2001). This study solely focuses on classical musical work and adopts its definition from the Merriam-Webster dictionary: "of, relating to, or being music in the educated European tradition that includes such forms as art song, chamber music, opera, and symphony as distinguished from folk or popular music or jazz ("Classical," 2015)." Its period expands from the 11th century to the present day which includes Medieval, Renaissance, Baroque, Classical, Romantic, 20th Century, and Contemporary, and the form of classical music includes Orchestral Music (symphony, concert, ballet, suite, etc.), Chamber Music (string trio, piano trio, string quintet, etc.), Solo Instrumental Music, Vocal Music, Opera, etc.

1.4.1.2 Expression

The definition of expression by the IFLA Study Group on FRBR is "the intellectual or artistic realization of a work in the form of alpha-numeric, musical, or choreographic notation, sound, image, object, movement, etc., or any combination of such forms" (1998). In this study, "expression" refers to the realization of classical musical work by certain musicians or group's performance in a certain time and place. The delivering method of this expression can include studio performance, concert, event performance or recording process.

1.4.1.3 Manifestation

Manifestation is “the physical embodiment of an expression of a work” (IFLA, 1998). In this study, manifestation is a published musical expression in a certain physical embodiment. All formats of medium, physical or electronic, which contain the music expression, can be considered as a manifestation. This study does not include physical or electronic objects of music book, music score, or other materials in manifestation; only sound recordings of classical music performance in its carrier including CD, DVD, computer file (mp3), video file (clip).

1.4.1.4 Person

Person is a term which “encompasses individuals that are deceased as well as those that are living” (IFLA, 1998). It is, in this study, an individual (musician or related person) who is responsible for each musical work, its expression, or manifestation is defined as person. Examples of person in musical work are composer and writer (lyricist, librettist). Person in expression includes performer, conductor, sponsor, and director. The publisher (if applicable) and the representative person in publication can be manifestation of person.

1.4.1.5 Corporate Body

Corporate body is “an organization or group of individuals and/or organizations acting as a unit. The entity defined as a corporate body encompasses organizations and groups of individuals and/or organizations that are identified by a particular name, including occasional groups and groups that are constituted as meetings, conferences, congresses, expeditions, exhibitions, festivals, fairs, etc.” (IFLA, 1998). Corporate body in Music FRBR is a group that is responsible for each musical work, its expression[s], or manifestation[s]. A person in corporate body does not have to belong to a sole corporate body; s/he can be a member of any corporate body if

necessary. The examples of corporate body in work, expression, and manifestation are same as person entity above.

1.4.1.6 Attributes

Attributes of each entity serve as the means by which users formulate queries and interpret responses when seeking information about a particular entity (IFLA, 1998). Although all the semantic terms of attributes are kept in the background, in order to enhance users' understandability, the name of some attributes can change (i.e. Medium of Performance as Instrumentation, Numeric Designation as Opus Number or Music Number).

1.4.1.7 Relationship

In this study, I accept most of the relationships from the FRBR draft, and have modified or added relationships as necessary.

- Work is realized through an expression
- Work is created by a person/corporate body
- Expression is embodied in a manifestation
- Expression is realized by a person/corporate body
- Work has a successor: consecutive work series (e.g. part I, II…), or new arrangement (Mozart's K. 466 to Beethoven's Wow 58. Cadenzas for K. 466)
- Work belongs to a Work of Work (or Parent Work): Uniform title of series of work. e.g. Haydn's Paris symphonies (No. 82 - 87)
- Sibling work: other works from the Work of Work (collection)
- Expression has an Expression of Expression: (e.g. concert, performance)
- Sibling expression: different expressions from the same work

- Related expression: different expressions from the Expression of Expression (or in the same manifestation)

1.4.1.8 CMFRBR

This study introduces the extended model of FRBR suitable for classical music bibliographic records, CMFRBR. CMFRBR refers to the Classical Music bibliographical records representation based on the FRBR model.

1.4.1.9 FIRM

FIRM refers to the CMFRBR-based Information Retrieval system developed for this dissertation. FIRM is utilized to examine the usability of the CMFRBR model in Chapter 6.

1.4.2 Music Information Retrieval

Music Information Retrieval is defined as "an interdisciplinary research area devoted to fulfill users' music information needs" (Orio, 2006). In this dissertation, the term "music information retrieval" stands for the FRBR-based music metadata information retrieval, which describes the bibliographical information of musical pieces stored in a media format such as CD, DVD, computer files (e.g. MP3), score book, etc. Moreover, returned objects, such as attributes in each entity and relationship information between entities, will be considered the results of FRBR-based music information retrieval. As a result, MIR in this study does not include content-based music information retrieval (Casey et al., 2008).

2 REVIEW OF THE LITERATURE

This chapter reviews previous research on music information retrieval and music catalog in library settings. In addition, studies of metadata use and the relationship model in music information retrieval are introduced, as well as discussion of FRBR.

2.1 FRBR as a Conceptual Model of Cataloging System

2.1.1 Functional Requirements for Bibliographic Records

Functional Requirements for Bibliographic Records (FRBR) is a recommendation of the International Federation of Library Associations and Institutions (IFLA) to restructure catalog databases to reflect the conceptual structure of information resources (IFLA, 1998). FRBR defines relationships among entities such as Work, Expression, Manifestation, Item in Group 1, and Person, Corporate Body in Group 2.

FRBR identifies three groups of entities relevant to users of bibliographic information: Group 1 entities include “products of intellectual or artistic endeavor that are named or described in bibliographic records” (IFLA, 1998). Group 1 of FRBR consists of four entities: Work, Expression, Manifestation, and Item. The entities in the Group 1(Figure 2.1) represent the different perspective of user interests in the outcomes. The work defined as “a distinct

intellectual or artistic creation" and expression is 'the intellectual or artistic realization of a work". The definition of manifestation is "the physical embodiment of an expression of a work" and item refers "a single exemplar of a manifestation" (IFLA, 1998, p. 13). When FRBR is applied to music information, Group 1 plays an important role in music information retrieval because it contains and provides the music's bibliographic information (i.e., title, musician[s], instruments, publisher, etc.). Each entity is linked by certain relationships, i.e. "work is realized through expression"; therefore, the connections of all entities create an integrated workflow of music information.

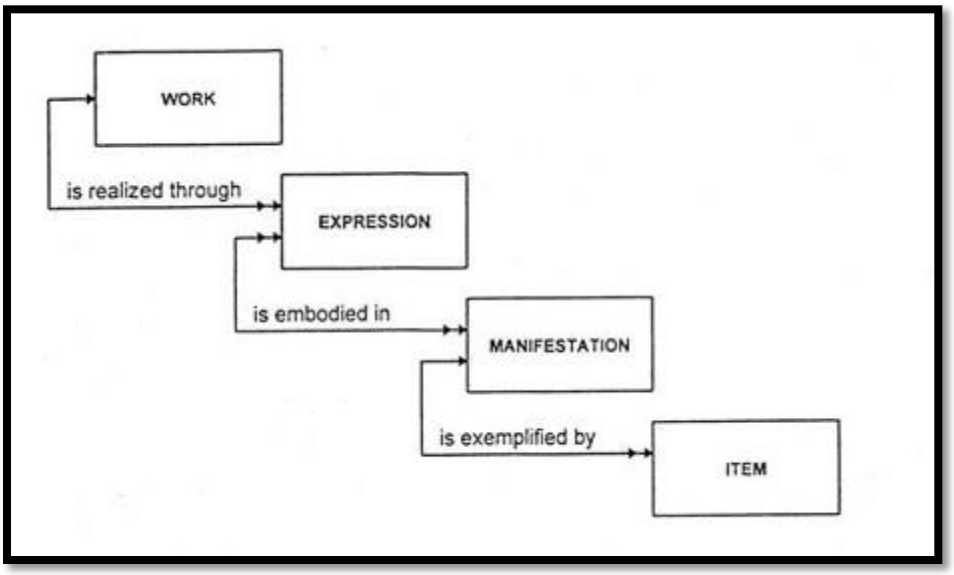


Figure 2.1 Entities in Group 1 and Primary Relationships (IFLA, 1998)

Group 2 includes "those entities responsible for the intellectual or artistic content, the physical production and dissemination, or the custodianship of the entities in the first group" (IFLA, 1998, p. 14). It consists of person (an individual) and corporate body (an organization or group of individuals and/or organizations). Group 2 represents the entities responsible for the

intellectual content, artistic content, and propagation of the entities in the first group. The entity, Person, enables users to draw relationships between a specific person (e.g., composer) and a work (e.g., musical work), or an expression of a work for which that performer or conductor may be responsible, or between a musical work and the musicians that performed the work. The person entity contains all biographical information of a specific person like, date of birth, date of death, and so forth. A corporate body (e.g., orchestra) plays the same role in FRBR that person does, and sometimes even replaces person (e.g., musician). In Group 1, one or more persons or corporate bodies can be involved in each entity based on the number of contributors of a musical work.

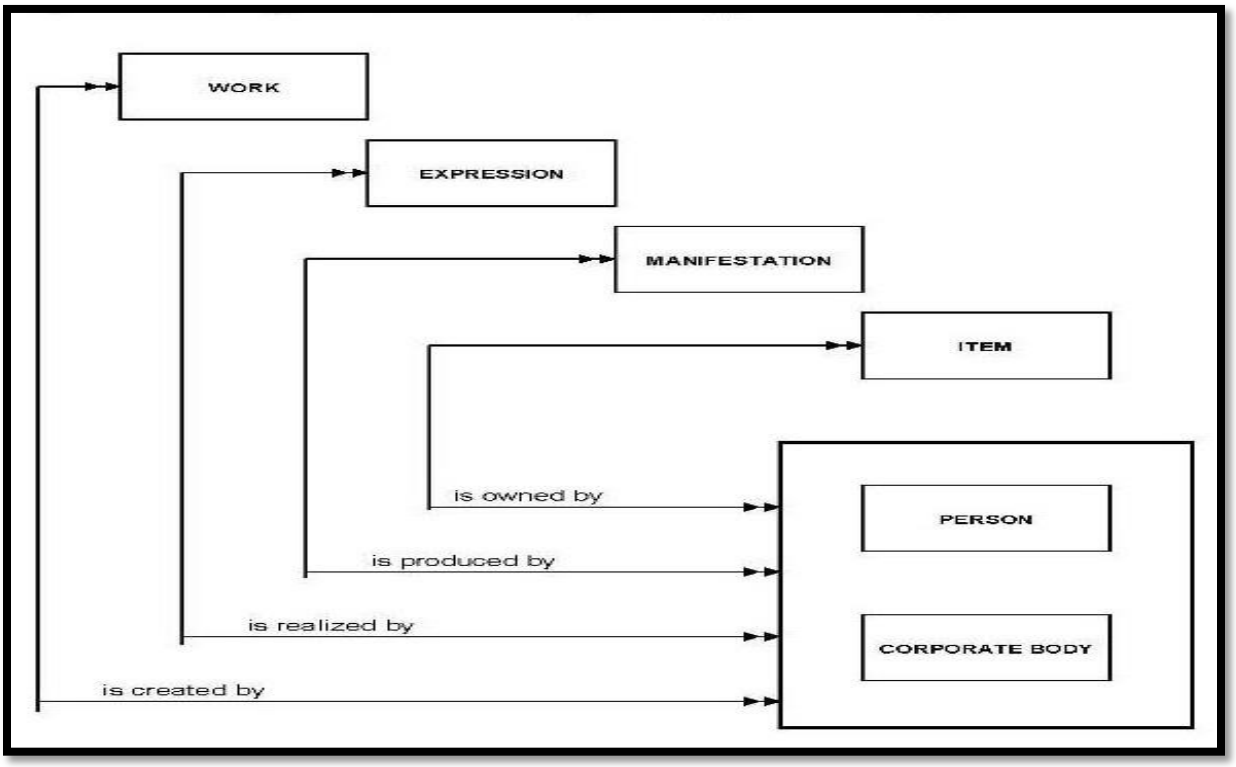


Figure 2.2 Entities in Group 2 and "Responsibility" Relationships (IFLA, 1998)

Group 3 entities "serve as the subjects of work" (IFLA, 1998, p. 17). This group consists of "concept" (an abstract notion or idea), "object" (a material thing), "event" (an action or occurrence), and "place" (a location). This group represents additional types of support for the work entity in Group 1 with a subject relationship. Work can have more than one concept, object, event, and/or place as a subject. By adding Group 3, work entity can enrich its subject information. For example, if a musical work exists with its attributes and relationships with Group 2, Group 3 can support detailed information such as the location of music creation, music composition event, music concept or genre, and so on.

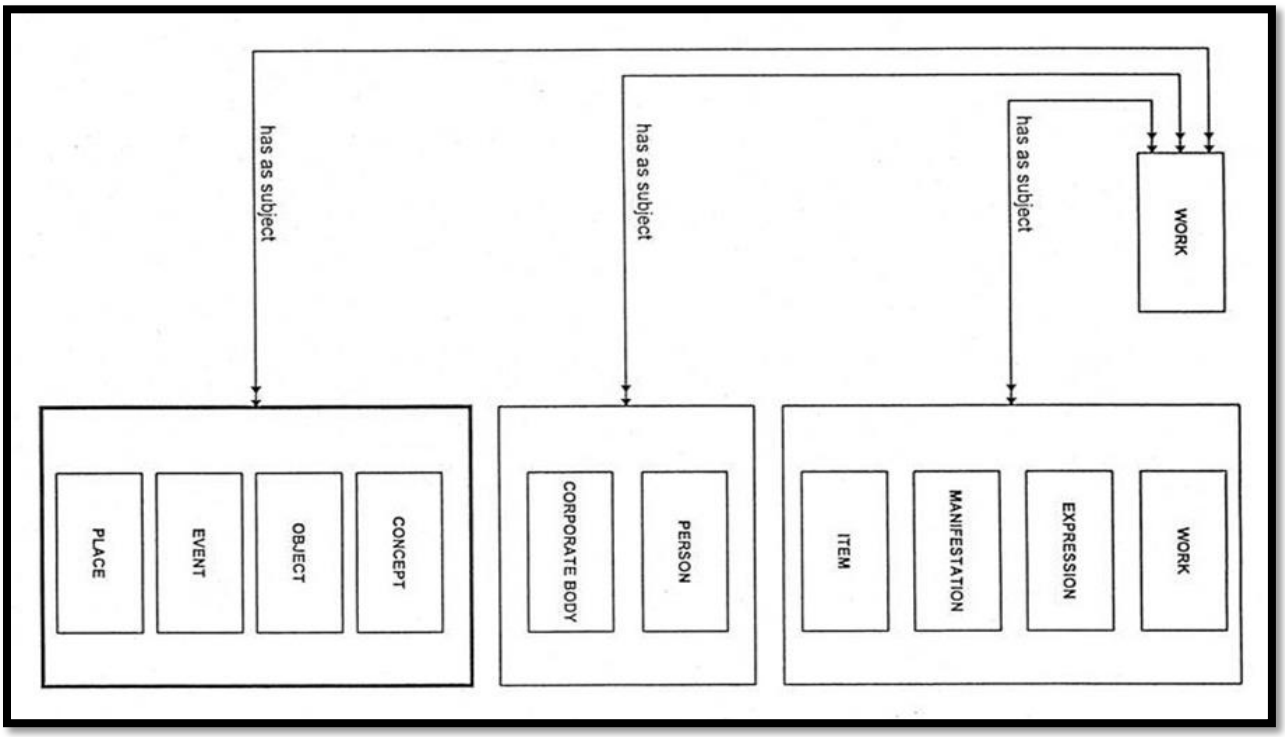


Figure 2.3 Entities in Group 3 and "Subject" Relationships (IFLA, 1998)

2.1.2 Research on FRBR

From the beginning of the new millennium, many libraries and library researchers endeavored to develop FRBR in different aspects. This chapter will review the FRBR as an entity-relationship model, application, system development, and evaluations based on the categories from the previous research (Merčun, Švab, Harej, & Žumer, 2013; Zhang & Salaba, 2009b).

2.1.2.1 FRBR as Entity-Relationship Model

FRBR has been considered a new representation model for bibliographic information and many previous studies discuss how FRBR can differentiate the representations of old bibliographic data of resources (Le Boeuf, 2005b; O'Neill, 2002; Riley, 2008; Riley, Hunter, Colvard, & Berry, 2007; Riva, 2007; Tillett, 2005; Zhang & Salaba, 2009a). In addition, Resource Description and Access (RDA), a new cataloging standard and a replacement of AACR 2, employed FRBR in its conceptual model for displaying relationships (Chapman, 2010; Seikel, 2013).

FRBR can draw the relationships between entities, and can place all versions of an intellectual work in a specific collection. Chapman (2010) and Riley, Mullin, and Hunter (2009) point out that AACR2 is a single item centered cataloging which can present limited relationships such as redundancy, while the FRBR model can present a whole map of relationships based on work entity. Maxwell (2008, p. 134) explains that "MARC was designed as a flat-file system, with all information about an item within a single bibliographic record divided into fields of fixed or variable widths….The bibliographic format record continues to contain aspects of all the FRBR entities in flat-file system." Each MARC record typically describes the bibliographic records of a single item, while the field records contain all of the

necessary information about the cataloged item without depending on other records (Takhirov, Aalberg, & Žumer, 2011).

One of the advantages of FRBR is that it facilitates both a search and exploratory interface so that music seekers can follow the relationships from person or work level to find the expression, as well as different versions of manifestations (Buchanan, 2006; Takhirov, Aalberg, Duchateau, & Žumer, 2012). Moreover, Bennett et al. (2003) note that FRBR is not only an assured model to enhance the functionality of search and retrieval tools for library patrons in a catalog system, but is also a more efficient model for cataloging practice. Merčun and Žumer (2009) emphasize that FRBR can help users explore search results and find relationships of the records as well. Collocating related bibliographic records within a set of clusters will help users navigate search results, understand relationships between items, and supply opportunities to access similar works and expressions. FRBR provides a better means for users to navigate possible relationships like different media formats, editions, languages, publishers, and so forth (Dickey, 2008). Tillett (2005) notes that "FRBR offers us a fresh perspective on the structure and relationships of bibliographic and authority records, and also a more precise vocabulary to help future cataloging rule makers and system designers in meeting user needs." FRBR hosts comprehensive descriptions of the item, its available formats, and the precise location and availability of each format. The system goes on to note the collection or location which houses a specific manifestation or expression of a work. Users want to know where the manifestation of the work is, in which formats it is available at a location, as well as related items culled by the FRBR system.

FRBR can define relationships well in a hierarchical structure. Entities in Group 1 normally have a "one to one" or "one to many" relationship with other entities. When work

collocates with expression, the relationships of the multiple expressions and manifestations of the same work can be shown in the display of a catalog system (Bowen, 2005). One work can have one or more expressions, and each expression can also have one or more manifestations, though a manifestation may have one or more manifestations. Therefore, FRBR is a hierarchical-structured model. Figure 2.4shows a simple picture of the FRBR structure.

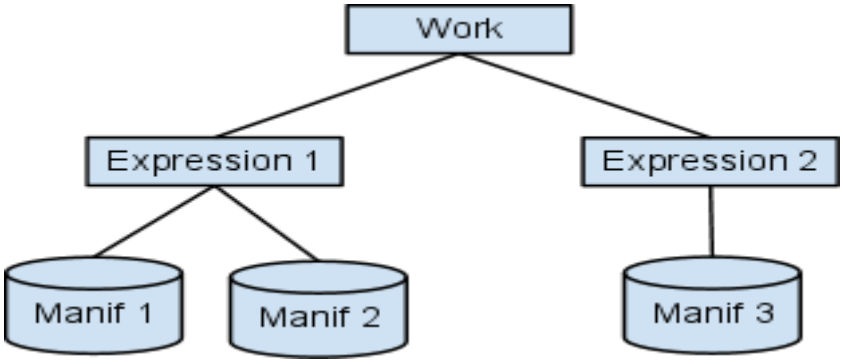


Figure 2.4 Simple FRBR Structure

A novel is a good representation of a hierarchical relationship. A novel (work level) can be translated into different languages or have different editions in the expression level, and its different manifestations can be published by various publishers and countries. For example, A Tale of Two Cities, originally written by Charles Dickens in 1859, has been published in multiple languages (i.e. French, German, Chinese, etc.). Figure 2.5 shows the example of this hierarchical relationship.

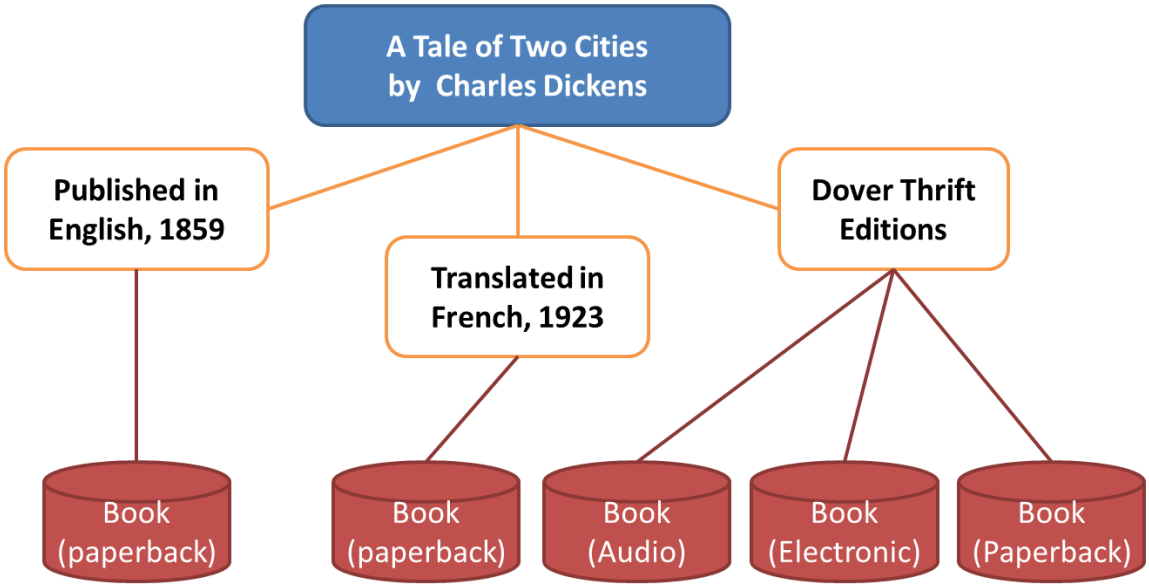


Figure 2.5 Hierarchical Relationship of book publication

A number of revisions have been published by several publishers at different times. Moreover, types of expressions such as voice recordings (i.e. audio books), illustrations, and digitalization (i.e. electronic book) of the novel have been repeatedly produced. In order to present the relationship between these products, it is possible to draw a hierarchical relationship based on the work, *A Tale of Two Cities*.

2.1.2.2 Applications, Systems, and Evaluation of FRBR

Many FRBR-based projects in the past decade attempted to apply FRBR in their library catalog database as a conceptual model and converted its MARC records into FRBR-based records. The Online Computer Library Center (OCLC) implemented FRBR records with projects like WorldCat (http://www.worldcat.org/), FictionFinder (http://fictionfinder.oclc.org/; discontinued), and Work Records in WorldCat (http://frbr.oclc.org/research/pages/index.html). The OCLC found that implementing a FRBR-based representation system with a catalog database is feasible

(Bennett et al., 2003; Hickey & O'Neill, 2005; Hickey, O'Neill, & Toves, 2002; O'Neill, 2002; Pisanski & Zumer, 2007). It was found that work and manifestation levels are possibly already identified in existing catalog records; however, identifying the expressions of work were problematic due to the lack of expression attributes (O'Neill, 2002). The problem of defining the expression entity has been reported in various studies, and Richard P. Smiraglia (2012) arranges the issues of expression in cataloging as technical problems, identifiable issues, modeling issues, etc., by giving the examples of previous studies. According to Le Boeuf, however, these issues are not a true modeling problem of expression in FRBR; the problem is caused by cataloging practice (Le Boeuf, 2005a).

Other examples of large-scale FRBR projects in libraries are the Australian National Bibliographic Database (Rajapatirana & Missingham, 2005), AustLit: the Australian Literature Gateway (Ayres, 2005; Ayres, Kilner, Fitch, & Scarvell, 2002; Kilner, 2005), and the MusicAustralia (integrated into Trove in June 2012) projects (Ayres, 2005). These projects were led by the National Library of Australia and universities in Australia. They successfully achieved their goal of implementing FRBR in their database. According to Ayres (2005), integrating an enriched FRBR-based view with the traditional bibliographic view benefitted users who were seeking information.

The evaluation of FRBR leads to the investigation of catalogers' or indexers' usability. Therefore, it is necessary to find how users behave when seeking information in a FRBRized cataloging system. A Delphi study finds, when contemplating possible issues with the FRBR model, library experts are most concerned with whether or not the FRBR model is appropriate for the user (Madison, 2006; Zhang & Salaba, 2009a, 2009b). Compared to other areas, a small number of user evaluations and user task studies were conducted (Hanrath & Kottman, 2015;

Pisanski & Zumer, 2010a, 2010b, 2012). A few researchers conduct user evaluation using the developed systems (Hardesty et al., 2012; Notess, Dunn, & Hardesty, 2011; Sadeh, 2008; Salaba & Zhang, 2012; Zhang & Salaba, 2012). Although these studies demonstrate that users can successfully identify FRBR entities and relationships, there has been less focus on how users can find metadata information and detailed relationships among FRBR-based music representation (Žumer, Salaba, & Zhang, 2012). It is generally considered to be an important contribution to the understanding of the entities and relationships that are of interest to the end user (Takhirov et al., 2011). IFLA defines user tasks as four steps: find, identify, select, and obtain. Not all entities can be applied in each task. For example, users can find, identify, and select work and expression, but cannot obtain work or expression. Not all user studies follow the user task of the FRBR draft, but many studies are processed based on the user task suggestion.

2.2 FRBR as Music Information Representation Method

2.2.1 FRBR-Based Music Representation

Several researchers perceive that FRBR can serve as a data representation model of musical bibliographic information in the library cataloging system, and adopted the FRBR model in music catalogs (Ayres, 2005; Dunn, Byrd, Notess, Riley, & Scherle, 2006; Le Boeuf, 2005b; Minibayeva & Dunn, 2002; Riley, 2008; Riley et al., 2007; Richard P Smiraglia, 2001).

Most FRBR projects in the past decade made efforts to successfully migrate the bibliographic records of music from MARC to FRBR. However, the projects had difficulties including the many attributes of work and other entities needed to realize the benefits of the application of the FRBR model. This was mainly due to the lack of detailed descriptions and

relationships in previous catalog records where these attributes can function as information resources to users. This is because a MARC record of a music item does not contain enough bibliographical description of the musical work, expression, and person entity. This dearth of prior information leaves many fields in FRBR entries empty after converting from MARC, thus crippling the FRBR system. While this is not the only problem when converting to FRBR, it can severely limit the development of relationships between musical works and persons. In order to link the complex relationship between work, expression, and person, the FRBR model provides the entities of person and corporate body in Group 2 and establishes relationships with the entities in Group 1. The bibliographic records of music have more entry fields to fill in than those of printed materials, such as books in a library cataloging system, because, for instance, various levels of person such as composer, conductor, performer, and librettist exist in work and performance levels. In a MARC entry, catalogers used 7xx fields (added entries) to describe the additional information to improve the search results and present better information about the item. The 100 and 7xx fields often contain person and corporate body information, including the titles of works or performances (Takhirov et al., 2012). In the context of music FRBR, common usages of added entries are to include additional persons such as composers, performers and conductors. Using these fields, it is possible to extract person/corporate body and link with the musical work. This will be able to draw relationship between music and persons.

FRBR is designed to support the representation of the multiple or related resources. However, it has limitations when representing relationships with hierarchical structure. S. Lee and Jacob (2011) argue that FRBR has difficulty portraying dynamic resources because its firm hierarchical structure makes its relationship not fully supported between groups of entities and attributes. When the FRBR model is applied to music records, the relationships among work,

expression, manifestation, and person and corporate body seem complex. For sound recordings, especially with music, Bowen (2005) states that a specific music event or performance is an expression level, so that all products of the event are the manifestation of the expression. In the expression level, multiple musical works by different composers can be played by musician(s) and/or conductor at one concert. Then, in the manifestation level, the concert could be recorded to various media formats with a specific title for the concert which is not related to the title of the musical works. For example, two pianists record Beethoven's piano sonatas in an album, and release it with different titles. In addition, one famous music columnist may collect his/her favorite classical music from various composers (i.e. Beethoven, Mozart, Bach, etc.) and release them in various media formats. In most of these cases, it will be difficult to represent the relationship of music information because defining the relationship of the musical works and the musicians in work and expression levels is complex. Adding to this, when these Expressions are released in different types of containers such as CDs and DVDs, another complexity of music relationship between containers take places in Manifestation level.

When a smaller music collection or a particular composer's musical works adopt the FRBR model, it is anticipated that a simple network structure model can be established. However, when the FRBR model covers a library's entire music collection, it is difficult to define the relationship due to the complication of the network-like arrangement. Therefore, it is hard to say whether real FRBR displays would be in a hierarchical structure or, in fact, have network structure. According to Pisanski and Zumer (2010a), a true FRBR display should be a network structure, not a hierarchy, because various works and expressions can be contained in a single manifestation. Similar problems could occur if music records employ the FRBR model.

Figure 2.6 shows an example of the complexity of a music record's relationships of a specific concert, and Figure 2.7 shows an example of another complex model of a music record's relationships of studio recording.

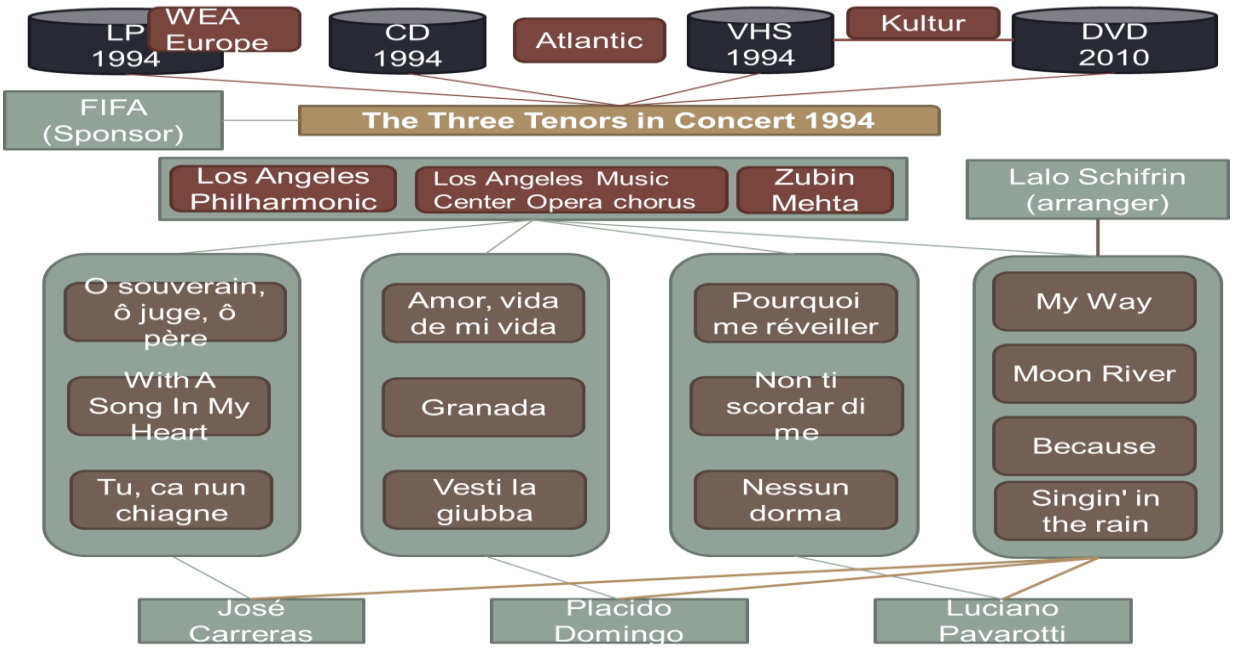


Figure 2.6 Three Tenors Concert for USA World Cup 1994

In Figure 2.6, it is assumed that a performer (e.g., Placido Domingo) did not contribute the entire concert because he performed three songs solo, and four songs in trio. Thus, it is necessary to represent the information of the entire concert. Therefore, this study suggests employing the representative entity, which contains all expressions in a concert.

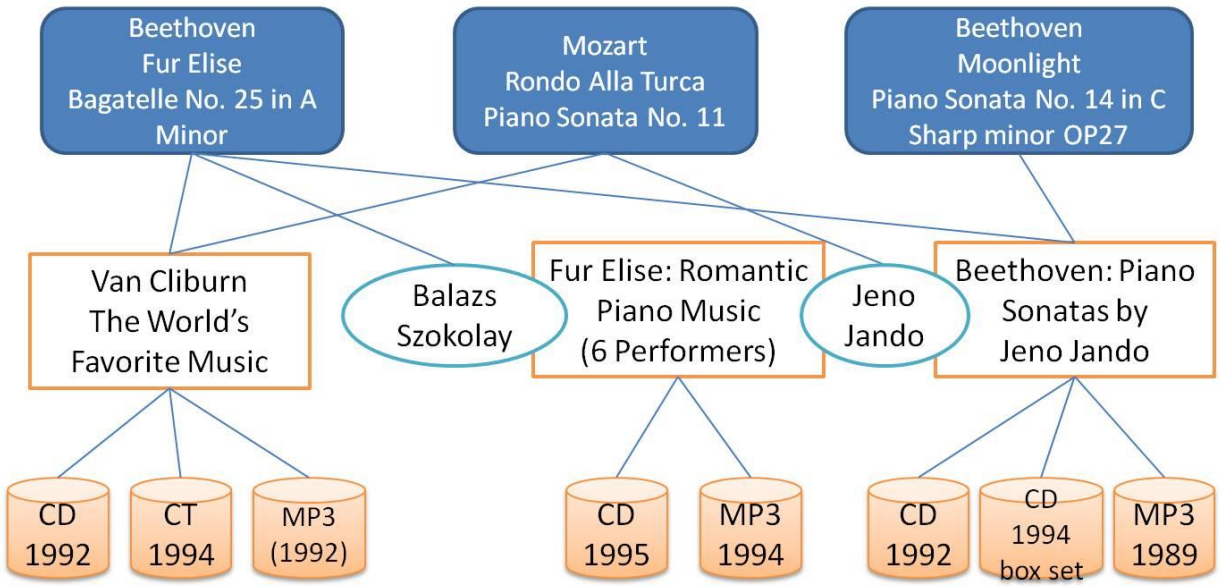


Figure 2.7 Complexity of Music Records Relationship

Another problem occurs when music information is applied to FRBR. Le Boeuf (2005b) demonstrates that four entities in FRBR can highlight the four distinct meanings that a single word such as "score" may have in common speech. In other words, score can be repeated in all entities when it has different characteristics. Score is a work when it is used in the sense of musical work or when its role is the base of the derived product/performance of a musical work. When score is the abstraction in a composer's mind with its concept of contents or text, it is expression. Manifestation is the publication of musical work.

Moreover, format variation on intellectual property is another question that how to present the relationships between printed and digitized (electronic) versions as realizations of the same content (Oliver & Curran, 2004).

2.2.2 Variations Projects

Variations projects are long-term digital library projects, which provide online access to find sound recordings and music scores, led by William and Gayle Cook Music Library on the Bloomington Campus of Indiana University. Variations projects have three stages of project history: Variations, Variations2, and Variations3. The Variations projects adopt FRBR as a major data model from Variations2. This literature mainly discusses the Variation2 and 3 of which the data model is FRBR. The modified FRBR framework (Figure 2.8) and Variation Example (Figure 2.9) show selected entities that especially represent and fit well to music collections – Work (title, composer), Expression which replaced by Instantiation (performer, conductor, and instrument), Container replacing Manifestation (Type of media, Date, Publisher, Genre, etc.), and Media Object as Item (single music file) (Dunn et al., 2006; Hemmasi, 2002; Minibayeva & Dunn, 2002; Notess & Dunn, 2004; Riley et al., 2007; Scherle & Byrd, 2004).

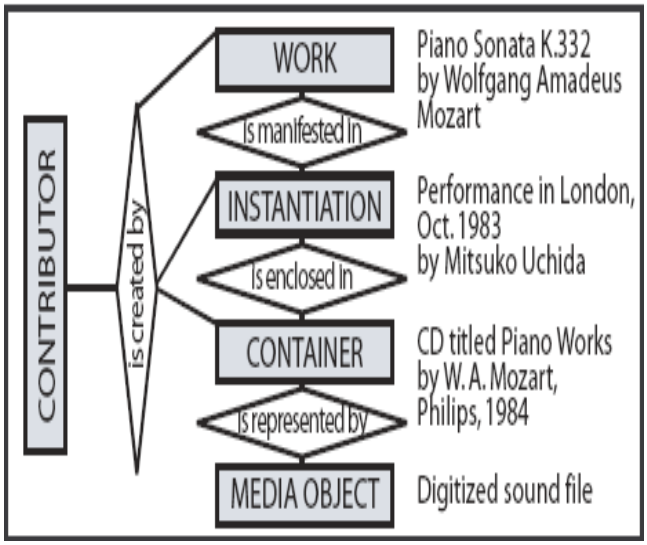


Figure 2.8 Variation Model

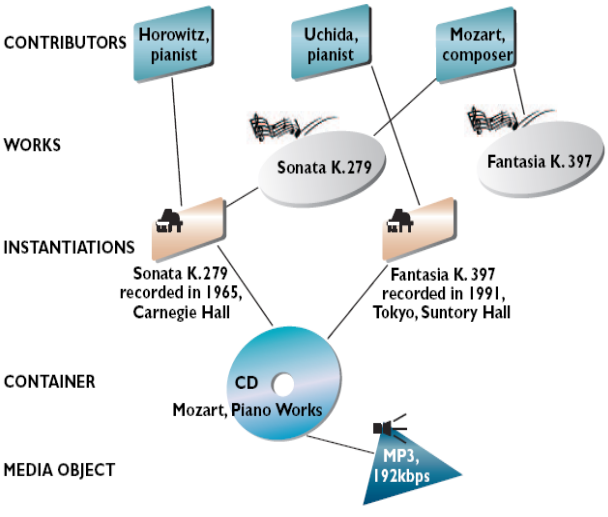


Figure 2.9 Variation Example

The data flow chart in Figure 2.10 shows a sample representation of the FRBR model applied to the Variation 3 project (Riley et al., 2007). The chart represents different levels of persons (composer and pianist) involved in work and expression, and their works and expressions are embedded into manifestation and item levels. Manifestation and item contain all of the music's work and bibliographical records.

Although each entity contains information relating to the music, it is still difficult to find the relationships between works (if there are parallel level or similar works), or person and corporate body. Moreover, a single manifestation that contains multiple expressions has common information between those expressions that explicitly defines important relationships. It is understood that the problem resides in the old catalog system, which did not separate the expression information in MARC, causing incorrect relationship information between performer and expression.

If there are parallel levels of works under a certain title of work collection (e.g., Haydn's Paris Symphony – Symphonies Nos. 82-87), it should show the relationships between works. Currently, FRBR does not support the relationships in this way; it lacks the related information necessary for users. Similar to work, expression information should also describe the relationships between expression entities if they occur under a specific time or space, like a concert.

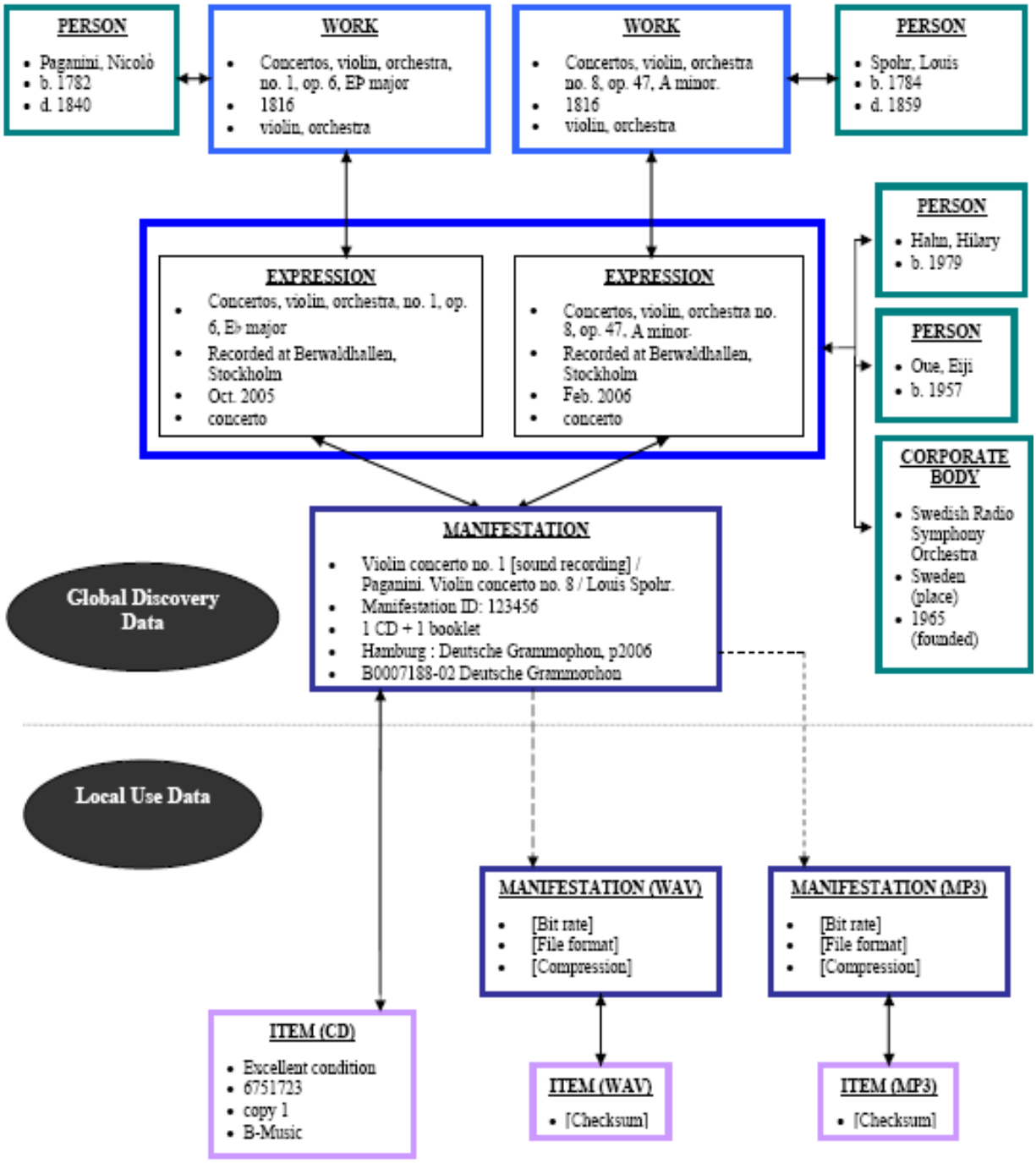


Figure 2.10 FRBR Representation of Variations3 (Riley et al., 2007)

2.3 Music Information Retrieval

2.3.1 Metadata Based Music Information Retrieval

Music Information Retrieval (MIR) is an interdisciplinary research area that has grown out of the need to manage burgeoning collections of music in digital form (Futrelle & Downie, 2002). Bosma et al. (2006) assert that music information retrieval is the co-work between musicology and computer science to retrieve musical objects. Information professionals, such as music librarians and library scholars, make many efforts to work in the music information retrieval field as well.

Based on the characteristics of music resources, there are two major music information retrieval areas: 1) content-based music information retrieval and 2) metadata-based music information retrieval. Content-based MIR systems are mainly concerned about music pattern similarities. Content-based MIR has many advantages for music experts as they have better knowledge on patterns of music tone, melody, pitch, etc. (Casey et al., 2008). However, it is relatively less helpful to non-expert users while seeking for music resource, due to the users' lack of knowledge of musical contents. When users search by rhythm or keys, they have to know the exact rhythm or keys. Most novice users usually only vaguely remember the melody of music. Therefore, they cannot represent the music with the exact rhythm or keys. Although MIR research relies heavily on content-based retrieval methods, there are efforts by librarians to combine content search and traditional metadata search that can provide improved access to music for their patrons (Riley & Mayer, 2006). Metadata for music resources consists of various performers, recorded dates, played instruments of each media format in addition to basic information of title, composer, composed date, etc.

2.3.2 Music Information Retrieval on the Web

Lee and Downie's survey (2004) shows that metadata has an important experience enrichment aspect for users. In their survey, the top three methods in searching are title, lyrics, and artist information. This study shows that music information seekers prefer to search with metadata rather than other information such as genre, review, or background information. Similarly, some studies assert that most music seekers would rather search information based on metadata descriptions than other possible approaches (Cunningham, Jones, & Jones, 2004; Downie & Cunningham, 2002; Isaacson, 2002). Other studies reveal that users often request bibliographic information of music including title, performer, date, orchestration (instrument), genre, etc. (Bainbridge, Cunningham, & Downie, 2003; J. H. Lee, 2010). However, it is often hard for novices to search for music information with low-level musical knowledge. Orio (2006) reveals that the utilization of appropriate metadata is notably useful to retrieve relevant information only if users know the information. Non-experts are faced with a problem when performing metadata-based searches, as a pre-assumption of metadata-based search is that users already know part of music metadata information before searching. With this point of view, Kim and Belkin (2002) determine the limitations of metadata-based music information retrieval, which is that novice users sometimes do not know or use musical terms. Chen and Butz (2009) also examine non-expert users that have a high level of difficulty in expressing their musical preferences in a formal way, and often change their minds during the search process.

One option for novice music searchers is to seek advice from others on the Web. In the current Web environment, non-expert users are able to find recommendations, annotations, tags, or Question & Answer sets from other users in order to obtain new information of music. In the Web-based music collection, users' contributions, which enrich the annotations and tags, help its

collection and description of collection as well as through collaborations. Previous studies explain the importance of Web communication among users in searching for music information. Some studies analyze the social Question & Answer sites such as Google Answers and Yahoo! Answers, and found that users' interests and needs of music resources, especially bibliographic information (Bainbridge et al., 2003; Cunningham & Laing, 2009; J. H. Lee, 2010). According to Chen and Butz (2009), digital technology changes the way of organizing, browsing and searching for music. Since many novice users find advice from their surroundings and Web-based community, it would be beneficial to have social recommendation, annotation and a tag feature, which would allow users to find ideas about music information from the system. Interaction within social communities gives users the ability to enrich their music search experiences. Furthermore, it is expected that novice users' problem of selecting proper query terms will be somewhat solved by providing other users tags, annotations and recommendations. Previous studies also suggest that music information collaboration systems should integrate searching and browsing seamlessly and offer functionalities such as query recommendation, which go beyond explicit search, in order to allow users to find unexpected but acceptable results (Bentley, Metcalf, & Harboe, 2006; Chen & Butz, 2009; Cunningham, Reeves, & Britland, 2003).

2.4 Summary

Previous studies found a number of music information needs on the Web, and a large portion of needs are related to bibliographic record of music to find certain music. Based on the users' information need of music, FRBR can play a significant role to represent music information, and provide search and browsing option to retrieve music information.

Previous research presents FRBR-based music information in the library catalog, and conducts user experiments based on the user task that the FRBR draft suggests. The results of user experiments demonstrate that FRBR can provide its users with a better way to find bibliographic information. Although users can successfully identify FRBR entities and relationships, there have been gaps in whether or not users can find and identify attribute information of the entities and detailed relationships between entities.

Most user studies have been conducted in a library environment; this lacks user evaluation on the Web, where people may want to find information about musical work, expression, and manifestation entities. This study will examine the performance and perception of users using FRBR-based music searching and browsing as compared to Web-based keyword search. In addition, the FRBR-based system in this study suggests additional attributes, relationships, and higher levels of work and expression entities which will enrich describing music information.

3 PHASE 1: Finding the Appropriate Attributes and Relationships of FRBR Entities for Classical Music

3.1 Introduction

When the FRBR model is applied to music records in a catalog, it is expected to be able to describe the relationship between work, expression and manifestation. With the relationship information, users may enhance their chance of learning musical information, including the background of music. Each entity has its own particular attributes and can supply more efficient information with these attributes. Also, in Group 2, the attributes contain person and corporate body's feature, which are related to work, expression, and manifestation. Therefore, it is possible to make connections between work/expression/manifestation and person/corporate body by applying a relationship description. However, in this study, the target entities are only work and expression in Group 1, and person and corporate body entities in Group 2. Manifestation and item entities in Group 1 are disregarded because the focus of the study is how users are aware of background information (like work, expression and person) in cataloging records, and how influential they consider these new entities to be in bibliographical records in the new cataloging model.

Based on the setting of the survey, the research question is identified under RQ 1.

RQ 1.1: What are the important features (attributes and relationship between entities) of FRBR to represent classical music?

RQ 1.1 is a sub question of RQ 1, and the remaining question (RQ 1.2) will be answered in Phase 3.

3.2 Finding Important Attributes and Relationships in Music FRBR

3.2.1 Selection of Attributes of an Entity and Relationships

The FRBR final draft (IFLA Study Group on the Functional Requirements for Bibliographic Records & International Federation of Library Associations and Institutions. Section on Cataloguing. Standing Committee, 1998) suggests different types of attributes by entities, and has many relationship descriptions between entities. Additional attributes were also adopted, such as place of work, place of expression, and biography of person, based on the suggestion by the consultation with four music school students from Carnegie Mellon University and the University of Pittsburgh and the Variations project (Riley, 2008). While the music students discussed FRBR, they examined and referred to the FRBR final draft, Variations project, and the report from Library of Congress (Delsey, 2002). After consultation, some attributes of each entity that the FRBR final draft suggested were rejected because they do not match with musical resources, for example, coordinates (cartographic work) of work, scale (cartographic image/object) of expression, etc.

In work entity, the attributes selected for musical work are: title of work, form of work, date of work, other distinguishing, intended audience, context for work, medium of performance,

numeric designation, and key. Moreover, CMFRBR model includes some additional attributes, such as place of work (i.e. composition place), nature (history/background) of work, purpose (i.e. dedication) of work, language, identifier, genre, duration, and music era (music style), but at the same time it does not include some attributes proposed in the FRBR final draft, such as intended termination, coordinates (cartographic work), and equinox (cartographic work).

Expression entity has attributes related to classical music, such as: the title, form, date, and language of expression, other distinguishing, the extensibility, revisability, summarization of content, critical response and use restrictions of expression, and medium of performance. Additional attributes that are similar to work are place of performance, key, and duration of expression. Unnecessary attributes for expression of classical music were excluded, such as, extent of the expression, sequencing pattern (serial), expected regularity of issue (serial), expected frequency of issue (serial), type of score (musical notation). Since this study mainly focuses on classical music works, the performances of a work and their sound recordings in manifestation, *type of score in expression* was not considered as an attribute in expression. However, it will be included when the future study embraces other media formats such as book and music score in manifestation.

Group 2 (person and corporate body) was considered separately when examining attributes, because attributes can be applied with a different strategy to person and organization. For person entity, name, dates of person, title of person, and other designations associated with the person are the original attributes, and roles are applied in relationship part. Moreover, place of person (i.e., place of birth/death) and biography are considered as additional attributes. In the case of corporate body entity, name, number, place, date, other designations associated with body, and address are adopted attributes with an additional attribute, biography. APPENDIX A

provides the full lists of the attributes and relationships between the entities of the CMFRBR model.

3.2.2 Survey Design

A survey was designed to evaluate the importance of attributes and relationships in the music catalog. The entry-survey asked for participants' thoughts about and experiences with music cataloging systems in terms of music information seeking, including their search skill, frequency of music catalog searching, music search skill, the satisfactory level of catalog searching, etc.

In the main survey, participants rated the importance of the attributes of the musical work, expression, person and corporate body using the 5-point Likert scale (1-Strongly Disagree, 5-Strongly Agree). The survey questionnaire simply asked the importance of attributes, for example, "Do you agree that 'Title of Work' (a word, phrase, or group of characters naming the work. e.g. Wiegenlied, D. 498) attribute in Work Entity for music FRBR is important?"

In addition, the relationship descriptions between work/expression and person (or corporate body) were evaluated in the same method of attributes. Four relationship descriptions have been selected to examine the importance of relationships between works.

- Parent work: representative work title of sibling works, e.g., Joseph Haydn's Symphony Nos. 82-87 have a parent called Paris Symphonies
- Sibling work: parallel level works from the parent work(s), e.g., Symphony Nos. 82-87 share a sibling relationship from Paris Symphonies by Joseph Haydn
- Similar work: the works which have similar or same title, e.g., Symphony No. 1 by various composers
- Successor: sequel relationship between works, e.g., Part 1 and 2

In the relationships in expression, participants were asked how important it is to find a relationship in:

- Sibling expression: different expressions from the same work
- Parent expression: whole concert information, if applicable
- Related expression: different expressions under parent expression

When the participants decided on the importance of relationships in work and expression, they were also asked to rank their priority among the relationships. This rank was used for finding higher priority when two or more relationships were rated with the same score.

In terms of the relationship between work/expression and person/corporate body, the participants were asked to value the importance of the person's (or corporate body) role(s) to describe the relationships with musical work/expression.

Different from the parent-child relationship, the part/whole relationship between musical work and expression was also asked to be rated. For example, a single part of a musical work can be performed in different expressions. APPENDIX B provides the entire survey questionnaires used in this study.

3.2.3 Participants

A short survey was designed to find the importance of attributes, entities, and relationships of music FRBR. Fifteen participants were recruited from the University of Pittsburgh and Carnegie Mellon University, and were asked how music attributes and relationships are important to represent music information for cataloging purposes. One third (N=5) of participants are music professionals, including music school students, music experts, and music librarians. Five participants were information professionals who work or study in Library and Information

Science or Information Science. The rest of the participants were non-professional university students and classical music fans (N=5). Prior to the survey, each participant learned the concept of the FRBR model in a 30-minute introductory session. During this session, the extra attributes that were added for each entity were explained and were presented separately from the original attributes. The participants were asked to rate both the original and additional attributes because the survey results were expected to help decide whether certain attributes should be kept or dropped for the future study. After the training session, the participants answered the questionnaires using a Web-based survey application.

3.3 Survey Results

3.3.1 Participants' Background and Music Search Experience

In the pre-survey, I asked the participants' thoughts about a music cataloging system in terms of music information-seeking. Among 15 participants:

Eleven participants (73.3%) rated themselves to have good or excellent skills in searching for music. Eight participants (53.3%) responded to search with music catalog once or more than a month and three participants (20%) mentioned never having searched music resources in the library cataloging system. The satisfaction rate of the current library music catalog system was very low; only two participants (13.3%) were satisfied with library search results, whereas 33.3% (N=5) of participants were dissatisfied. Five of them felt neutral about the cataloging system.

Five participants who were not satisfied with cataloging system specified the reasons why they have difficulties with finding music information:

1. Difficulty with the search function (N=3, 60%)
2. Difficulty finding similar items (N=4, 80%)
3. Difficulty identifying the item I intend to find (N=3, 60%)
4. Difficulty finding appropriate media format (N=4, 80%)

Moreover, some notable comments about their reason of dissatisfaction were addressed by participants, such as, "*List all related items of each search term*," "*finding background of music*," "*showing duplicate records, indicating all available media formats, searching by ensemble*," and "*more various tagged words (tagging system improvement)*."

Eight participants (53.3%) answered that they have at least heard about the idea of FRBR, and half of them (N=4) rated their knowledge level of FRBR as good or excellent. These four participants have a library and information science background. Neither music experts nor music students answered that their knowledge of FRBR was good.

3.3.2 Rating the Importance of Attributes

In the main survey, the participants were asked to rate the importance of attributes of each entity to describe musical information for the cataloging system.

Participants rated the importance of attributes of the musical work, expression, person and corporate body using the 5-point Likert scale (1-Strongly Disagree, 5-Strongly Agree). In addition, relationship descriptions between work/expression and person (or corporate body) were rated in same method. The top four most important attributes in representing the music information of work in FRBR were title (M = 4.67), medium of performance (M = 4.13), form (M = 4.00), and context (M = 3.87) of work. Moreover, participants rated 3.8 on average for date, genre, and piece style. On the other hand, nature of work, purpose of work, place of work,

and duration of work were rated less important attributes. In terms of the relationship of work, they agreed that the relationship between work and person (creator of work) was important (*M* = 4.47). Table 3.1 shows the average rating of the attribute in Work entity.

Table 3.1 Average Rating of Work Attributes

	Strongly Disagree	**Disagree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**	**Total**	**Average**
Title of Work	0	0	1	3	11	15	4.67
Medium of Performance	0	0	2	9	4	15	4.13
Form of Work	0	0	4	7	4	15	4.00
Context of Work	0	0	4	9	2	15	3.87
Date of Work	0	0	4	10	1	15	3.80
Genre of Work	0	0	3	12	0	15	3.80
Piece Style of Work	0	0	5	8	2	15	3.80
Numeric Designation	0	0	6	7	2	15	3.73
Other Distinguishing of Work	0	0	6	8	1	15	3.67
Language of Work	0	0	5	10	0	15	3.67
Intended Audience of Work	0	1	7	6	1	15	3.47
Key	0	1	7	6	1	15	3.47
Nature of Work	0	0	11	3	1	15	3.33
Purpose of Work	0	0	11	4	0	15	3.27
Place of Work	0	2	9	4	0	15	3.13
Duration of Work	0	2	10	3	0	15	3.07

The top 5 attributes in expression that were rated to be important to represent music information were title (*M* = 4.6), medium of performance (*M* = 4.13), language (*M* = 4.0),

summarization of content (*M* = 3.93), and date (*M* = 3.8). Participants gave a relatively low rating for key of expression (*M* = 3.4), critical response to expression (*M* = 3.2), revisability of expression (*M* = 2.87), and extensibility of expression (*M* = 2.67). The importance of a relationship between expression and person (contributor, e.g. performer or conductor) was rated 4.27 on average. The average ratings of attributes in expression level are shown in Table 3.2.

Table 3.2 Average Rating of Expression Attributes

	Strongly Disagree	**Disagree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**	**Total**	**Average**
Title of Expression	0	0	0	6	9	15	4.60
Medium of Performance in Expression	0	0	2	9	4	15	4.13
Language of Expression	0	0	3	9	3	15	4.00
Summarization of Content	0	1	2	9	3	15	3.93
Date of Expression	0	0	3	12	0	15	3.80
Context for Expression	0	0	6	7	2	15	3.73
Place of Expression	0	0	5	10	0	15	3.67
Form of Expression	0	0	9	4	2	15	3.53
Other Distinguishing of Expression	0	0	8	6	1	15	3.53
Use Restrictions on Expression	0	1	7	5	2	15	3.53
Duration of Expression	0	0	7	8	0	15	3.53
Key of Expression	0	0	9	6	0	15	3.40
Critical Response to Expression	0	2	8	5	0	15	3.20
Revisability of Expression	0	6	5	4	0	15	2.87
Extensibility of Expression	0	8	4	3	0	15	2.67

In the person entity, the top rated attributes of person entity were name (*M* = 4.8), biography (*M* = 4.13), date of birth/death (*M* = 3.93), and title (*M* = 3.87). Place of birth/death, (*M* = 3.47) and other designation associated with Person (*M* = 3.53) were considered less important among Person attributes. In terms of person or artists, users' queries and interest heavily leans toward the name and biography, which is similar to Lee and Downie's survey (2004). Table 3.3 provides the rank of top attributes in the person entity.

Table 3.3 Average Rating of Person Attributes

	Strongly Disagree	**Disagree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**	**Total**	**Average**
Name of Person	0	0	0	3	12	15	4.80
Biography/History of Person	0	0	3	7	5	15	4.13
Dates of Person	0	0	4	8	3	15	3.93
Title of Person	0	0	3	11	1	15	3.87
Other Designation Associated with Person	0	0	9	4	2	15	3.53
Place of Person	0	0	8	7	0	15	3.47

In Corporate Body, name (*M* = 4.6), biography (*M* = 3.93), and place (*M* = 3.87) were rated top 3 among the attributes. The interesting point is that they rated place of corporate body as 3.87 on average, but gave only 3.0 on average to address. By this, I assume that when comparing the value of weight between address and place, the place attribute provides enough information of corporate body to users. Moreover, participants' music information seeking about attributes in corporate body seems very similar with ones in person because both entities have analogous top-rated attributes. Table 3.4 shows the rank of attributes in corporate body.

Table 3.4 Average Rating of Corporate Body Attributes

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Total	Average
Name of Corporate Body	0	0	1	4	10	15	4.60
Bibliography/history of Corporate Body	0	0	3	10	2	15	3.93
Place Associated with Corporate Body	0	1	2	10	2	15	3.87
Date Associated with Corporate Body	0	0	7	7	1	15	3.60
Other Designation Associated with Corporate Body	0	1	9	3	2	15	3.40
Address	0	0	2	11	2	15	3.00
Number Associated with Corporate Body	0	6	5	4	0	15	2.87

3.3.3 Relationship Representation

In terms of relationships, the participants were asked how important the relationships of musical works are with four different relationships: has sibling work; has similar work; has successor; and has parent work. The relationship “has parent work” was rated 4.33 on average and was ranked top. The relationship “has sibling work” stood at second with 3.93 rating on average. The relationship “has similar work” and “has successor” received the ratings 3.87 and 3.67, respectively.

In the relationships in expression, participants were asked how important it is to find a relationship in parent expression, sibling expression, and related expression. Both sibling expression and parent expression were rated 4.0 on average, but when ranked by high priority, sibling expression was ranked the highest (nine out of 15 participants ranked it the highest

among the relationships). Thus, it can be inferred that users were more interested in finding the performance information of the same musical work. Related expression was rated 3.67, and placed the last among the relationship description of expression.

In terms of usefulness of the relationships representation in work and expression (e.g., related expressions of the same concert or sibling expressions of the same work), users highly agreed (M = 4.27) that they find useful music information from the relationship representation. Moreover, participants answered that FRBR can help users understand music information and relationship easier than the old cataloging system (M = 4.33).

The role(s) of relationships between musical work/expression and person/corporate body were also examined. Examples of the roles of relationships are as follows: Beethoven's role in Sonata No. 1 is composer, and the role of Yo-Yo Ma in Beethoven's Sonata No. 1 is performer. The participants strongly agreed (M = 4.6) that FRBR representation would help music searchers find the roles of relationships between person and musical work/expression.

Concerning creator(s) of music, participants considered lyricist to be the same as creator. 86.7% of participants (13 out of 15) agreed that lyricist or librettist could be viewed as creator. Two comments from the participants who did not agree that a lyricist is a creator mentioned, "*Sometimes composers adopted famous poem, novel, sentence....*" and "*Value of lyricist is lower than composer in classical music, can be considered as contributor same as performer*".

In terms of the part/whole relationship between musical work and expression, 80% of participants (N=12) answered that the part is still regarded as an expression of a work even if it is not the whole musical work. Three comments from the participants who did not agree with the part/whole relationship said, "*If each movement has different meaning and all combined movement make new meaning of music, each movement can be considered as different music*";

"*Partially agree: if the music work consist of several movements/part. If one or more parts of whole music work played in the performance, it is part of music, but still considered as the music work*"; and "*Piece of work→ users may want to listen specific movement only*." These comments are valuable opinions to consider; however, the majority decision that a partial performance of a musical work can be considered one expression from the same musical work in FRBR-based classical music information should be generally accepted.

3.4 Findings

This study identified the important attributes of each entity of FRBR for library cataloging purposes, and how users' understanding would be enhanced by representing the relationships model. It was found that within the attributes in work and expression, participants considered title, medium of performance, date, and role of person/corporate body as important attributes and relationships in both entities.

In terms of relationship representation, it was found that people would like to see useful relationship information, such as the parent/sibling of work, the sibling expression from a work, and the person-creation-work relationship. In addition, the role relationship that linked entities in Group 2 to entities in Group 1 was identified to be useful in describing the bibliographic information of classical music.

As previous studies found (Hardesty et al., 2012; J. H. Lee, 2010; Salaba & Zhang, 2012), there is a similarity in using FRBR attributes or relationships in order to find music information. Also, the results indicate that participants' music information seeking about the musical work and expression in cataloging is somewhat similar with ones on the Web. People's

music information needs rely on attributes such as title of music, person's name, genre/form of music, instrument, etc.

In addition, this study found that the participants rated additional attributes higher than the original ones from the FRBR draft. For example, genre and music era (piece style) were ranked highly among the Work entity. Similarly, place of expression, biography of person and corporate body were highly ranked. Therefore, it would be useful to employ new attributes in FRBR entities for music information retrieval. In addition, it was suggested that the history or background of work are useful to describe a musical work entity.

The results of this survey imply that attributes of each entity can enrich descriptions of musical bibliographic information, and these attributes help users find improved music information.

3.5 Discussion

This study addressed the RQ 1.1 "What are the important features (attributes and relationship between entities) of FRBR to represent classical music?". The survey results indicated which attributes were important for delivering music information to users. In cataloging, a number of necessary attributes should be filled out to enrich bibliographic information of classical music in each entity. Moreover, relationship information (like roles of creator or performer between work/expression and person/corporate body, and sibling and parent relationship in work and expression) needed to be clearly stated in order to enhance user's understanding of the music information.

Therefore, based on the results of the survey, this study propose a new term, CMFRBR, which refers to the Classical Music bibliographical records representation based on the FRBR model. This model was used for the final experiment, which examined the usability of FRBR-based classical music search system in Chapter 5.

In order to represent more enriched music information from the FRBR final draft (1998), this study decided to include additional attributes such as place of work, summarization, genre, music period, duration, place (both in work and person), etc., for each entity. The main difference between CMFRBR and the FRBR final draft is that CMFRBR is a specialized model to describe classical music bibliographic records, whereas FRBR is a general model to describe bibliographic records. Therefore, CMFRBR contains more precise information of classical music work, expression, and person/corporate body by employing additional attributes and relationships.

CMFRBR adopted various relationships from the FRBR final draft and additional relationships, such as parent work (work of work) and parent expression (expression of expression). As the FRBR final draft mentions, the usage of aggregates were similar to a parent-child concept, work-set or super work (Hickey et al., 2002; Tarango, 2008). The definition of a parent is specified as a uniform title of a set of works or expressions. It not only contains a title, but includes attributes which cover the general information of a set of works or expressions, such as background/history, summary, and date. For example, the date of a parent work covers an entire period of a work set composition, and the history provides a general background of the entire collection of works. Musical works rarely have more than one parent. For instance, Il cimento dell'armonia e dell'inventione N. 1-4 by Antonio Vivaldi, popularly known as the Four Seasons, is made up of four concertos, so it is a parent of the four concertos. Moreover, these

four concertos are the first four works of Il cimento dell'armonia e dell'inventione, Op. 8 which is a set of 12 concertos. Therefore, these four concertos have two parent works.

Similar to the parent work, the parent expression consists of several attributes such as date, place, and summary. In terms of the realization relationship, the contributors in a parent expression include the person and corporate body of each expression in an entire event which various musicians perform in different expressions of an event.

A parent entity is necessary because it is possible for a user to find related works or expressions from a parent by the creation of new relationships between children works or expressions. Aside from the parent-child relationship in expression, it is possible to draw another relationship between a work and its expressions, called sibling expressions. This helps music seekers find all realizations of a musical work, and each expression can indicate other expressions of the same work realized by the same or different musicians.

Another important relationship adopted by CMFRBR is the role of the person and corporate body for the entities in Group 1, which draws the connections how the person (or corporate body) contributed to work and expression entities. Figure 3.1 presents the relationship descriptions among the entities and role types of group 2 for group 1 entities. As seen in APPENDIX A, person or corporate body fill various roles in work and expression, and this relationship provides users with a clear understanding of how person or corporate body was involved in creating work and performing the musical work.

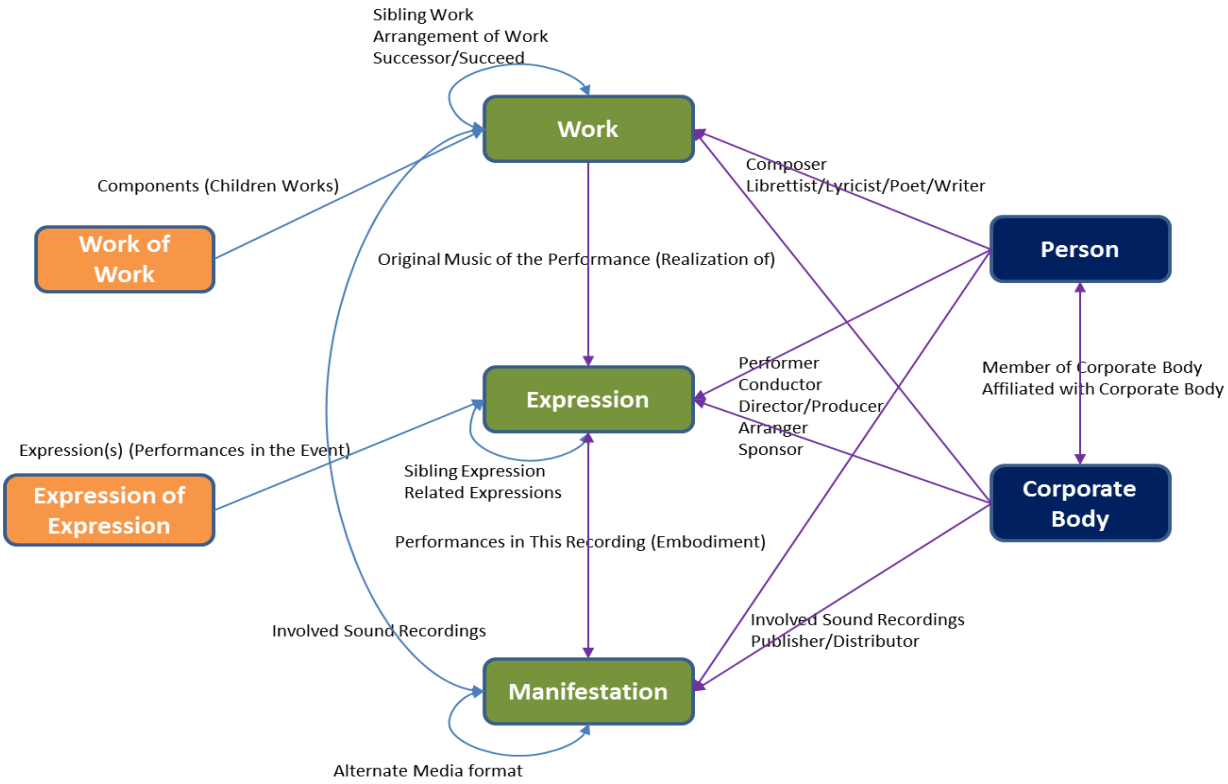


Figure 3.1 Relationships among Entities

Based on the results, the next step of the research was designed with a content analysis to closely examine how general users find, identify, select, and obtain music information on the Web.

4 PHASE 2: Analyzing Use of FRBR with Finding Classical Music Information from Social Q&A Sites

4.1 Finding FRBR Attributes and Relationships in Yahoo! Answers

From the consultations with music experts and the results of finding important attributes and relationships for classical music in Phase 1 (Chapter 3), it was found that the CMFRBR model is not only appropriate for the new cataloging rule, but can also be applied to Web-based information providers by providing entity, attributes, and relationship. Therefore, in order to find the feasibility of the CMFRBR model for Web-based music information retrieval, Yahoo! Answers, a social Question & Answer site, was examined. From the consultation with music experts, such as music students and scholars, it was found that they already know what they want to seek and how to find music information. However, the general public's information approach would be different from that of experts. Therefore, the results of a previous study in Chapter 3 to find the appropriate attributes and relationships of CMFRBR entities for classical music in the cataloging was compared with real questions from the general public's information needs in classical music. To achieve these goals, the following research questions were identified under RQ 2: Can FRBR-based classical music representation provide better help for users to find music?

- RQ 2.1: What is the general public's information need (i.e., entities, attributes, and relationship) of classical music on the Web?
- RQ 2.2: What change in FRBR-based classical music representation should be made to help general public on the Web find classical music information?

The remaining questions (RQ 2.3 and RQ 2.4) will be answered in Phase 3.

4.2 Data Collection

Yahoo! Answers was selected as a source of a dataset because it is one of the most representative social reference sites in the world. The questions were selected from the category "classical music," the sub-sub-category of "Entertainment & Music". Due to the high volume of questions in this category, some adequate query terms such as *Beethoven, performance, recording*, and so forth were used to selectively collect questions from Yahoo! Answers. The total number of returned questions is 500, which were asked from May 2007 to June 2013. Among the returned question set, almost 350 questions were fitted to classical music information. The rest of the questions were filtered out, as they were not directly related to classical music, including questions such as "How do I sell recordings of Public Domain music?" or "What's the best way to make a professional sounding piano recording?" The questions selected for analysis, for example, "Where can I find the music to the American Ballet Theatre's production of Don Quixote?" could match with the attributes in manifestation and corporate body. Also, in terms of relationship, it is possible to connect expression and corporate body (realization) to expression and manifestation (embodiment). All the questions used in this study contained at least one or more FRBR attributes or relationship representation related words or phrases.

4.3 Coding Process

Various categories of codes were created with ATLAS.ti, a qualitative research software. For the coding process, two types of main codes (code family), Entity and Relationship, were defined. Since the scope of this study is to find the proper attributes of each entity of the FRBR model matching with social reference questions, attributes and relationship descriptions related to classical music were employed as sub codes. Moreover, additional sub codes were assigned to include additional attributes and relationships that were proposed in Phase 1. Therefore, the categories were organized with main codes, which were classified by types of entities and other categories that do not belong to the sub codes. Below is the list of main and sub codes defined for the coding.

- Main codes (Code Family)
    - Work, Expression, Manifestation, Person, Corporate Body – types of entities in FRBR.
    - Relationship – Relationship description between entities or attributes
- Sub codes of each main code

Table 4.1 Sub Codes of Main Codes (continued).

	Sub Codes		
WORK	Title of the work	Form of work	Date of the work
	Other distinguishing characteristic	Intended audience	Context for the work
	Medium of performance	Numeric designation	Key
	Language	Music style (period)	

EXPRESSION	Title of the expression	Form of expression	Date of expression
	Language of expression	Other distinguishing characteristic	Extensibility of expression
	Revisability of expression	Extent of the expression	Summarization of content
	Context for the expression	Critical response to the expression	Use restrictions on the expression
	Medium of performance	Language of expression	Key of expression
MANIFESTATION	Title of the manifestation	Publisher/distributor	Edition/issue designation
	Place of publication/distribution	Statement of responsibility	Date of publication/distribution
	Fabricator/manufacturer	Series statement	Form of carrier
	Extent of the carrier	Physical medium	Capture mode
	Dimensions of the carrier	Manifestation identifier	Terms of availability
	Source for acquisition/ access authorization	Access restrictions on the manifestation	Playing speed (sound recording)
	Groove width (sound recording)	Kind of cutting (sound recording)	Tape configuration (sound recording)
	Kind of sound (sound recording)	Special reproduction characteristic	System requirements (electronic resource)
	File characteristics (electronic resource)	Mode of access (remote access electronic resource)	Access address (remote access electronic resource)
PERSON	Name of person	Dates of person	Title of person
	Other designation associated with the person	Place associated with the person	Biography
CORPORATE BODY	Name of the corporate body	Number associated with the corporate body	Place associated with the corporate body
	Date associated with the corporate body	Other designation associated with the corporate body	Biography
RELATIONSHIP	Affiliation (P-CB)	Alternative Format (M-M)	Embodiment (E-M)
	Expression-Parent (E-E)	Expression-Person/CB (E-P,CB)	Expression-Sibling (W-E,E)
	Realization (W-E)	Work-Creation-Person (W-P,CB)	Work-Parent-Children (W-W)
	Work-Sibling (W-W)	Work-Similar (W-W)	

An example of coding is below:

*<Manifestation: access address>*Where can I find the music to the *<Relationship: expression – person/corporate body><Corporate Body: Name>*American Ballet Theatre's*</Corporate Body: Name>*production of <Expression: Title> Don Quixote*? </Expression: Title></Relationship: expression – person/corporate body></ Manifestation: access address >*.

Generally, a word or phrase was assigned with a single code. However, as shown in the example, more than two codes can be co-assigned in one question or the same code can be repeated in a question. The highest number of individual codes that occurred or co-occurred in a question was seven.

4.4 Findings

The total number of single codes in the data was 613. The most frequent code families were Relationship, Manifestation, and Work. Table 4.2 shows the frequency of the code families.

Table 4.2 Number of Occurrences of Code Family

Code Family	Number of Occurrence
Corporate Body	14
Expression	87
Manifestation	107
Person	59
Relationship	241
Work	105

A general pattern of users' questions about classical music in Yahoo! Answers was regarding how to find sound recordings of specific music by certain musicians. During the coding process, the relationship between the entities and attributes was also identified. One third of the quotations were coded as relationships because most questions contain two or more entities or attributes connected by the relationship description. Therefore, the relationship codes played important roles as the linkage between entities and attributes.

The frequency of code occurrence showed that the most occurring sub codes (attributes) in each code family were title of work (N=49), person (corporate body) realization in relationship (N=75), name of person (N=47) and name of corporate body (N=11), access address (remote access electronic resource) of manifestation (N=46), and medium of performance of expression (N=25).

The most occurred codes in the Work entity were title (n=49), purpose/nature (n=11), piece style (n=9), other distinguishing (n=8), and medium (N=8). It is no surprise that Yahoo! Answers users mention the work title in their question, as previous studies have shown similar results (Bainbridge et al., 2003; Lee, 2010). Interestingly, some questioners asked about the background or history of the composition of the musical work.

In Expression, the most frequently addressed attributes were medium of performance (N=25), date (N=20), title (N=10), place (N=8), and duration (N=8). It seems that some classical music fans seek out information about specific events, including where and when an event was held. The question "*where can i find the New York philharmonic North Korea concert online*?" is a good example of one looking for a certain performance in a particular place. One of the interesting facts observed is that people sometimes mentioned or asked about the date, including

the year, of a performance. Mostly, these questions were redirected to ask how they can find the recordings of the performance held in a certain time and place.

Access address (remote access electronic resource) (N=46), form of carrier (N=21), title (N=12), and publisher/distributor (N=8) were the top four frequently mentioned attributes in the manifestation code family. Due to the characteristics of Web-based social references, many questions contained the links or addresses of particular sound recordings. Moreover, many people seemed to care about the physical (or electronic) form of carrier (e.g. CD or mp3m video clip). Some previous studies also reported that people seek certain types of musical sound recordings that they prefer (J. H. Lee & Downie, 2004; Salaba & Zhang, 2012). A question from the data set, "*Okay. So I saw this video of Pavarotti singing 'Ingemisco' on Youtube ... Anyway, is there a CD recording of this performance? I REALLY want to find it, but all I can find is a DVD recording!*" also shows a user's need for a specific type of containers of expression. These types of questions have been coded with both Form of Carrier and Relationship: Alternative Format.

In terms of relationship, Expression-Person/CB (N=75), Work-Creation-Person (N=42), Expression-Sibling (N=40), Realization (N=24), and Embodiment (N=22) were identified to be the most-used relationships from the question set. In Yahoo! Answers, people asked many questions about the best performance of a specific musical work. The common patterns of questions about the sibling expression relationship of a specific music from Yahoo! Answers are "*Which collection of Beethoven's Symphony Performances is best?... Which would you recommend?*" These kinds of questions were coded as sibling expression. Although recommendation is one of users' needs to find music information, FRBR-based music information can provide only the expression information of a musical work.

Compared to the library catalogs, not all attributes from the FRBR model were coded. For example, more than 50% of attributes, such as series statement manifestation and revisability of expression, were never asked in the question sets. The total number of codes that appeared at least once in questions was 44. Table 4.3 presents the frequency of sub codes occurred by code families.

Table 4.3 Frequency of Code Quoted (continued).

Code Name	#	Code Name	#
Corporate Body			
Corporate Body	3	Corporate Body : Name	11
Expression			
Expression	8	Expression: Duration	8
Expression: Date	20	Expression: Medium of Performance	25
Expression: Language	5	Expression: Title	10
Expression: Place	8	Expression: Summarization	3
Manifestation			
Manifestation	11	Manifestation: Access Restrictions on the Manifestation	4
Manifestation: access address (remote access electronic resource)	46	Manifestation: form of carrier	21
Manifestation: date of publication/distribution	5	Manifestation: publisher/distributor	8
Manifestation: title	12		
Person			
Person: Biography/History	6	Person: Dates/Place	1
Person: Name	47	Person: Other Designation	5

Relationship

Relationship: Affiliation	12	Relationship: Alternative Format	12
Relationship: Embodiment	22	Relationship: Expression-Parent	3
Relationship: Expression-Person/CB	75	Relationship: Expression-Sibling	40
Relationship: Realization	24	Relationship: Work-Creation-Person	42
Relationship: Work-Parent-Children	9	Relationship: Work-Sibling	1
Relationship: Work-Similar	1		

Work

Work: Context	4	Work: Date	3
Work: Duration	4	Work: Form	3
Work: Key	1	Work: Language	0
Work: Medium	8	Work: Numeric Designation	5
Work: Other distinguishing	8	Work: Piece Style	9
Work: Purpose/nature	11	Work: Title	49

During the analyzing process, codes were mostly used and analyzed with co-occurrence among attribute and relationship or attribute and attribute. A total of 392 codes co-occurred in the dataset. The most frequently co-occurring codes were work title and relationship of work creation (N=22) and the relationship between persons' name and their performance (N=21). Sixteen co-occurred codes were about work composer and musical work creation. Moreover, 16 questions were asked about the relationship Embodiment & Relationship: Expression-Person/CB that describes a particular performance is contained by a sound recording. Based on the top ranked co-occurring codes, questioners commonly mentioned the musicians' names and music titles when they asked about the works, and then maybe seek for the performance information and sound recordings of the performance. Moreover, by this observation, it can be inferred that public users usually start their music seeking with a piece of musical information such as

composer or performer's name and work title. Table 4.4 shows the number of co-occurrence among the categories. Some codes have been repeated in this table due to the co-occurrence with several codes. Not all codes are listed in the table; it only shows the codes that co-occurred with others more than five times.

Table 4.4 Co-Occurrence of Codes (continued).

Co-occurrence		#
Work: Title	Relationship: Work-Creation-Person	22
	Relationship: Expression-Person/CB	6
	Relationship: Expression-Sibling	5
	Relationship: Realization	5
	Manifestation: access address (remote access electronic resource)	5
Relationship: Work-Creation-Person	Work: Title	22
	Person: Name	16
	Relationship: Realization	6
	Relationship: Expression-Sibling	6
	Relationship: Expression-Person/CB	5
Relationship: Expression-Person/CB	Person: Name	21
	Relationship: Embodiment	16
	Expression: Date	12
	Relationship: Affiliation	11
	Relationship: Expression-Sibling	7
	Corporate Body: Name	7
	Manifestation: access address (remote access electronic resource)	6
	Work: Title	6
	Expression: Place	5
	Relationship: Work-Creation-Person	5
Person: Name	Expression-Person/CB	21
	Relationship: Work-Creation-Person	16
	Relationship: Affiliation	8
Corporate Body : Name	Relationship: Expression-Person/CB	7
	Relationship: Affiliation	6

Relationship: Realization	Expression: Medium of Performance	6
	Relationship: Work-Creation-Person	5
	Work: Title	5
Manifestation: form of carrier	Relationship: Alternative Format	8

Among the codes, the ones that co-occurred the most with other codes were Relationship: Expression-Person/CB (N=128), Relationship: Work-Creation-Person (N=77), Person: Name (N=64), and Work: Title (N=62). This implies that the relationship between person/CB and expression has an important pattern: people are interested in finding out classical music related person information because people tend to ask questions about who performed which music. Similar to the relationship between person/CB and expression, a commonly asked question in Yahoo! Answers was regarding who composed particular music or a certain composer's composition list (Relationship: Work-Creation-Person). In addition, 51 embodiment relationship codes were assigned with other codes, including Relationship: Expression-Person/CB 16 times. As previously mentioned, I assume that the purpose of the questions containing expression information is to find the sound recordings of a specific performance by certain performers.

In terms of attributes, person's name, title of music, work and access address of manifestation have been coded more than the other attributes. It is assumed that many questioners mentioned at least one or more person's name or work title with other content when asking about classical music. Similar to previous discussion, due to the characteristics of the Web Q&A services, users asked for the Web address where they can find manifestation or related information of performances.

Table 4.5 Single Codes Co-occurred with Other Codes

Co-occurrence by Codes	#	Co-occurrence by Codes	#
Corporate Body			
Corporate Body	8	Corporate Body : Name	20
Expression			
Expression	12	Expression: Date	23
Expression: Duration	9	Expression: Language	2
Expression: Medium of Performance	23	Expression: Place	11
Expression: Summarization	1	Expression: Title	6
Manifestation			
Manifestation	27	Manifestation: access address (remote access electronic resource)	33
Manifestation: Access Restrictions on the Manifestation	2	Manifestation: date of publication/distribution	3
Manifestation: form of carrier	18	Manifestation: publisher/distributor	6
Manifestation: title	6		
Person			
Person: Name	64	Person: Biography/History	2
Person: Other Designation	1		
Relationship			
Relationship: Affiliation	34	Relationship: Alternative Format	17
Relationship: Embodiment	51	Relationship: Expression-Parent	3
Relationship: Expression-Person/CB	128	Relationship: Expression-Sibling	46
Relationship: Realization	33	Relationship: Work-Creation-Person	77
Relationship: Work-Parent-Children	14	Relationship: Work-Sibling	2
Work			
Work: Context	5	Work: Date	4
Work: Duration	1	Work: Key	1
Work: Medium	4	Work: Numeric Designation	4
Work: Other distinguishing	10	Work: Piece Style	3
Work: Purpose/nature	8	Work: Title	62

The top five codes that co-occurred with “Relationship: Expression-Person/CB” were Person: Name (N=21), Relationship: Embodiment (N=16), Expression: Date (N=12), Relationship: Affiliation (11), and Corporate Body: Name and Relationship: Expression-Sibling

(N=7). From this result, it could be interpreted that questions about expression information generally accompany questions about performer (person or corporate body) and sound recordings of the performance.

On the other hand, Relationship: Work-Creation-Person appeared with Work: Title (N=22), Person: Name (N=16), Relationship: Realization (N=6), Relationship: Expression-Sibling (N=6), and Relationship: Expression-Person/CB (N=5). Therefore, it could be deduced that when people ask questions about classical musical works, people find work title and person's name from the relationship, identified with Relationship: Work-Creation-Person. Additionally, the relationships, creation of work, performance of the work, and different performance of the same work are commonly asked together from users' questions about classical music information.

4.5 Discussion

In the coding and data analysis processes, it was found that the description of the attributes and relationship of FRBR can fulfill users' information needs about classical music.

The results of this study have answered the RQ 2.1: "What is the general public's information need (i.e., entities, attributes, and relationship) of classical music on the Web?"

From the analysis of questions in Yahoo! Answers, three major patterns were observed.

First, questioners tend to ask for manifestation information, especially for a website or URL, where they can obtain a physical or electronic version. In addition, people want to obtain certain type of media format of sound recordings they prefer. This implies that the general

public's need in social Q&A sites regarding classical music is to find and listen to a classical musical work in particular media formats on the Web.

Secondly, people ask for different performances of famous musical works, which was coded with a sibling expression relationship. They also ask for information on famous performers (conductor, instrumentist, and singer) and detailed information about performances like place, date, or other expression information. This indicates that general users are not only interested in the musical work itself, but they are also eager to listen to different interpretations of music by various musicians.

Lastly, questions were asked to find title (of expression and work) or person (or corporate body). By providing links to other resources such as YouTube, people tend to ask for the title of the music in the video clip, the performer's name, or how they can find other performances by the performer.

For RQ 2.2 "What change in FRBR-based classical music representation should be made to help general public on the Web find classical music information?", it is found that not all of the attributes that appear in the library's cataloging setting are used in Web-based social Q&A sites. For examples, some attributes such as statement of responsibility, fabricator/manufacturer, and source for acquisition/access authorization in manifestation are only used for the library catalog system, and these attributes and features were never asked by questioners in the Web-based Q&A site. Although only 33 attributes and 11 relationships were coded in this study, these codes provide sufficient evidence about which attributes and relationship information is important for general users to seek for classical music information.

I analyzed the chosen answers of the questions from Yahoo! Answers to examine whether those answers included the attributes or relationship descriptions of FRBR model.

Except for the subjective opinions in the answers, around 110 out of 350 answers provided bibliographic information of classical music that FRBR representation also can provide. Even though this analysis was not entirely performed on correct answers, it is clear that FRBR-based classical music representation can contribute public users' information needs about classical music. Based on the users' questioning and answering behaviors in Yahoo! Answers, it demonstrated that FRBR can play a significant role in identifying entities and attributes of information from questions in social Q&A sites. The FRBR model provides a proper framework to represent classical music information, including the background or historical information with several attributes in work, performance information in expression, access address, form of carrier in manifestation, and alternative format in relationship that people ask for.

The users' questions in this study include at least a piece of metadata related to classical music, which means that general users know a piece of information when they search for music. This fact indicates that users perform Known-Item search. It presumes that users may know some information about the music, but it is difficult to interpret how high their knowledge level of music is. With this perspective, especially for novice users, FRBR can make a contribution toward finding related musical work information because the FRBR provides well-organized attributes and relationship information. The relationship descriptions between entities (for example, work-person or person-expression) will be important features for users to find music information which they did not expect. The FRBR model can support these richer, unexpected browsing functions through relationship descriptions that allow users to search and explore the music information and relationships from work or person level to other entities or vice versa.

5 PHASE 3: Comparative Study of Two Classical Music Information Systems

This chapter introduces the experimental systems, plain text-based classical music representation and FRBR (Entity Relationship model) based classical music representation, and the designs of the experiment that compare them. The first section introduces the FRBR-based classical music search system and its data sets. The second section provides detailed information about the experimental design and describes the plain text based classical music system. The last section summarizes the experiment's study variables.

This study introduces two terms related to FRBR-based classical music representation and its information retrieval system. First, CMFRBR (Classical Music representation based on the FRBR model) refers to the Classical Music bibliographical records representation based on the FRBR model. The other term, FIRM, is used to refer to the CMFRBR-based Information Retrieval system of classical Music.

5.1 FIRM System Design and Data

5.1.1 FIRM System Design

This study used Ontopia (http://www.ontopia.net/) to develop a CMFBRB-based classical music search system, called FIRM. Ontopia is an open source suite of tools for building applications based on Topic Maps, formally ISO 13250 (http://www.isotopicmaps.org/), a standard for the

representation and interchange of knowledge, with an emphasis on the findability of information (Ontopia home page). Ontopia provides features such as an ontology designer, a data editing tool, query language function, Web service access points, database storage, and a visualized display of search results. Moreover, it is suitable to represent the CMFRBR because its features include presenting relationships, entities, and attributes.

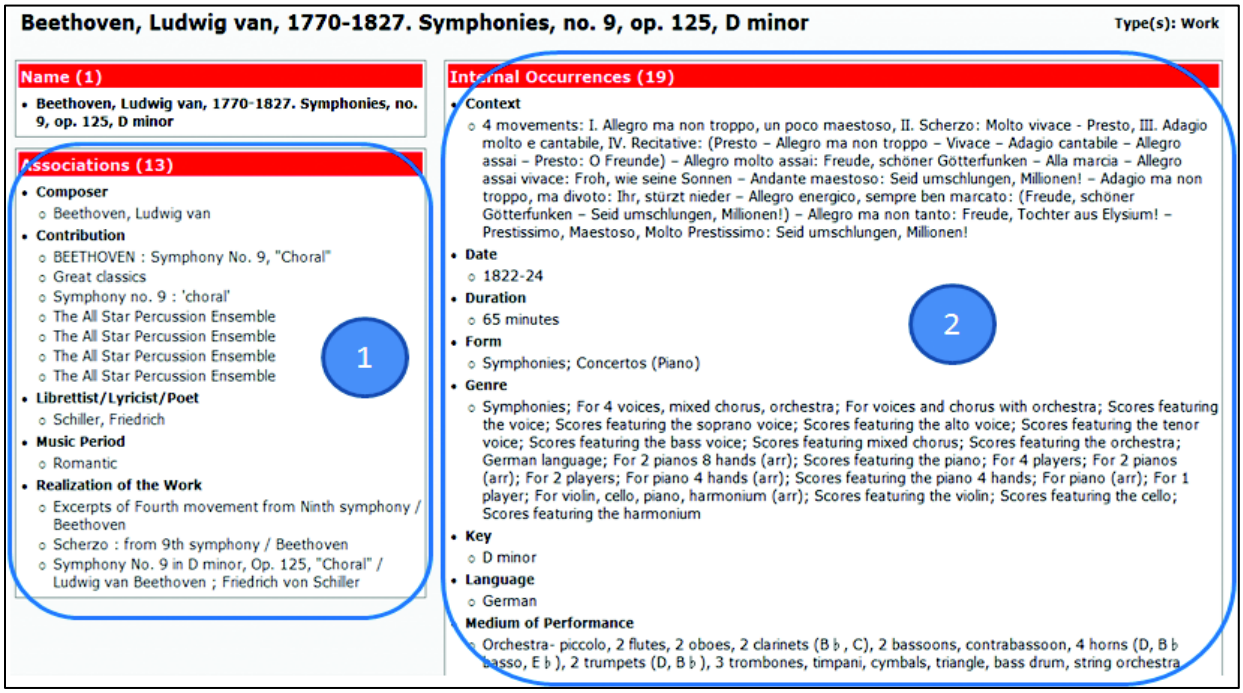


Figure 5.1: Screenshot of Work Information in FIRM

Figure 5.1 illustrates a screenshot of the work of Beethoven's Symphony No. 9. The left panel of the display (Area 1) represents the relationships between a work and other entities. These entities include expression (i.e. realization of work), manifestation (i.e. contribution), person (i.e. composer/librettist), or corporate body. The panel on the right side (Area 2) provides the information about the musical work, generally called attributes. Each page represents all

information about an entity and relationships among a work, an expression, a manifestation, and person and/or corporate body.

CMFRBR implementation in Ontopia (FIRM) comprises seven types of entity pages including work, expression, manifestation, person, corporate body, work of work, and expression of expression. Each entity page contains different relationship descriptions and attributes information according to the character of the entity. For example, in person page, predefined person's roles were composer, librettist, conductor, sponsor, performer, and etc. It also has a relationship with other entities, such as composition of work, author of libretto, performance of expression, affiliation with corporate body, family with person, and so forth.

The collection of the FIRM covered 1,050 musical works, 240 expressions, 75 manifestations, 345 persons, 74 corporate bodies, 15 expressions of expression, and 22 works of work pages.

5.1.2 Data Collection for FIRM

5.1.2.1 Resources of Work and Person/Corporate Body Information

The collection has been built on Ontopia with attributes and relationship information. As the current FRBR-based catalog systems does not contain enough attributes in each entity, I have collected metadata of classical musical work, person, and corporate body from various resources including ClassicalArchives (http://www.classicalarchives.com), Classical Net (http://www.classical.net/), International Music Score Library Project (http://imslp.org/wiki/Main_Page), Library of Congress Subject Authority Headings (http://authorities.loc.gov/), Naxos Classical Music (http://www.naxos.com/), Oxford Music Online (http://www.oxfordmusiconline.com/), and Wikipedia (http://www.wikipedia.org/). Aggregated data was converted into CMFRBR

attribute suitable data. All of the work titles and personal names used in this system were borrowed from the Library of Congress Subject Authority Headings (http://authorities.loc.gov/).

5.1.2.2 Selection of Musical Work and Composers

The music collection is intended to include the most popular classical musical works that were selected based on how frequently they were mentioned in the following resources:

- 100 Greatest Classical Music Works (www.digitaldreamdoor.com/pages/best-classic-wks.html)
- The 50 Greatest Pieces of Classical Music (http://en.wikipedia.org/wiki/The_50_Greatest_Pieces_of_Classical_Music)
- The Classic FM Hall of Fame (http://www.classicfm.com/hall-of-fame/)
- Classical Music Top 150 (http://www.classiccat.net/toplist.php)

Since many musical works are repeated in the most popular music lists, only around 150 musical works were initially selected to be included in FIRM's dataset. As the collection of 150 works is too small to build a classical music system, more than 900 musical works were added in accordance with the rank of composers. The list of top 100 greatest composers was selected from diverse resources, for example,

- classical-music-online.net (http://classical-music-online.net/stat/?type=top_persons&person_ type =composer),
- classical-music.com (http://www.classical-music.com/great-composers) by BBC Music Magazine,
- classical music composers frequently mentioned on the Web by Google (https://www.google.com/search?q=classical+music+composers), and

- classicalcat (http://www. classiccat.net/)

A selection of composers was made in order to narrow down the number of composers, because this study cannot include all classical music composers from the Medieval period to Modern time. Therefore, the number of composers was limited to 60 of the top 100 ranked composers (some of the top composers were excluded due to the copyright law) which, when added to composers already in the collection, brought the total number of composers to 75 with 1,050 different works. Table 5.1 shows the distribution of a number of works per composer.

Table 5.1 distribution of a number of works per composer

Number of Works	Number of Composers
> 40 -95	5
> 20-40	17
> 5-20	12
< 5	41

The number of musical works for each composer was not deliberately assigned. However, more highly ranked composers have more music included in the collection and lower ranked ones have less music included. Well-known composers, like Beethoven, Bach, and Mozart, have higher chances of being searched for by users seeking for information about the composers themselves and their musical works; as previous studies have discussed, people may search with composers' names in order to find their music (Kim & Belkin, 2002; J. H. Lee & Downie, 2004; J. H. Lee, Downie, & Cunningham, 2005). Therefore, it is natural to consider that the system should include a higher number of musical works for popular composers.

In order to find a composer's popular music, Google search was chosen to provide the list of compositions by composer ("Beethoven Compositions" in Google search). It is not publically known how Google selects the composers' composition list in the result page. Matching the top classical music resources with the top musical works of the composers' composition list in Google search results showed great overlap. Therefore, Google might provide the music list based on the most frequently mentioned or searched for works on the Web, thus identifying the most popular music of the composer. Figure 5.2 shows the results of searching for Bach on Google and on Classicalcat.net (works are marked with red rounded rectangles).

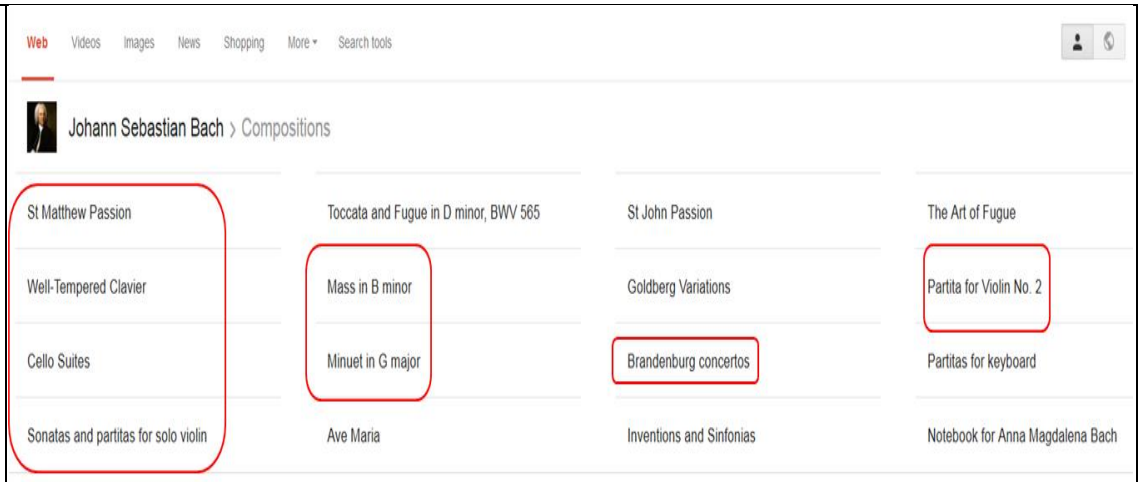
<table>
<tr><td>Google</td><td> 
</td></tr>
<tr><td>Classicc at.net</td><td> 
</td></tr>
</table>

Figure 5.2 Similarity between Google search and Classical Music Resource

Note that the rest of the musical works from classicalcat.net were also found within Google search results in the second results page of the composer's composition list. The names used in the two search results sometimes refer to individual works (e.g. Violin Partita No. 2 in classcialcat.net) and sometimes refer to work sets (e.g. Sonatas and Partitas for solo violin in Google) to which the individual work belongs.

5.1.2.3 Resource of Expression and Manifestation Information

The expression and manifestation information has been collected from the Library of Congress Online Catalog (http://catalog.loc.gov/) and WorldCat of OCLC (Online Computer Library Center, http://www.worldcat.org/). Although I endeavored to collect as many attribute records as possible, the small size of CMFRBR's data collection that was manually generated was due to a lack of music metadata fitting the CMFRBR's attributes. Metadata based on the attribute descriptions was inserted and filled out for more than 80% of the attributes in Work, Manifestation, Person, and Corporate Body entities. However, as a previous study points out (O'Neill, 2002), because catalog records do not contain enough expression information, only a few basic attributes (i.e. title of expression, date and place of expression) have usually been filled out. Even finding the title of an expression was problematic because there is little information on expression in the music catalog. Therefore, the title of the expression from the contents list in the 505 field of the catalog was adopted. If the title of expression could not be identified, the record was not created. Furthermore, if the 100, 511, 650, and 7XX fields of MARC records provide the participants' names of certain performances (i.e., conductor and performer with an instrument), the realization of a relationship between expression and person (or corporate body) could be established.

5.2 Comparative Study Design

5.2.1 Research Questions

The purpose of the study is to examine the usability of FIRM (CMFRBR-based Information Retrieval system of Classical Music) to investigate the user experience while users locate their needed information using FIRM's entity relationship representation. It is compared to their experience using IMSLP (International Music Score Library Project), which is a Web-based plain text display system comparable to CMFRBR except not being based on an Entity-Relationship model. IMSLP is further described in the following sub-section.

The research questions for this study are described below:

1. RQ 1.2: Do users experience FIRM's attributes and relationships among entities as a useful and positive aid in satisfying their information needs? Moreover, does FIRM give users a better user experience when compared to IMSLP?
2. RQ 2.3: Can the attributes and the relationships of the CMFRBR representation in FIRM provide the user with a superior objective and subjective experience when searching for classical music information compared to IMSLP?
3. RQ 2.4: Which internal factors (independent variables: language, music knowledge, and search skills) influence the users' search performance and subjective experience?

These (RQs 1.2, 2.3, and 2.4) are the sub-questions of the main research questions (RQs 1 and 2), and the remaining sub-questions (RQs 1.1, 2.1, and 2.2) contributed to the formulation of the main research questions in Phase 1 and 2.

5.2.2 Baseline System

The selected baseline system of this study is the plain text-based classical music representation system provided by the International Music Score Library Project (IMSLP), also known as the Petrucci Music Library (http://www.imslp.org), an open online library project for storing scanned music scores, music media files, and work information mainly for classical music. The project's main goal is to collect every public domain classical music score and create an open music database. IMSLP provides access for its users to classical music scores from both the public domain and from composers who are willing to share their music without charge. Audio recordings are also available on the site (Mortensen, 2014; Mullin, 2010).

5.2.2.1 Difference between IMSLP and FIRM

IMSLP provides general information about classical music (Figure 5.3). FIRM separates the pages based on the representation of the CMFRBR model, whereas IMSLP's musical work page includes work, performance, recording, and music score together; only the person page (composer or librettist) is separated from the work page.

IMSLP provides relationships such as work and person (composition, libretto, and performance), related works, and parent and sibling work; however, not all relationships of parent and sibling information have been established. Related pages of the work are connected via hyperlinks, and some links direct to external websites such as Wikipedia or other websites that provide information on the musical work. IMSLP provides only minimal information of expression and manifestation, such as performer's name, published (uploaded) date of recordings, and a few pages include detailed information like date of performance, medium of performance, place of performance, etc.

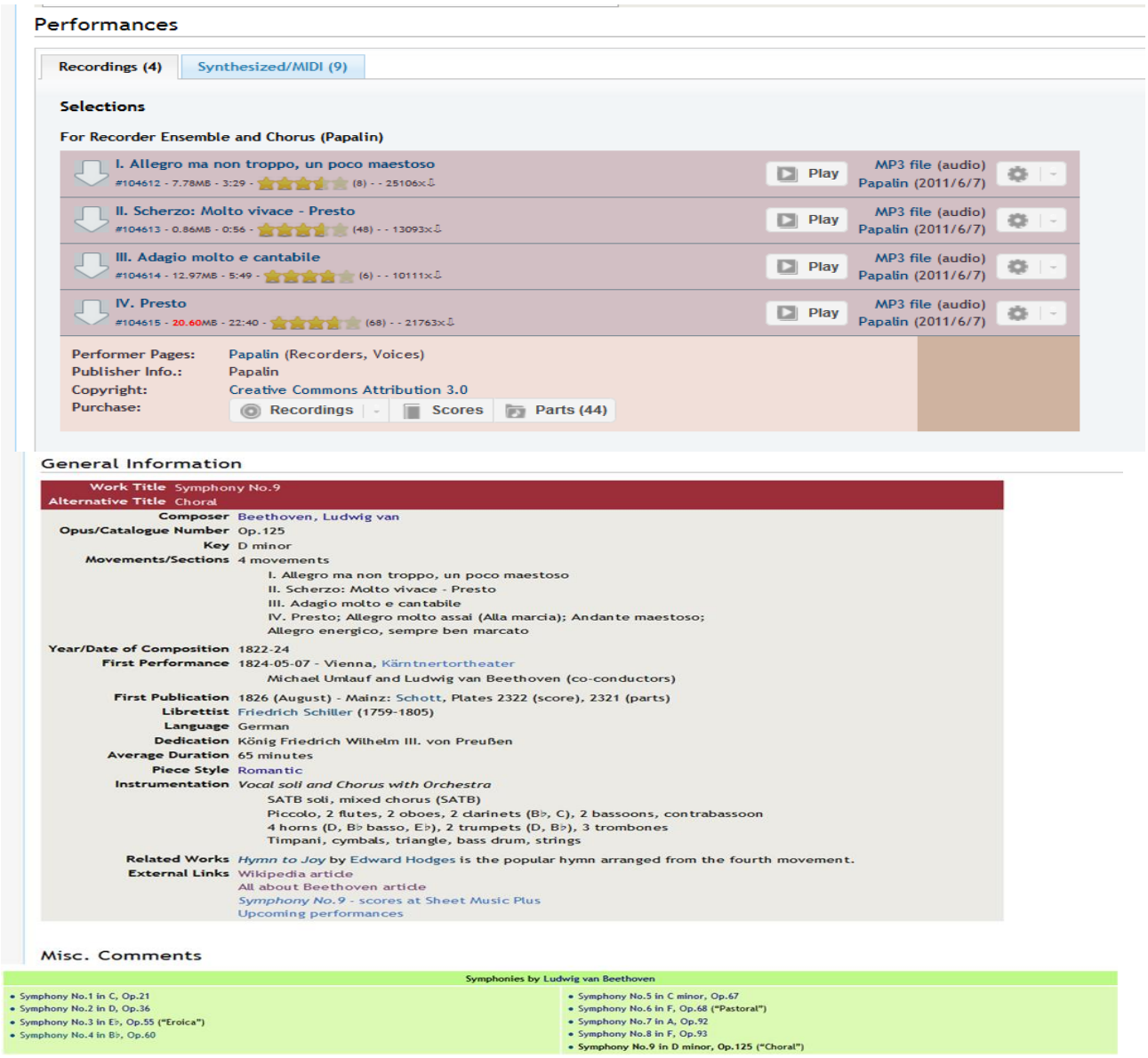


Figure 5.3 Performance, Recordings, and General Information in IMSLP Page

A concern about IMSLP is that the display of the work page contains various pieces of information which necessitates its users to scroll up and down. In addition, the relationship description is not well organized and intuitive to explore (Encelle et al. 2009; Mullin, 2010). However, compared to other music information search systems such as Wikipedia, Naxos Music Library, or Classical Music Net, users can find better organized and FRBR-like structured

information of expressions and manifestations in IMSLP. Thus, IMSLP is the classical music search system that is most compatible to FIRM.

5.2.2.2 Similarity between IMSLP and FIRM

IMSLP provides organized metadata records of musical works, person information and location of manifestations. In the works page, the metadata fields in IMSLP are similar to FIRM's attributes of Work entity. There are many similar attributes in work; however, FIRM is based on the CMFRBR's entity-relationship model, whereas IMSLP's structure is a plain text based description without the explicit relationship information available in FIRM. In general, the information available on IMSLP is comparable to CMFRBR's except for the Entity-Relationships present in CMFRB. Therefore, IMSLP was selected as a comparative system since it is one of the best FRBR-like classical music search methods on the Web. Table 5.2 shows a mapping of information between IMSLP and FIRM.

Table 5.2 Attributes of IMSLP and FIRM Work

IMSLP	FIRM
Composer	Relationship with Person (Role)
Work Title	Title of Work
Alternative Title	Other Distinguishing of Work
Opus/Catalogue Number	Numeric Designation
Key	Key of Work
Number of Movements/Sections	Context
Average Duration	Duration of Work
Dedication	Purpose of Work
First Performance	N/A
Year/Date of Composition	Date of Work
Year of First Publication	N/A
Librettist	Relationship with Person (Role)
Language	Language of Work
Piece Style	Music Period
Instrumentation	Medium of Performance
Extra Information (external link, e.g. Wikipedia)	Summarization of Work
Genre Categories	Genre of Work
Tags	N/A
N/A	Intended Audience of Work
N/A	Place of Work
Genre Categories	Form of Work

As with work entity, the metadata fields of the person page in IMSLP are expected to be relatively similar to FIRM's attributes of person entity. Table 5.3 displays the similarities and differences of the attributes of person entity between IMSLP and FIRM.

Table 5.3 Attributes of IMSLP and FIRM Person

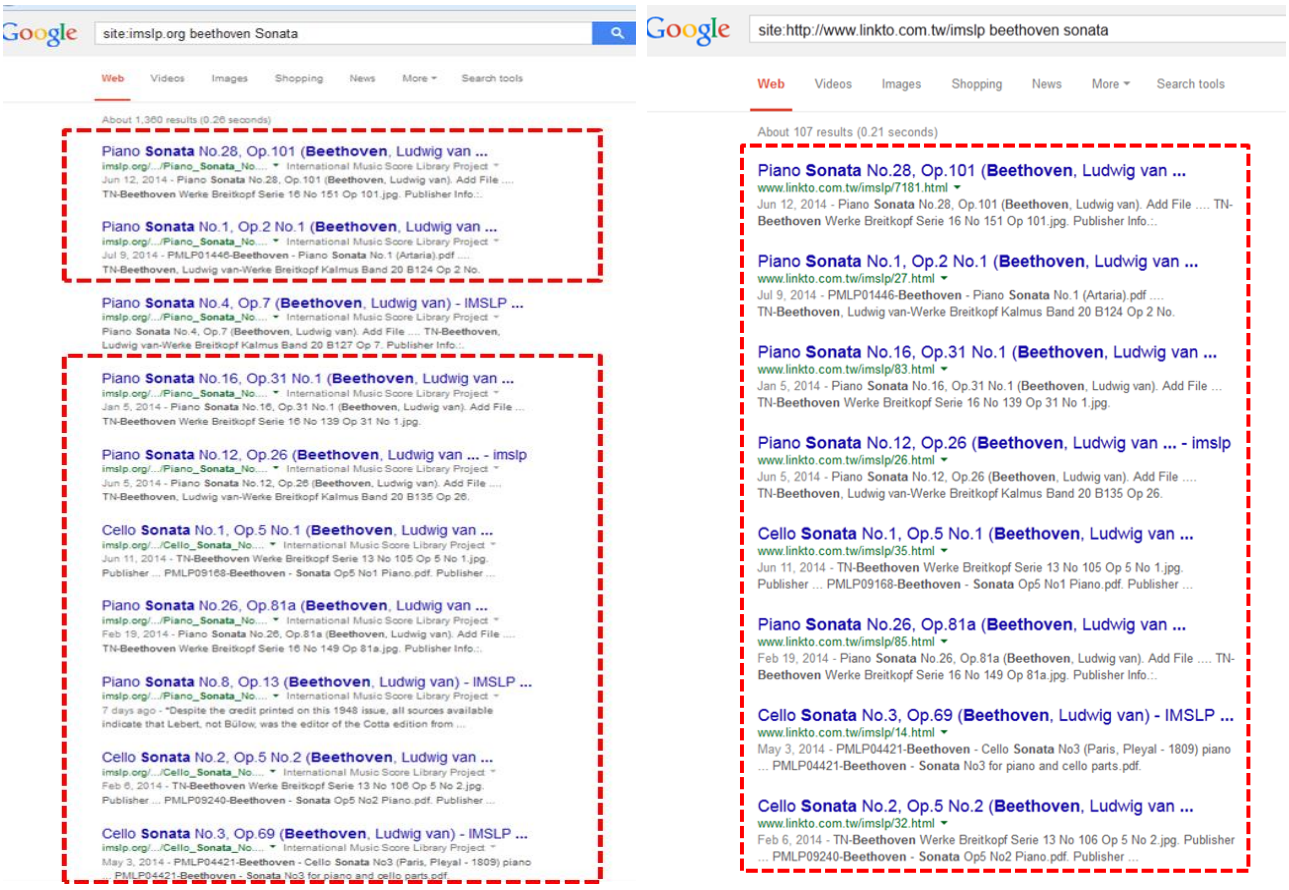
IMSLP	FIRM
Name	Name of Person
Birth Date	Date of Birth
Died Year	Date of Death
Alternate Names	Other Designation of Person
Time Period (Music Style)	N/A
Nationality	N/A
Biography Link (Link to Wikipedia if available)	Biography
Compositions	Relationship with Work
N/A	Place of Birth
N/A	Place of Death
N/A	Occupation

5.2.2.3 Selection of IMSLP Dataset

Because FIRM includes only 1,050 works and 345 persons and IMSLP includes more than 88,009 works, 12,199 composers, and 320 performers (as of Jan. 2015), it is fair to select a portion of IMSLP resources to have a collection of similar size for the purpose of comparison between two systems. This study did not include some musical works composed in the 20th century due to the copyright issues in IMSLP, where the musical works must be in the public domain in either Canada or the US. In order to keep same musical works listed in IMSLP and FIRM, the works that IMSLP could not list were excluded from FIRM as well. Thus, about 1,200 IMSLP cached pages of musical works and composers have been downloaded, which match the work and person pages in FIRM.

In order to create a similar environment with IMSLP, I saved all downloaded IMSLP pages on a database system and requested that Google index them so the search results of the

database could be similar to the original site. Figure 5.4 presents how similar the search results are with the same search term “Beethoven sonata” between IMSLP (left) and local site (right).



IMSLP **Local Site**

Figure 5.4 Search Results Similarity Between IMSLP and Local Site

To make user’s search experience with the local site identical to the IMSLP system, the target page was programmed to automatically redirect to the IMSLP’s work or person page when a user clicked the search result of the database system.

5.2.3 Task Sets

5.2.3.1 Procedure of Collecting Questions

As was found in Phase 2 (Chapter 5), many public users asked questions concerning classical music in Yahoo! Answers, a social Q&A site. Questions used for the task sets were collected from real questions in Yahoo! Answers. Questions in Yahoo! Answer's Classical Music category that pertained to the bibliographic information of classical music were first selected, since such information is suitable to be applied to attributes and relationships in the CMFRBR model. This study did not include questions requesting opinions or subjective open-ended questions related to classical music in Yahoo! Answers. This was due to the following: (1) the major concern of this study was to examine how users find bibliographic information of classical music from music information resources. (2) Open-ended and subjective questions usually do not have fixed answers (Jahnke, 2010, p. 48). Involving these questions would have complicated the analysis. This study acknowledges that the reported results may not be able to be generalized to opinion-type question sets, which require more complicated experimental settings.

In addition, all the questions about the classical musical works which are copyrighted in US or Canada were excluded, as IMSLP does not allow publishing pages for copyrighted classical musical works. Therefore, this study accepted questions in Yahoo! Answers that only address musical works which are published in IMSLP and duplicated in FIRM.

5.2.3.2 Examples of Tasks

Among the questions, ones that meet both IMSLP metadata fields and CMFRBR's attributes were selected for task sets. Some of CMFRBR's attributes (such as a composer's place of birth/death or summary of a work) were not selected for task sets, as they are not part of the

IMSLP metadata fields. I classified question sets according to the attributes of each entity and relationship description. The example of the whole set of search tasks (Task #4) about Bach's Brandenburg concertos is shown in Table 5.4. Each task set consists of a statement and five sub-task questions. Some sub-questions might contain one or more questions. For example, the question, "*When* and *Where* did Cambridge Concentus perform Concerto No.3?", needed to be answered with both the time and place of the performance. APPENDIX C lists the entire experimental task sets used in the experiment.

Table 5.4: Example of Question Set (Task #4)

Statement: You are listening to Bach's Brandenburg Concertos and it consists of 6 single concertos (nos. 1-6).			
Entity	**Sub-Task**	**Attribute/ Relationship**	**FRBR User Task**
Work	What are the instruments in Concerto No. 3?	Medium of Performance	Select
Expression	When and Where did Cambridge Concentus Perform Concerto No.3?	Date, Place	Identify
Manifestation	Identify the Permanent Link of Cambridge Concentus' Sound Recordings.	Access Address	Obtain
Person	Identify composer's Variant Name (Alternative Names/Transliterations).	Other Designation	Identify (FRAD)
Relationship	When (years) were the concertos composed?	Composed year of siblings	Find

Similar to previous studies (Pisanski & Zumer, 2010a; Salaba & Zhang, 2012) that examined user tasks suggested by the FRBR final draft (IFLA, 1998), this experiment also adopts the criteria of user tasks from FRBR in the question sets: find, identify, select, and obtain the information of work, expression, and manifestation. Since the FRBR draft does not contain

user tasks on the person entity, this study adopts the user tasks of person from the Functional Requirements for Authority Data (FRAD) to bridge the gap (Patton & IFLA Working Group, 2009). Table 5.5 shows examples of the sub-tasks of each entity and relationships.

Table 5.5 Examples of the Sub-Tasks

Entity	Question Examples	Attribute/ Relationship	FRBR User Task
Work	What musical instruments (medium of performance) were intended to be used?	Medium of Performance	Select
	In what language was this piece originally written?	Language	Select
	Name the movements of Mozart's Requiem in order	Context	Identify
	What is the purpose of the music composition (i.e. dedication)?	Purpose	Find
Person	When and where was s/he born?	Time, Place	Identify (FRAD)
	Identify composer's Variant Name (Alternative Names/Transliterations).	Other Designation	Identify (FRAD)
Expression	When and where was performance done?	Time, Place	Find
	What musical instruments were used in this performance?	Medium of Performance	Find
Manifestation	When was the performance published?	Date	Find
	What is media format?	Form of Carrier	Identify
	Find the permanent link of this media	Access Address	Obtain
Relationship	This is the last part of "Der Ring des Nibelungen (The Ring of the Nibelung)". Find the other parts of this musical work.	Sibling Works	Find
	These four concertos were published as part of a set of twelve concertos. Find the title of the set.	Parents-Child	Find
	Find the published media of this performance.	Embodiment	Identify
	Who was the librettist (lyricist) of the opera?	Work - Person	Identify

5.2.4 Experiment Procedures

To understand how CMFRBR's representation in FIRM efficiently works for searching and browsing compared to IMSLP, I performed a lab-based user study which consisted of a survey, a live experiment and a structured interview. In the laboratory-based experiments, participants were requested to search for specific music information about a particular composer and extended their search to the expression and manifestation level in both FIRM and the baseline system, IMSLP. The experiment was set up as a comparative study in order to evaluate the usability of both the FIRM and IMSLP search. International Organization for Standardization (ISO) (1998) defined usability as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Figure 5.5 shows the structure of the experiment. This study is approved by the University of Pittsburgh Institutional Review Board (IRB) (IRB#: PRO12040138).

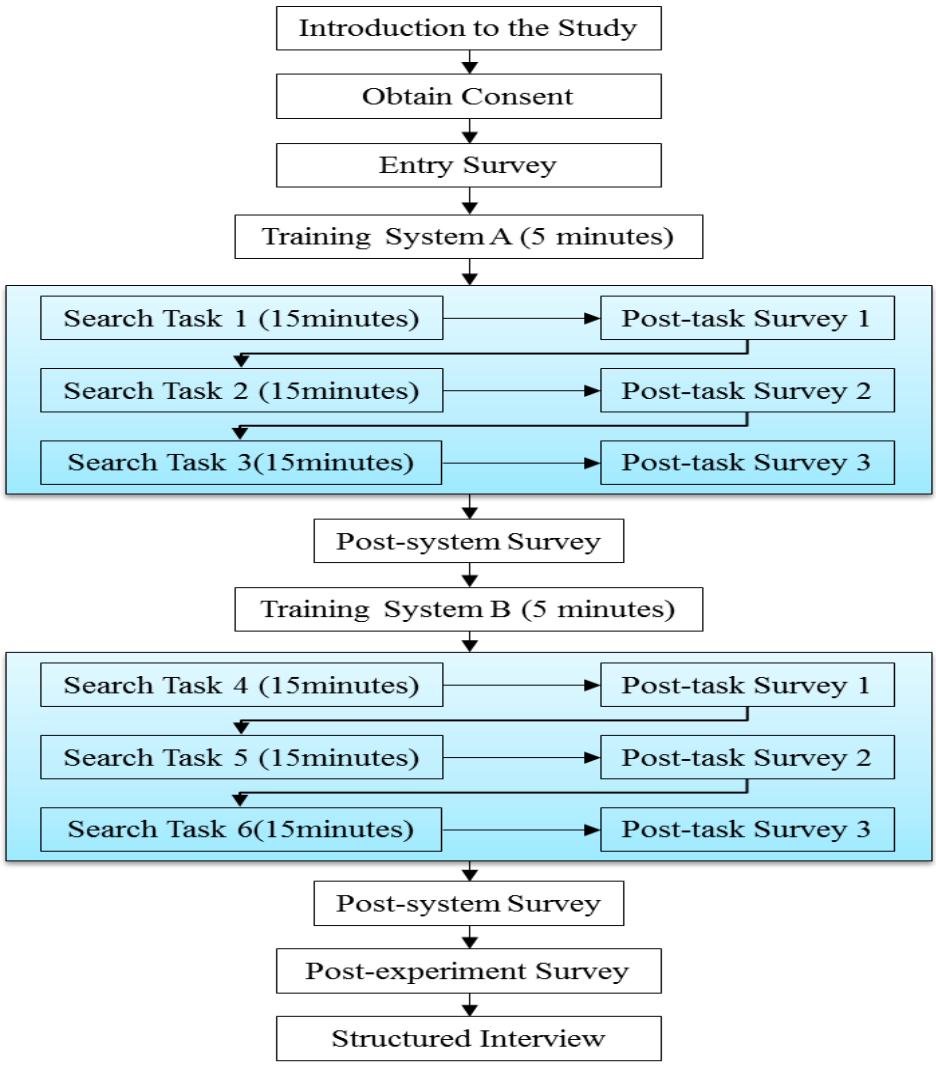


Figure 5.5 The Structure of the Experiment

After obtaining signed consent from the participants, the experiment began with an entry survey obtaining participants' demographic and background information and an introductory session for FIRM and IMSLP's classical music search. Prior to searching in each interface, participants had training sessions to learn how to search for classical music information in IMSLP or in FIRM for five minutes each. In order to search for classical music information in both systems, they needed to understand the structure of search process that consists of three

levels: *page, information,* and *answers*. In the training session, the participants learned the definition of *page, information,* and *answers*. This study defined finding a *page* as a user's finding relevant pages within the search results display. After selecting the relevant pages for each question, the participants were requested to find relevant *information* on the selected page. Then, the user finally determined the *answers* to questions from the relevant information.

After the training sessions, each participant was asked to conduct three sets of search tasks in IMSLP and FIRM for 15 minutes each. Each participant performed six search tasks, using FIRM on three tasks and the other three with the baseline system (IMSLP). Each task consisted of five sub-task questions that asked about work, expression, manifestation, person, and relationship information. The details of task sets were introduced in Chapter 5.2.3. Each task had a 15-minute limit to complete but participants were allowed to finish the task earlier than the time allotted: the participant could either go on to the next task or take a break until time was up. If a participant failed to find an answer in each sub-task in a task set, s/he could abandon the task with a penalty that added three minutes to the actual experiment time, within which the participant had to complete the given tasks for each sub-task (which never happened during the experiment). A task consisted of five sub-tasks, which the participants were allowed to complete in any order.

The experiment rotated the task sequence in order to avoid possible bias caused by learning and fatigue. The Graeco-Latin square design was used to rotate the sequence of the search systems and the tasks (Kelly, 2009).

Table 5.6 provides the sequence of the tasks of each subject. Each row was performed by two subjects. The list was passed through twice in order with the first participant being S1, and the thirteenth participant also being an S1 subject.

Table 5.6 Task Rotation with Graeco-Latin Square

Subject	**IMLSP Search (session 1)**			**FIRM Search (session 2)**		
S1	Q1	Q2	Q6	Q3	Q5	Q4
S2	Q2	Q3	Q1	Q4	Q6	Q5
S3	Q3	Q4	Q2	Q5	Q1	Q6
S4	Q4	Q5	Q3	Q6	Q2	Q1
S5	Q5	Q6	Q4	Q1	Q3	Q2
S6	Q6	Q1	Q5	Q2	Q4	Q3
Subject	**FIRM Search (session 1)**			**IMSLP Search (session 2)**		
S7	Q1	Q2	Q6	Q3	Q5	Q4
S8	Q2	Q3	Q1	Q4	Q6	Q5
S9	Q3	Q4	Q2	Q5	Q1	Q6
S10	Q4	Q5	Q3	Q6	Q2	Q1
S11	Q5	Q6	Q4	Q1	Q3	Q2
S12	Q6	Q1	Q5	Q2	Q4	Q3

At the end of each task, the study used a post-task survey questionnaire to inquire about participants' pre-knowledge of the music, ease of search, and satisfaction level of finding page, information, and answers. After finishing the three tasks in each system, participants were also requested to complete the post-system survey which asked for their overall satisfaction level with finding music information and the relationships among the entities of the system.

After the entire experiment (meaning that a user finished all six tasks) each participant took a post-experiment survey, reporting his or her preferred music search method and opinions of how well the CMFRBR representation in FIRM handled the attributes and the relationships of classical music information. The participants also completed a short structured interview about his or her experience of music search in both FIRM and IMSLP. The interview intended to

obtain individual opinions about using FIRM, which could not be gathered from the experiment alone. During the interview, the participants were asked about advantages and disadvantages, overall satisfaction and any additional comments to improve CMFRBR and FIRM. APPENDIX D, APPENDIX E, APPENDIX F, and APPENDIX G provide the entire lists of questionnaires of the survey and interview.

The study used screen and voice recording software, *Camtasia* and *oCam*, to capture participants' screen movement. Participants' actions were recorded and observed on how they found the answers using screen recordings, which included how many times they searched with different query terms, and the number of page views to reach the answer. Other measures included the total time spent on each task and the correct rate of their answers. The participants were asked to freely express their impression or thoughts during their search process. Their unstructured speech helped this study understand what users were thinking while searching and browsing for music information, and allowed the observer to catch the users' perspective toward their classical music information retrieval process. This technique was marginally beneficial to understand users' needs and perspectives when seeking classical music information.

5.3 Definitions of Experimental Variables

The following data was collected during the experiments in order to answer the research questions.

5.3.1 FRBR User Task

First of all, an analysis of participants' search performance based on the FRBR user task criteria, i.e., find, identify, select, and acquire or obtain, was conducted as shown in Table 5.4 and Table 5.5.

Following the general user task categories defined in the FRBR final draft:

a) to ***find*** materials corresponding to the user's stated search criteria;

b) to ***identify*** an entity;

c) to ***select*** an entity appropriate to the user's needs; and

d) to ***acquire*** or ***obtain*** access to the described entity (IFLA, 1998)

This study measured the number of correct answers for each task, which consisted of five questions asking for bibliographic information about classical music. In each task, participants sought answers to attributes of work, expression, manifestation, and relationship questions. Since the FRBR draft does not contain user tasks on person entity, this study adopts the user tasks of person from the Functional Requirements for Authority Data (FRAD) to bridge the gap (Patton & IFLA Working Group, 2009). This study has six tasks and each of them has five questions. Some questions require complex answers which were composed of two or more different entities or attributes. For example, the question, "When and where did Cambridge Consentus perform Concerto No.3?", explicitly asked users to identify the date and place attributes of the

expression. For some other tasks, users might be required to identity the relationship among the entities, and then they can, in turn, use that information to find correct answers to the given question. These kinds of questions required that the participants use extra steps to complete the task. One example of such a question is: "Did the composer write the words for the symphony (which is identified in the task statement)? If not, who is the lyricist? When was s/he born?" The original question set of this study has 30 questions. These 30 questions have been further divided into 42 questions since one question might include one or more attributes or relationships. These 42 questions were designed to match FRBR's user tasks. This study's "FRBR's user tasks" are comprised of eleven works, seven expressions (performance), seven manifestations (sound recording), eight persons, and nine relationships (Table 5.7).

Table 5.7 Questions by FRBR Tasks (continued).

Entity	FRBR User Tasks	Attribute/ Relationship	Frequency of Tasks
Work	Select	Medium of Performance	6
	Find	Purpose, Background	2
	Identify	Movement	1
	Select	Other distinguishing	1
	Identify	Music Period	1
Expression	Find	Time, Place	3
	Find	Medium of Performance	4
Manifestation	Find	Place, Date	3
	Identify	Form of Carrier	2
	Obtain	Access Address	2

Person/ Corporate Body	Identify (FRAD)	Time, Place	4
	Identify (FRAD)	Other Designation	2
	Identify (FRAD)	Occupation	2
Relationship	Find	Sibling Works	1
	Find	Parents-Child	2
	Identify	Work - Person	4
	Find	Publisher	2

5.3.2 Subjective/Objective Variables

This study adopts both subjective measurements and objective measurements for a more comprehensive understanding of classical music seekers' search behavior and perception on both FIRM and IMSLP.

Subjective measurements refer to the participants' perceptions or attitudes toward their search experiences. The experiment gathered participants' survey and interview responses in four categories for subjective measures: 1) Ease of completing a search (in finding pages, information and answers) in a task; 2) Self-assessment level of satisfaction (in obtaining information and answers) in a task; 3) Overall ease of finding music information of entities and relationships in each system; and 4) Participants' preference for a search platform.

The objective measurements in this study represent a user's performance in his or her searching and exploration process that does not rely on a user's perception toward the search performance. For objective measurements, this experiment collected five types of performance logs: 1) Percentage of task completion; 2) Time spent on each task; 3) Number of queries the participants issued to answer a question in the task; 4) Number of pages viewed in each task; 5)

Percentage of correct answers per task. Table 5.8 in the next section summarizes the subjective and objective measures with usability characteristics.

5.3.3 Usability Characteristics Measurements

Hornbæk (2006) identifies commonly-used measures of usability studies. He analyzes usability research based on the three characteristics of usability defined by the International Organization for Standardization (1998): *effectiveness, efficiency,* and *satisfaction*. This study adopted the identified measures that fit the user experiment and survey results into these three pre-defined categories. Thus, two dimensions of analyses, Objective/Subjective measurements under usability measures and Effectiveness/Efficiency/Satisfaction measurements under usability characteristics, are used respectively.

According to International Organization for Standardization (1998), *effectiveness* is "accuracy and completeness with which users achieve specified goals." *Efficiency* is defined as "resources expended in relation to the accuracy and completeness with which users achieve goals" and *satisfaction* is "freedom from discomfort, and positive attitudes towards the use of the product." Table 5.8 shows Hornbæk's usability characteristics and measurements that match the measurements of the experiment.

Table 5.8: Measurement Methods

	Metric	Usability Measures	Usability Characteristics
Objective Measurement	Percentage of task completion	Binary task completion	Effectiveness
	Time spent on a task	Task completion time	Efficiency
	Number of queries the participants issued to answer a question in the task	Use frequency	Efficiency
	Number of pages viewed in the task	Information Accessed	Efficiency
	Percentage of correct answers per task	Accuracy	Effectiveness
Subjective Measurement	Ease of completing a search in a task	Ease-of use	Satisfaction
	Self-assessment of the outcome of interaction	Users' Assessment	Effectiveness
	Overall satisfaction in each system	Perception of outcome	Satisfaction
	Participants' preference for a search platform in post experiment survey	Preference	Satisfaction

5.3.4 Summary of Study Variables

In the study, 24 participants were recruited to search and browse bibliographic records of classical music on FIRM and IMSLP in order to determine whether they were efficient, effective, and satisfactory systems for music information seekers. The experiment consisted of a background survey, training sessions, search tasks, post-task survey, post-system survey, post-experiment survey, and short interview. This study had two search systems, FIRM and IMSLP; it was designed to examine how users search for and explore classical music information in different entities, attributes, and relationship views. For each search task, the participant was required to find five answers related to classical music in 15 minutes. The analysis of data was mainly grouped into two sections: (1) Users' objective performance of their search tasks; (2) Users' subjective perception of their search performance.

To discover the internal factors of participants' performances and perceptions, this study included various independent variables and constructs in the analyses. Several covariates including music knowledge, language in which classical music was first learned, and music search skills were collected from the background survey at the beginning of the experiment. The independent variables were all demographic variables as shown in Table 5.9.

Table 5.9 The summary of the variables for the performance analysis (continued).

Conditions	Dependent Variables (DV)	Independent Variables (IV)

Performance (Objective)	• Search: Number of Queries Issued
	• Page: Number of Pages Viewed
	• Time: Time Spent on Each Task
	• Success: Success Rate
		• Music Search Skill
		  ○ Very Poor (1) – Very good (5)
		• Classical Music Knowledge Level
		  ○ Very Poor (1) – Very good (5)
		• Language First Used Learning Classical Music
		  ○ English Learned Group
		  ○ Non- English Learned Group
		• Classical Music Term Familiarity (For Non-English Learned Group only)
		  ○ Familiar Group
		  ○ Non-Familiar Group
		• Participants' Occupation
		  ○ Librarians
		  ○ Graduate Students
		  ○ Undergraduate Students
		  ○ Others

Perception (Subjective)	• Ease-of-use
	  ○ Finding Page
	  ○ Finding Information
	  ○ Finding Answer
	• Satisfaction
	  ○ Obtaining Information
	  ○ Obtaining Answer	

Overall Perception (Subjective)	• Ease-of-use of Finding Information
	  ○ Work
	  ○ Performance (Expression)
	  ○ Recording (Manifestation)
	  ○ Person/Corporate Body
	  ○ Relationship
	• Music Search Preference to Search for Entity Information
	  ○ IMSLP
	  ○ FIRM	

The search interface and search tasks were repeated and rotated, causing each participant to experience both interfaces and all search tasks in the experiment. The objective variables, including number of search queries, number of pages viewed, time spent, and the success rate of correct answers, were counted by observing each participant's performance.

One subjective variable, ease-of-use, was defined with 5 values using a Likert scale (very difficult = 1; very easy = 5), indicating the level of a participant's perception of the ease-of-use of finding certain variables (page, information, and answer). The other subjective variable, satisfaction level of their performance of finding information and answers, was also defined with a 5-point Likert scale (very dissatisfied = 1; very satisfied = 5). In overall ease-of-use of finding entity (work, expression, manifestation, person/corporate body) and relationship information, participants rated using a 5-point Likert scale (very difficult = 1; very easy = 5) as well. The preferred music search interface had two values which represents their preferred system to find entity information (IMSLP = 0; FIRM = 1).

For the independent variables, music search skill and classical music knowledge, were defined with 5-point Likert scale (very poor =1; very good =5). The language first learned classical music separated out those participants who learned classical music in English and those who first learned classical music in a different language. Those participants who did not first learn classical music in English were asked if they were familiar with classical music terms in English on a Yes/No basis.

5.3.5 Participant Group Information

5.3.5.1 Target Participant Group

The final target user group for the experiment was the general public who is interested in classical music but does not have professional knowledge of it.

All participants were recruited by requesting information on their background in the music domains; specifically, music school students or music professionals were excluded from being participants in this study as their domain knowledge may reduce their efforts for finding certain music information. These individuals may not need to search for information, but can simply recall the answers from their memory, particularly when they already know the required music information.

The assessment of the participants' knowledge level relies on their own subjective judgment because it is difficult to define the line between music experts and non-experts. For example, if a participant had studied at a music school, but had not worked in the music domain for several years, it is difficult to claim that the participant still has professional music skill or knowledge. Yet participants who do not have professional training experience may assert professional knowledge if they have been interested in music for a long time. Previous studies defined novice music listeners as musicians with limited training and non-professional knowledge, where experts are advanced degree holders in music or teaching experience, both of which indicate a difference in the dimensions used to make judgments of stylistic similarity (Gromko, 1993; Miletto et al.,2011). Based on this criterion, this study defines the novice as a person who does not have any advanced education in the music domain.

The requirement of the participants is that they have music search experience. It is not necessary to have knowledge of the FRBR model. All participants had to be 19 years old or older.

The participants were recruited from the general public in Pittsburgh, PA, USA. Twenty four participants took part in the experiment over the course of two different experimental sessions in order to evaluate and compare FIRM and IMSLP-based music information search from September, 2014 to November, 2014. Participants were paid at the rate of $10 per hour and the average duration of the experiment was one hour and thirty minutes.

5.3.5.2 Participants' Demographics

Table 5.10 shows the demographic characteristics of the participants.

Table 5.10 Demographic Information of the participants (continued).

Characteristic	Frequency (N=24)	Percentage (%)
Occupation		
Librarian	2	8.3
Graduate Student	11	45.8
Undergraduate Student	8	33.3
Others	3	12.5
Knowledge of Classical Music		
Very Poor	2	8.3
Poor	7	29.2
Fair	13	54.2
Good	2	8.3

Music Search Skill		
Poor	5	20.8
Fair	7	29.2
Good	7	29.2
Very Good	5	20.8
Languages (First learn Classical Music)		
In English	12	50
Other languages	12	50
Library Catalog Search		
Never	20	83.3
Less than Once a Month	3	12.5
Once a Month	1	4.2
Starting Point of Music Search (Multiple Selection)		
Google	23	95.8
YouTube	15	62.5
Library Catalog	2	8.3
iTunes	2	8.3
Others	5	20.8

The participants consisted of 2 librarians, 8 undergraduate students, 10 graduate students, and 3 other professionals. Among the students, their majors included anthropology, biology, computer engineering, economics, information science, pharmacy, physical therapy, political science, psychology, public affairs, rehabilitation, and social works. This study excluded music school students since the main purpose is to investigate the usability of different classical music bibliographic records search systems for the general public who may not have a professional music background.

Twelve participants (50%) first learned classical music in English. Among the remaining (N=12) who did not first learn classical music in English, languages included Chinese, Japanese, Korean and Taiwanese, six of whom answered that they were not familiar with basic classical music terms, such as movements, key, and opus number.

Two (8.3%) out of the 24 participants rated their prior knowledge of classical music as very poor; seven (29.2%) rated their knowledge as poor; and 13 participants (54.2%) rated their knowledge as fair. The rest (N=2, 8.3%) rated their knowledge of classical music as good.

In terms of music search skills, five participants (20.8%) rated their music search skill as poor, and seven (29.2%) participants evaluated themselves as fair. The rest of the participants (N=12, 50%) considered their search skills for musical resources to be good or better. In this study, due to the small number of participants, I categorized the music knowledge group and music search group as two broad groups, which are the lower level group and the higher level group in the in-depth analysis.

The majority of the participants (N=20, 83.3%) never searched for music in a library catalog system. Only one participant regularly searches for music information in a library catalog.

Among the participants, 95.8% (N=23) responded that they started their music search with Google, and 15 (62.5%) selected YouTube. Two participants (8.3%) responded that their starting point for searching for classical music was a library catalog system. Five answered they start search for classical music in ProgArchives, Spotify, and Wikipedia.

Four participants (17.4%) had known about FRBR prior to the experiment. Of these four, two participants estimated their knowledge about the FRBR model to be good, since their

occupation was librarian. Based on their ratings, the other participants of this study did not have prior knowledge about FRBR.

5.4 Results of User Experiment

5.4.1 User Experiment Analysis

In order to examine the statistical differences, this study employed the statistical software SPSS, version 22. In this study, I compared the results of the CMFRBR's Information Retrieval of classical Music Search System (FIRM) and IMSLP's classical music search system. As the survey results were not normally distributed, Mann-Whitney U tests were mainly performed to examine the results for any statistical differences among the user tasks between the two systems. (Nachar, 2008). Wilcoxon signed rank tests were utilized to analyze the differences of users' overall perception between two systems as well. This study did not measure the percentage of task completion as only one out of 144 tasks was not completed within the given time. It is important to note that this study compared the differences between an implemented FRBR-based classical music search system, FIRM, and a FRBR-like music search system (IMSLP). The study results do not claim that FIRM, based CMFRBR, have been compared with non-FRBR classical music search system.

5.4.1.1 Analyses of Objective Measurements

The user performance log analyses include time spent, number of queries issued, number of pages viewed, and the success rate of finding correct answers.

Table 5.11 shows the results of the Mann-Whitney tests of the objective measurements.

A Mann-Whitney test suggested that users' search performance in FIRM (N = 72, U_F = 62.11, *M* = 4m48s, *Mdn* = 4m05s) had significantly better outcomes than IMSLP (N = 72, U_I = 82.89, *M* = 5m56s, *Mdn* = 5m32s) in terms of time spent, $p = .003$, $r = .25$, which indicated that the participant spent significantly less time to complete their search tasks in FIRM than IMSLP.

The experiment assigned one point as the rate of correct answers for each task (0.2 points for each sub-task), and compared the success rates between the systems. A Mann-Whitney test indicated that the success rate of correct answer in FIRM (U_F = 76.44, *M* = .989 points, *Mdn* = 1) was significantly higher than IMSLP (U_I = 68.56, *M* = .967 points, *Mdn* = 1), $p = .027$, $r = .18$, thus, it inferred that users may be more successful when using FIRM in order to obtain classical music information.

Because of the system's workflow, the minimum required number of page views in IMSLP is two, including work page and person page, whereas FIRM requires four pages which are work, expression, manifestation, and person/corporate body pages; therefore, the number of pages viewed is set equal to the number viewed minus the minimums defined above. The mean difference between IMSLP (U_I = 85.99, *M* = 3.64, *Mdn* = 3) and FIRM (U_F = 59.01, *M* = 1.81, *Mdn* = 2) is 1.83, which indicated that the participants viewed more IMSLP pages to find answers and information than those of FIRM ($p < .001$, $r = .33$). Meanwhile, a Mann-Whitney test indicated that there is no significant difference of the number of search queries between FIRM (U_F = 71.23, *M* = 1.44, *Mdn* = 1) and IMSLP (U_I = 73.77, *M* = 1.53, *Mdn* = 1), $p = .637$, $r = .04$.

Table 5.11 Value of User Performance

Measurements	Search	Page	Time	Success
Mann-Whitney U	2500.5	2226	1844	2308
Mean of IMSLP (N=72)	1.53	3.64	5m56s	.967
Mean of FIRM (N=72)	1.44	1.81	4m48s	.989
Z	-.473	-3.931	-2.989	-2.210
p	.637	.000***	.003**	.027*

From the results of the Mann-Whitney tests, participants' performances of search tasks with FIRM is better than with IMSLP, particularly in time spent, pages viewed, and the success rate of correct answers. This result implies FIRM provides the better search and browsing interface to find classical music information and provides an easier method to find relevant information and answers for classical music searching for its users.

5.4.1.2 Analyses of Subjective Measurements

The perception rating was based on participants' responses to a post-task survey that asked about ease-of-use and satisfaction with their search process. The total number of questionnaires for each search system was 72 (each participant completed three tasks in each system). A Mann-Whitney test was adopted to evaluate users' responses on ease-of-use and satisfaction level because the distribution of the result is not normal. Both subjective ratings, ease-of-use and satisfaction level, are defined with a 5-point Likert scale. A higher value indicates better satisfaction and being easier to find music resources. Table 5.12 presents the statistical results of the ease-of-use and satisfaction level analyses of user perception.

First, participants described how easily they found relevant pages about classical music from the search result display. A Mann-Whitney test indicated that participants believed finding

relevant pages was significantly easier in FIRM (U_F = 79.24, M = 4.17, Mdn = 4) than IMSLP (U_I = 65.76, M = 3.81, Mdn = 4), p = .041, r = .17. Similarly, the mean ranks of the ease-of-use in finding relevant information in IMSLP was 62.25 (M = 3.43, Mdn = 4) and that of FIRM was 82.75 (M = 3.99, Mdn = 4). A Mann-Whitney test shows that the ease-of-use level of FIRM in finding relevant information is significantly higher than IMSLP search, p = .002, r = .26. Moreover, participants' perception on finding answers with FIRM (U_F = 88.74, M=4.10, Mdn=4) is significantly greater than that of IMSLP (U_I = 56.26, M=3.21, Mdn=3), p < .001, r = .40. In terms of ease-of-use for finding music resources, the results of the analyses indicated that the participants' believed finding music related resources with FIRM were significantly easier than with IMSLP.

As Table 5.12 presents, the participants' subjective satisfaction ratings with their search performance between the two search systems were also significantly different. In the satisfaction level of obtaining music information, a Mann-Whitney test demonstrates that participants were significantly more satisfied with their performance with FIRM (U_F = 80.47, M = 4.11, Mdn = 4) than with IMSLP (U_I = 64.53, M = 3.78, Mdn = 4), p = .015, r = .20. In addition, a Mann-Whitney test indicated that participants' satisfaction with FIRM (U_F = 84.85, M = 4.17, Mdn = 4) in obtaining answers received a significantly higher score than IMSLP (U_I = 60.15, M = 3.57, Mdn = 4), p < .001, r = .31.

Table 5.12 The ease-of-use and Satisfaction Level of User Perception

Themes	Ease-of-use			Satisfaction	
Measurements	**Find Page**	**Find Information**	**Find Answer**	**Obtain Information**	**Obtain Answer**
Mann-Whitney U	2107	1854	1423	2018.5	1702.5
Mean of IMSLP (N=72)	3.81	3.43	3.21	3.78	3.57
Mean of FIRM (N=72)	4.17	3.99	4.1	4.11	4.17
Z	-2.044	-3.09	-4.851	-2.443	-3.728
p	.041*	.002**	.000***	.015*	.000***

In summary, the participants indicated that FIRM was easier to use for finding music information and they were more satisfied with FIRM than with IMSLP. This implies that searching for classical music in FIRM provides the participants with a better search experiences than IMSLP.

5.4.1.3 Analyses of Overall Subjective Measurements

Overall Ratings of Entity Information Search

After finishing three tasks in each system, a post system survey was conducted to question participants (N=24) about the overall ease-of-use level of using each system to find classical information on work, expression (or performance), manifestation (or sound recording), person/corporate body and relationships. A Wilcoxon signed rank test was run to determine if there were differences in finding musical resources between FIRM and IMSLP. Table 5.13 presents the participants' perception of overall ease-of-use of finding information of each entity and relationship description on each system.

A Wilcoxon signed rank test indicated that the median ease-of-use level ranks in work in FIRM (W_+ = 123.00, *Mdn* = 4) is significantly higher than IMSLP (W_- = 13.00, *Mdn* = 3), p = .003. The same was true with the work task, a Wilcoxon signed rank test found that finding expression information in FIRM (W_+ = 63.00, *Mdn* = 4.00) was significantly easier than in IMSLP (W_- = 3.00, *Mdn* = 3.5), p = .006. In the search for manifestation information, FIRM (W_+ = 93.00, *Mdn* = 4.00) also received a significantly higher rating than the ease-of-use for IMSLP (W_- = 12.00, *Mdn* = 3.5), p = .10. Moreover, the sum of ranks of the ease-of-use in finding person are 74.50 (FIRM: *Mdn* = 4.00) and 3.50 (IMSLP: *Mdn* = 3.5), respectively. A Wilcoxon signed rank test indicated that finding person in FIRM is significantly easier than IMSLP, p = .005. In the relationship description, a Wilcoxon signed rank test revealed that participants experienced higher satisfaction in FIRM (W_+ = 132.50, *Mdn* = 4.00) than IMSLP (W_- = 3.50, *Mdn* = 3.5), p =.001.

Similar to the subjective perception of ease-of-use in the post-task survey, participants' responses on FIRM received higher ratings than IMSLP in finding entity information and relationship descriptions that infers CMFRBR representation in FIRM provides better and easier description of classical music information than IMSLP.

Table 5.13 Overall Ease-of-use of Finding Information of Entities and Relationship

Measurements	Median of IMSLP (N=24)	Median of FIRM (N=24)	Z value	P value
Finding Work	3.00	4.00	2.936	.003**
Finding Expression (Performance)	3.50	4.00	2.743	.006**
Finding Manifestation (Sound Recording)	3.50	4.00	2.592	.010*
Finding Person/Corporate Body	4.00	4.00	2.835	.005**
Finding Relationship Information	3.00	4.00	3.388	.001**

An exit survey was conducted after participants completed all search tasks in both systems. Participants rated the level of agreement on how well FIRM provided organized information to help people understand musical resources and relationships among music entities. A combined 54.2% (N=13) of participants strongly agreed and 45.8% (N=11) agreed that FIRM can provide better-organized music information than IMSLP. In addition, most participants (N=23, 95.8%) agreed or strongly agreed that the relationship representation of FIRM will help music finders understand the relationships between work, expression, manifestation, and person/corporate body.

System Preference

Participants were requested to choose between FIRM and IMSLP for their preferred system for locating information on musical work, expression, manifestation, person/corporate body, and their interrelationships. Table 5.14 provides the results of the system preferences between FIRM and IMSLP.

Table 5.14 System Preference of Finding Classical Music Information

Measurements	IMSLP	FIRM
Finding Work Information	3 (12.5%)	21(87.5%)
Finding Expression (Performance) Information	6 (25%)	18 (75%)
Finding Manifestation (Sound Recording) Information	3 (12.5%)	21 (87.5%)
Finding Person/ Corporate Body Information	1 (4.2%)	23 (95.8%)
Finding Relationship Information	0 (0%)	24 (100%)

In finding work information, 21 participants (87.5%) selected FIRM, whereas three participants (12.5%) preferred IMSLP. During the interview, they explained how they liked

FIRM and IMSLP for their preferred search system to find work information. Most participants who selected FIRM commented that the organization of FIRM was easier to use to find work information answers.

"It shows very clear lists and category" –S1

"FRBR organizes various work information better than Web. It is easier to observe work information at first sight". –S6

"FRBR breaks up the information so that it is not all on one page and the information is easier to digest and look at" -S18

The comments from the participants who selected IMSLP as their preferred system to find work information included

"FRBR has too many options (too busy and overwhelming)"- S2

"Pages are only about works, so search only returned works" – S16

Twenty-three participants preferred to use FIRM to search for person/corporate body information over one who preferred IMSLP. The majority of the comments are about the organization of FIRM which provided a more intuitive information display than IMSLP. In addition, FIRM provided more attributes to describe person information.

"Easy to identify the roles of person/corporate body as well as their overall career achievements" – S4

"Good categorization and comprehensive content" – S13

They sometimes selected FIRM to find person information because IMSLP did not provide enough information about person/corporate body.

"IMSLP didn't provide clear information about metadata because of missing place or present time information in an unorganized way" – S5

"Web lacked a lot of information and the information they had on persons was very limited and not organized well" – S19

Eighteen participants (75%) responded they would opt for the performance search in FIRM rather than IMSLP, which six participants (25%) preferred. Similarly to comments about other entities, their major comments were about information organization and detailed attributes.

"The layout is clear, I can see it immediately when I access this page" – S24

"Contains more details such as the exact place and date" – S17

Some participants preferred to use IMSLP for their performance information search method since its layout of the performance information section is clear and located on the top of the work page.

"Tables in IMSLP make it obvious that it displays the performance information" – S3

"Web shows performance information within very few scrolls" – S6

In manifestation information, 21 participants (87.5%) liked FIRM, whereas IMSLP was selected by three participants (12.5%). Same as with the other entities, their main concern with finding manifestation information was information organization.

"Although the process to find the link is a bit difficult for me, the information about the sound recording is more clearly specified in FRBR. Also, it is hard to locate the publisher identity/information on the Web." – S9

"It [FRBR] was more organized and clear" – S13

Meanwhile, the advantage of IMSLP for finding manifestation information was that user can listen to the piece of classical music on the page.

"I like how you can play music to see what it sounds like. But also information was clearer than FRBR" – S11

"It [IMSLP] offered the MP3 file on the page" – S21

Remarkably, all participants (N=24) responded that they would like to search in FIRM when they were searching for the relationship descriptions between a musical work/expression/manifestation and person/corporate body. It is clear that they preferred to see

the relationship information in a separated pane which shows only relationship information among entities. Moreover, the hierarchical structure of the CMFRBR model provided a clear representation of relationship descriptions to the participants.

"IMLSP has no specific labels for relationships." – S5

"FRBR draws connection between the work information so that it was easier to find relationships of music and person." – S6

"Having the separate panes was helpful" – S14

"I like the hierarchical structure of FRBR" – S17

"The link between music work and person provides good structure to understand" – S24

Interview Comments

During the interview, the participants were requested to comment on the advantages and the disadvantages of using FIRM.

Advantages

As found in the previous section, the main advantage of FIRM was that it provided better organization of information. Several participants also preferred separated entity pages so that they could find information only related to certain entities.

"FRBR organized the information well" - S18

"Separated pages are an advantage to find information that I need" - S9

"I like FRBR because it breaks up the pages so I can find information from the certain entity page" -S16

"I like the FRBR better because it tells me what page I'm on. For example, I know that I'm on the page with sound recording. The only thing coming out of that page is sound recording. However on the website [IMSL], all the information was on one page which made it a little bit difficult for me to sort out the information. I like information that is in its own category. I don't like all the information on one page." - S23

In addition, relationship descriptions provided a better representation for users about where they could find related music information. Since FIRM is based on CMFRBR's entity relationship model, users can start browsing in any related page to work, and finally reach the work pages they need. For example, participants first click the expression or work of work page to eventually access the work page in FIRM.

"Browsing: FRBR is easy to click and find other related pages" – S4

"Good relationship description in FRBR structure" – S7

"FRBR leads user to follow the direction in its structure and less time consuming" – S10

"Work of work provides very good and organized information of the works and the collection itself." – S11

"I don't know the authority name file, Therefore, I wanted to start from where I am confident with the names (or information I know), because I didn't want to wander around…: I know that there is related information or pages where I can reach to the destination I want to go." – S15

"FRBR can click any related page (e.g. manifestation), and take the link to the original work page. Easy to browse and easy to move between WEM [Work, Expression, Manifestation]" - S19

Disadvantages

The disadvantages of FIRM were caused by the lack of familiarity with CMFRBR's organizing entity relationship model. Especially because CMFRBR adopted work title and person name from the name authority file from the Library of Congress, some users complained about the difficulty of understanding people's names and the titles of the works. Some titles of music were in different languages (e.g. German or Italian) which prevented users from finding the right work pages they wanted (i.e. confusing the German title and the English title for the same musical work). Additionally, when a sub-piece of a work has a unique name, it was difficult for participants to combine two titles (e.g. identifying "Spring" as part of "The Four

Seasons"). They also had difficulties in distinguishing the entity and attribute names due to the lack of knowledge of the terms used by CMFRBR's entity relationship model.

"FRBR's title ... subject heading - difficult to verify. Have to take links to verify work expression or manifestation information" -S2

"Terms in FRBR are difficult to understand, Expression Manifestation" – S6

"Title in other language makes it difficult to find right pages and alternate title is sometimes missing" –S21

The participants also claimed that the interface and structure of FIRM was not easy to understand in the initial stage of the tasks although they had a five-minute training session to get used to FIRM. It seems they needed more time to learn the system.

"Need short amount of time to get used to FRBR- After then FRBR gave good insight" -S17

"Need FRBR training – jargons, structure" – S4

"FRBR is difficult to understand: the page information at the beginning" -S5

Summary

To sum up, the participants spent less time finding answers and had higher success finding correct answers in FIRM. Participants gave higher scores to FIRM than to IMSLP in terms of ease-of-use of finding music and satisfaction level of their search process. Moreover, they preferred to use FIRM over IMSLP when they looked for classical music information by the entities and relationship description.

In the interviews, the participants clearly stated the advantages and disadvantages of FIRM and CMFRBR's entity relationship model. It was found that FIRM provided better organized music information and clear relationship descriptions to its users. Although users had to click more pages to find entity information, they preferred separate pages which contained

only information about one entity per page. FIRM, however, was considered to be a difficult system for first-time users; they needed more time to learn the system environment. The terminologies used in FIRM were not easy to understand for the users. It was necessary to change and update to easier terms on the end user side (e.g. Numeric Designation to Opus number or music catalog number).

5.4.1.4 FRBR User Task

This study examined the FRBR User Task, which IFLA's FRBR study group suggested. I measured the number of correct answers of each task which consisted of five questions asking for bibliographic information of classical music as mentioned in Chapter 5.3.1. Among 24 participants, 20 participants (83.3%) got a perfect score in the task of CMFRBR's FIRM, and 15 participants (62.5%) reached the same score in IMSLP.

As seen in Table 5.15, the total number of questions regarding work entity in each system was 132 (11*12). While participants perfectly found, identified and selected all correct answers in FIRM, they found five wrong answers in IMSLP. In IMSLP, four participants failed to find the background of musical work which indicated the second composer's name in Task 5. These outcomes also impacted the consequences of finding relationship between composer and work: if they failed to answer the first part of questions, they failed the rest of the question. Therefore, the four failed tasks in *background* of work and the four failed tasks in *Work – Person* relationship are for the same question, but were separate FRBR user tasks. The other failed question in *Work – Person* relationship was that a participant failed to locate the person of the "Work-Person" relationship, which also caused the FRBR user task of identifying the attribute of date of birth in the person entity in IMSLP to fail. For the *sibling works*, 91.7% (11/12) of the answers were correct in each system. *Parents-Child* relationship had 95.8% (23/24) correct answers.

Table 5.15 FRBR User Taks Success Rates

Entity	FRBR User Tasks	Attribute/ Relationship	Success FIRM	Success IMSLP	Frequency of Tasks
Work (11)	Select	Medium of Performance	100%	98.6%	6
	find	Purpose, Background	100%	83.3%	2
	Identify	Movement	100%	100%	1
	Select	Other distinguishing	100%	100%	1
	Identify	Music Period	100%	100%	1
Expression (7)	Find	Time, Place	97.2%	97.2%	3
	Find	Medium of Performance	100%	97.9%	4
Manifestation (7)	Find	Place, Date	94.4%	91.7%	3
	Identify	Form of Carrier	100%	100%	2
	Obtain	Access Address	100%	100%	2
Person (8)	Identify (FRAD)	Time, Place	100%	97.9%	4
	Identify (FRAD)	Other Designation	100%	100%	2
	Identify (FRAD)	Occupation	100%	100%	2
Relationship (9)	Find	Sibling Works	91.7%	91.7%	1
	Find	Parents-Child	95.8%	95.8%	2
	Identify	Work - Person	100%	89.6%	4
	Find	Publisher	100%	100%	2

In expression, a total of 84 questions for each system were asked to find correct answers. One participant failed in finding the time of performance (97.2%) in FIRM, and two users did not find answers of the time (97.2%) and instruments (97.9%) in IMSLP.

Manifestation has same number of questions with expression (N = 84) and participants successfully identify the form of carrier and obtain the access address in both systems. For the

published time and place, two participants did not find the publication date in FIRM (94.4%) while three participants did not find them in IMSLP (91.7%).

Participants successfully found most answers to identify the person information in both systems. The only wrong answer in IMSLP was the date of birth attribute as motioned in the *Work – Person* relationship above.

5.4.2 Factor Analyses based on the Independent Variables

This section demonstrates the results of analyses of participants' internal factors. During the pre-experiment survey, the participants answered their knowledge of classical music, the language first learned classical music, music search skill, occupation, music search frequency in library catalog and the knowledge of FRBR. The experiment survey was designed to analyze various internal factors because previous studies considered music knowledge, language and search skill as important variables (Byrd & Crawford, 2002; Duggan & Payne, 2008; Hargittai, 2002). In addition, some studies reported that education level did not effected on their music search (Lehtiniemi & Holm, 2011, 2013), and this study examines if there are different results from the previous studies. I compared the results of the FIRM and IMSLP's classical music search system by each factor. The analysis does not include the survey results of music search frequency in library catalog because majority participants (N = 20) never searched music information in the library catalog system, and the knowledge of FRBR was too skewed to be analyzed because only 2 out of 24 participants having good knowledge of FRBR.

5.4.2.1 Impact of Language Group

The participants in this study were separated into two language groups, 1) one participant group first learned classical music in English (N=12) and 2) the other group first learned classical music in other languages (N=12) including Chinese, Japanese, Korean and Taiwanese. To understand the impact of the two different language groups on users' performance and perceptions toward classical music search by their first learned language of classical music, I performed a Mann-Whitney U test to examine its impact. Table 5.16 presents the outcomes of Mann-Whitney U test in each system between language groups.

Table 5.16 Measurement between Language Groups (continue).

	System	Measurements	Mann-Whitney U	Z	Sig
Performance	**IMSLP**	Search	624.5	-0.336	0.737
		Page	549.5	-1.127	0.26
		Time	444	-2.298	.022*
		Success	592	-1.011	0.312
	FIRM	Search	634.5	-0.2	0.841
		Page	604.5	-.503	.615
		Time	580	-0.766	0.444
		Success	631	-0.553	0.58

	System	Measurements	Mann-Whitney U	Z	Sig
Subjective	**IMSLP**	Find Page	601	-0.551	0.582
		Find Info	589.5	-0.69	0.49
		Find Answer	409.5	-2.777	.005**
		Obtain Info	566	-0.982	0.326
		Obtain Answer	516	-1.556	0.12
	FIRM	Find Page	636.5	-0.14	0.888
		Find Info	602	-0.547	0.584
		Find Answer	560	-1.057	0.29
		Obtain Info	623	-0.303	0.762
		Obtain Answer	538.5	-1.322	0.186

In the analysis of objective measurements, the medians of time spent for the two groups, who first learned classical music in English, EG, (N = 12 * 3 tasks each = 36 observations) and Non-English, NEG, (N = 12 * 3 tasks each = 36 observations), were 4m50s (U_{EG} = 30.83) and 6m17s (U_{NEG} = 42.17) in IMSLP, respectively. The distributions in the two groups differed significantly, p = .022, r = .27. In IMSLP, however, the rest of the performance measurements showed no significant difference between language groups: number of search queries (p = .737, r = .04), number of page views (p = .26, r = .13), and rate of correct answers (p = .312, r = .12). In the case of FIRM, the Mann-Whitney tests did not find any significant differences between the language groups for any performance measure.

Meanwhile, for the ease-of-use level of finding answers in IMSLP, the medians of the EG and the NEG were 4.0 and 3.0, respectively. A Mann-Whitney test found that the self-rated ease-of-use of finding answers was significantly greater for the EG (N = 36, U_{EG} = 43.13) than the NEG (N = 36, U_{NEG} = 29.88), p = .005, r = .33.

These observations could imply that the Non-English group had difficulties finding answers to the task set in IMSLP search (longer time spent in search process), which could explain why their ratings of the ease-of-use of finding answers were lower than the English group. Meanwhile, the rest of the outcomes did not have significant differences between language groups, which mean that participants' first learned languages of classical music did not measurably influence their search of classical music information within the same interface, especially in FIRM.

On the other hand, this study examined if there were differences in the search performances and users' perceptions between FIRM and IMSLP within the language groups. Table 5.17 and Table 5.18 present the outcomes of the Mann-Whitney tests of users' performance and perceptions between the systems. In the performance analyses, the NEG's number of pages viewed was significantly lower in FIRM than IMSLP (p = .001, r = .56). In addition, the NEG's task completion time in FIRM (N = 36, U_F = 29.58, *Mdn* = 4m3s) is significantly lower than IMSLP (N = 36, U_I = 43.42, *Mdn* = 6m17s). A Mann-Whitney test indicated that the NEG spent significantly less time between the systems, p = .005, r = .33. The EG had a significant difference in page view (p = .026, r = .37) but did not have any significant difference in time spent between the systems, p = .173, r = .16. The rest of the performance logs did not show any significant difference between the two systems.

Table 5.17 Performance Analyses between Systems by Language group

Group	Measurements	Mann-Whitney U	Z	p
English Group	Search	644	-.058	.954
	Page	453.5	-2.227	.026*
	Time	527	-1.363	.173
	Success	596	-1.329	.184
Non-English Group	Search	608.5	-.575	.566
	Page	352	-3.373	.001**
	Time	399	-2.805	.005**
	Success	557	-1.787	.074

In the measurement of the subjective ratings by users, the English group's ratings in FIRM were significantly higher than IMSLP's in terms of ease-of-use of finding answers (p = .016, r = .28) and the satisfaction of obtaining answers (p = .017, r = .28). The Non-English group's ratings on the ease-of-use of finding music information (p = .003, r = .35), ease-of-use of finding answers (p < .001, r = .54), satisfaction with obtaining information (p = .024, r = .27), and satisfaction with obtaining answers (p = .004, r = .34) in FIRM were significantly higher than those for IMSLP. Based on the Mann-Whitney tests, it is possible to conclude that, regardless of the first learned language of classical music, participants perceived FIRM as somewhat easier and more satisfying than IMSLP although their performances in each system are not significantly different.

Table 5.18 Perception Analyses between systems by Language group

Group	Measurements	Mann-Whitney U	Z	Sig
English Group	Find Page	507	-1.668	.095
	Find Info	525.5	-1.441	.150
	Find Answer	444.5	-2.407	.016*
	Obtain Info	545.5	-1.221	.222
	Obtain Answer	448.5	-2.376	.017*
Non-English Group	Find Page	546	-1.220	.222
	Find Info	399	-2.971	.003**
	Find Answer	254	-4.607	.000***
	Obtain Info	464	-2.253	.024*
	Obtain Answer	407.5	-2.843	.004**

This study also examined users' overall perceptions of ease-of-use in finding entity and relationship information between the systems within each language group by means of the post-system survey, which was administered after performing three tasks on each system. The Wilcoxon signed ranks test was run to examine for the significant differences in perception between the two systems (Table 5.19).

The English group's sum of ranks of CMFBRB-based relationship description in FIRM was 43.00 (N = 12, *Mdn* = 4.5) while that of IMSLP was 2.00 (N = 12, *Mdn* = 3). A Wilcoxon signed ranks test indicated that the English group has a significantly higher rating of the relationship description between FIRM and IMSLP, $p = .013$.

Table 5.19 Overall Perception by Language Group

Language Group		Work	Expression	Manifestation	Person	Relationship
English	Z	-1.653	-1.857	-.966	-1.289	-2.481
	p	.098	.063	.334	.197	.013*
Non-English	Z	-2.598	-2.081	-2.401	-2.565	-2.388
	p	.009**	.037*	.016*	.010**	.017*

The Non-English group, meanwhile, gave higher ratings in all entities and relationship to FIRM. In work, FIRM received a median of 4 (N = 12, $W_+ = 36$) and IMSLP received a median of 3 (N = 12, $W- = 0$). A Wilcoxon signed ranks test revealed a significance of $p = .009$. In expression (performance) information, the Non-English group rated FIRM higher ($W_+ = 26$, $Mdn = 4.5$) than IMSLP ($W- = 2$, $Mdn = 3$). A Wilcoxon signed ranks test found a significant difference, $p = .037$. The medians of the participants' perceptions on manifestation (sound recording) of FIRM ($W_+ = 42.5$) and IMSLP ($W- = 2.5$) are 5 and 3, respectively, and a Wilcoxon signed ranks test indicated a significant difference, $p = .016$. In addition, FIRM ($Mdn = 4.5$) received the sum of ranks of 36, whereas IMSLP ($Mdn = 3$) had 0 in rankings for finding person information. The test showed significance, $p = .010$. Finally, relationship information was also significantly different with the median of FIRM ($W_+ = 42.5$) being 4 and that of IMSLP ($W- = 0$) being 3, $p = .017$.

To summarize, in terms of performance, there were no significant differences between language groups except for the time spent and ease-of-use of finding answers in IMSLP. This implies that FIRM provided an equally usable interface for both language groups. Based on each group's ease-of-use and satisfaction ratings on both systems, it is possible to speculate that the Non-English group's strong preference for FIRM is related to their superior performance on that

platform, whereas the English group, which rated both systems similarly, had more similar performance scores on both systems. In overall perception, both groups rated FIRM significantly higher than IMSLP, which tells that the relationship description in FIRM is experienced as better than IMSLP's regardless of language group.

Non-native group in the Familiarity with Music Terms

In the pre-experiment survey, I asked the Non-English group (N=12) if they were familiar with English terminology for classical music, e.g., instrumentation, movements, key, music era, librettist, etc. Six participants (50%) answered they were not familiar with the specific terminology of classical music, and the rest (N = 6) were acquainted with the musical terms. As in the analysis of language groups, I utilized the Mann-Whitney U test as the statistical method to examine the differences between the familiar with English terms (FM) and not familiar with English terms (NFM) groups in each search system. Table 5.20 presents the Mann-Whiney U test results between the term familiarity groups. In the performance analysis, the Mann-Whitney U test found that the success rate between the FM group (N = 18, U_{fm} = 21.03, M = .989, Mdn = 1) and the NFM group (N = 18, U_{nfm} = 15.97, M = .922, Mdn = 1) was significantly different, p =.036, r = .48, in IMSLP. Interestingly, as seen in Figure 5.6, except for the ease-of-use of finding pages in IMSLP, the participants in the NFM group voted higher ratings on ease-of-use and satisfaction than the FM group in both systems, even though the Mann-Whitney test did not find significance in ease-of-use and satisfaction in IMSLP. However, the ratings on FIRM are significantly different between the NFM and FM groups. The NFM group awarded FIRM significantly higher ratings to the ease-of-use of finding information (p = .031, r = .36), the ease-of-use of finding answers (p = .024, r = .38), the satisfaction of obtaining information (p = .032, r = .36), and obtaining answers (p = .041, r = .34) than those of the IMSLP. From the

observation of these results, the NFM group had stronger perceptions of ease-of-use and satisfaction in FIRM than the FM group, although their performance analyses did not have significant differences. This implies that the NFM group might consider FIRM to be the easier system to find classical music information regardless of their search performances.

Table 5.20 Measurements between the Terminology Farmiliarity Groups

	System	Measurements	Mann-Whitney U	Z	Sig
Performance	IMSLP	Search	143.5	-.720	.471
		Page	126.5	-1.139	.254
		Time	151.5	-.332	.740
		Success	116.5	-2.093	.036*
	FIRM	Search	146.5	-.674	.500
		Page	157.5	-.148	.883
		Time	155	-.221	.825
		Success	162	.000	1.000
Subjective	IMSLP	Find Page	142	-.662	.508
		Find Info	149.5	-.424	.672
		Find Answer	147.5	-.485	.628
		Obtain Info	144	-.631	.528
		Obtain Answer	136.5	-.860	.390
	FIRM	Find Page	133.5	-.991	.322
		Find Info	98	-2.154	.031*
		Find Answer	95	-2.254	.024*
		Obtain Info	99.5	-2.140	.032*
		Obtain Answer	101	-2.040	.041*

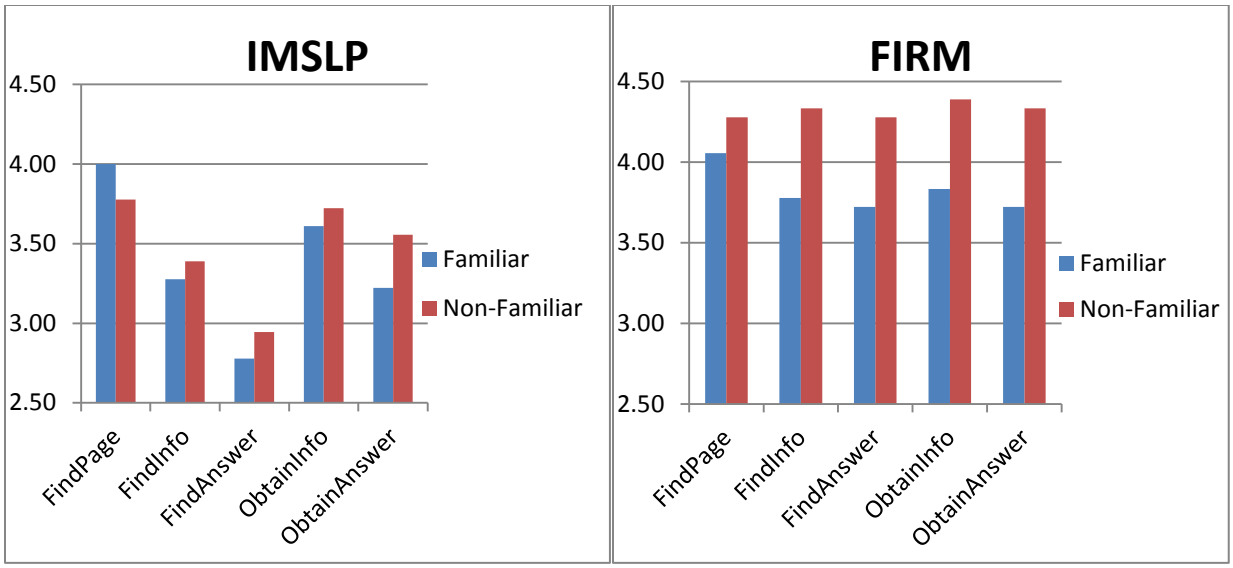


Figure 5.6 Ratings on the Subjective Ratings by Terminology Farmiliarity Groups

This study examined the difference of perception and performances between the search systems within the terminology familiarity group. Table 5.21, Table 5.22 and Figure 5.7 present the results of the measurements.

The FM group did not have significantly different search performances between the systems except the number of pages viewed. The Mann-Whitney U test found that FM group's additional page views between FIRM (N = 18, U_F = 13.75, *M* = 1.78, *Mdn* = 2) and IMSLP (N = 18, U_I = 23.25, *M* = 4.83, *Mdn* = 4) was significantly different, *p* =.006, *r* = .46. In addition, the FM group's time spent on both systems was marginally significant that they spent less time in FIRM than IMSLP, *p* = .052.

Meanwhile, the NFM group had significant differences in time spent between FIRM (N = 18, U_F = 15.03, *M* = 4m53s, *Mdn* = 4m05s) and the IMSLP (N = 18, U_I = 21.97, *M* = 6m27s, *Mdn* = 6m17s). A Mann-Whitney test indicated they spent significantly less time in FIRM than IMSLP, *p* = .048, *r* = .33. Moreover, the success rates of the participants in the NFM group are different between FIRM (N = 18, U_F = 21.03, *M* = .989, *Mdn* = 1) and IMSLP (N = 18, U_I =

15.97, M = .922, Mdn = 1). Repeated measures with a Mann-Whitney test showed a significant difference, p = .036, r = .35. The NFM group viewed more additional pages in IMSLP than FIRM and there is a marginally significant difference between the systems, p = .053. Based on this observation, it implies that FIRM can help its users who are not familiar with classical music terminology to find classical information with lower efforts, such as time spent, number of page clicks, and correct information.

Table 5.21 Performance Analyses between systems by Terminology Familiartiy Group

Group	Measurements	Mann-Whitney U	Z	p
Familiar Group	Search	154	-.303	.762
	Page	76.5	-2.739	.006**
	Time	100.5	-1.946	.052
	Success	162	.000	1.000
Non-Familiar Group	Search	154	-.366	.714
	Page	102	-1.935	.053
	Time	99.5	-1.978	.048*
	Success	116.5	-2.093	.036*

In the perception ratings, the FM group had difficulty only in finding answer in IMSLP (U_I = 12.97, M = 2.78, Mdn = 3) not FIRM (U_F = 24.03, M = 3.72, Mdn = 4). A Mann-Whitney test indicated that there are significant differences of finding answers between the systems, p = .001, r = .56.

The NFM group had more differences in the ease-of-use and the satisfaction between the two systems. First, there are significant differences in finding information between FIRM (U_F = 22.94, M = 4.33, Mdn = 5) and IMSLP (U_I = 14.06, M = 3.39, Mdn = 4), p = .008, r = .44. In

terms of the ease-of-use of finding answers, the participants' ratings on FIRM (U_F = 24.11, M = 4.28, Mdn = 4.5) is higher than IMSLP (U_I = 12.89, M = 2.94, Mdn = 3) and the results of a Mann-Whitney test show the significant differences between the system, p = .001, r = .55. In the satisfaction level of obtaining information, the medians were 4.5 (FIRM: U_F = 21.89, M = 4.39) and 4.0 (IMSLP: U_I = 15.11, M = 3.72), respectively. This indicates that there are significant differences between IMSLP and FIRM, p = .039, r = .34. Similarly, repeated measures in a Mann-Whitney test showed that the satisfaction with obtaining answers in FIRM (U_F = 22.56, M = 4.33, Mdn = 5) is significantly different from IMSLP (U_I = 14.44, M = 3.56, Mdn = 3.5), p = .015, r = .41. The results imply that the NFM group strongly perceived their use of FIRM to be easier and they were more satisfied with their search performances.

Table 5.22 Perception Analyses between Systems by the Familiarity with Musical Terminology

Group	Measurements	Mann-Whitney U	Z	p
Familiar Group	Find Page	159	-.101	.920
	Find Info	117	-1.576	.115
	Find Answer	62.5	-3.349	.001**
	Obtain Info	135.5	-.964	.335
	Obtain Answer	114	-1.633	.102
Non-Familiar Group	Find Page	114.5	-1.593	.111
	Find Info	82	-2.646	.008**
	Find Answer	61	-3.299	.001**
	Obtain Info	101	-2.060	.039*
	Obtain Answer	89	-2.430	.015*

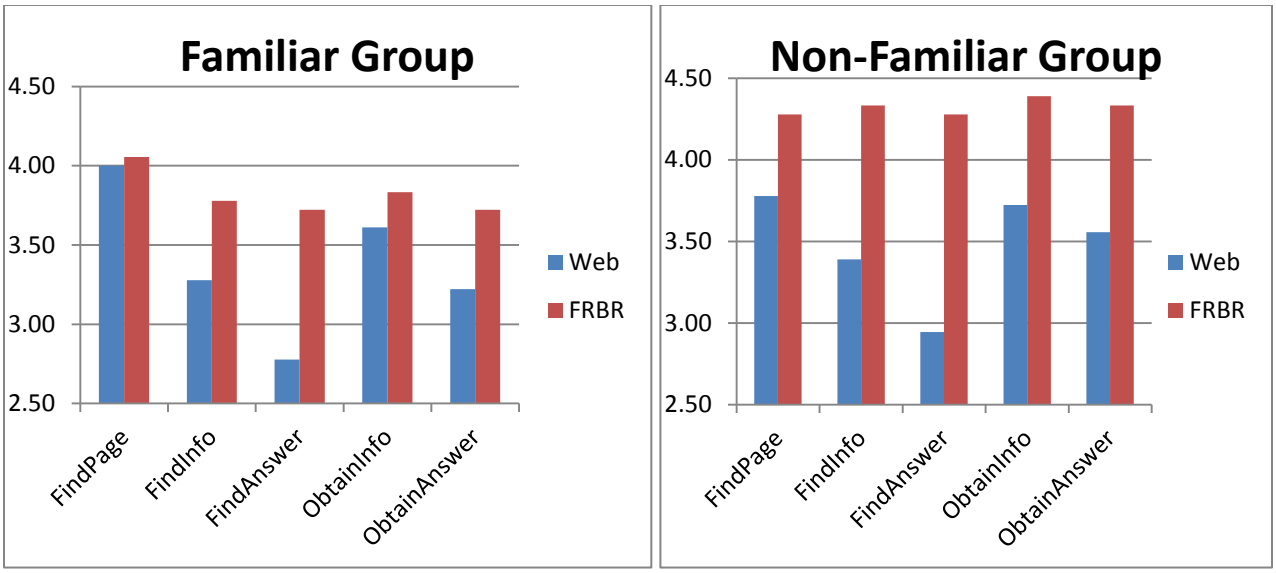


Figure 5.7 Ratings on the Systems by Terminology Farmiliarity Groups

Due to the small sample size (N_{FM} = N_{NFM} = 6), this study did not examine the participants' difference of overall perception of ease-of-use in finding entity and relationship between two systems.

5.4.2.2 Impact of Music Knowledge

Previous studies have found that music knowledge impacts users' search performance, which drives this study to further examine the impact of user knowledge (Duggan & Payne, 2008; Laplante, 2010). In the pre-experiment survey, the participants self-evaluated their knowledge of classical music in a 5-point Likert scale (1= very poor; 5 = very good). As presented in Table 5.10, nine participants (37.5%) rated their music knowledge as poor or very poor, whereas 15 participants (72.5%) answered they had fair or good knowledge of classical music. This study examined whether the participants' knowledge of classical music affected their search performances and perspective of the music search systems. Mann-Whitney tests were run to determine if there were significant differences. Due to the sample size, this study separated into

two large groups (Low = very poor and poor; High = fair and good) to measure the differences, although the values of the responses consist of four levels. No participant ever rated their knowledge of classical music as very good; therefore, only four of the five Likert scale responses were used. Table 5.23 presents the results between the knowledge groups. The Mann-Whitney test found a significant difference in the success rate in IMSLP. The low knowledge group (N = 27, U_L = 32.59, *M* = .941, *Mdn* = 1) had significantly lower success rate in finding correct answers than the high knowledge group (N = 45, U_H = 32.59, *M* = .982, *Mdn* = 1), *p* = .049, *r* = .23. This implies that the higher knowledge group may have had a better sense of how to find correct answers from IMSLP. The rest of the measurements did not reveal any significance, which implies that the participants' classical music knowledge did not influence their search performance and their perception for searching in both systems.

Table 5.23 Measurement between Music Knowledge Groups (continued).

	System	Measurements	Mann-Whitney U	Z	p
Performance	IMSLP	Search	512.5	-1.402	.161
		Page	552	-.656	.512
		Time	542.5	-.756	.450
		Success	502	-1.967	.049*
	FIRM	Search	543.5	-.981	.326
		Page	603	-.119	.905
		Time	516	-1.064	.287
		Success	575.5	-1.075	.282

	System	Measurements	Mann-Whitney U	Z	p
Subjective	IMSLP	Find Page	558.5	-.593	.553
		Find Info	576.5	-.378	.706
		Find Answer	479	-1.545	.122
		Obtain Info	504	-1.280	.200
		Obtain Answer	503	-1.272	.203
	FIRM	Find Page	581	-.334	.738
		Find Info	521	-1.063	.288
		Find Answer	601	-.081	.936
		Obtain Info	500	-1.347	.178
		Obtain Answer	507	-1.253	.210

Conversely, this study compared the differences between the systems within the knowledge group. From the performance logs, the low knowledge group had no significant performance difference between the two systems, whereas the high knowledge group had a significant difference in the number of page views and time spent (Table 5.24). The additional page views of the high knowledge group in FIRM (U_F = 36.26, M = 1.76, Mdn = 2) was significantly less than in IMSLP (U_I = 54.74, M = 3.76, Mdn = 3), p = .001, r = .36. In addition, the Mann-Whitney test found that the high knowledge group spent significantly less time in FIRM (U_F = 38.29, M = 4m25s, Mdn = 4m01s) than IMSLP (U_I = 52.71, M = 5m42s, Mdn = 5m00s), p = .009, r = .28. The results imply that the high knowledge group, in terms of time spent and page views, made less effort to find music information in FIRM, but the success rate between the systems was not significantly different.

Table 5.24 Objective Measurements by Knowledge Group between Systems

Group	Measurements	Mann-Whitney U	Z	p
Low Knowledge Group	Search	343	-.444	.657
	Page	256	-1.917	.055
	Time	279	-1.479	.139
	Success	299.5	-1.737	.082
High Knowledge Group	Search	998	-.161	.872
	Page	596	-3.397	.001**
	Time	688	-2.619	.009**
	Success	945	-1.373	.170

In the subjective responses, the participants in both groups rated FIRM higher on ease-of-use and satisfaction than IMSLP (Table 5.25).

First, the low knowledge group gave higher scores to FIRM (U_F = 32.65, M = 4.11, Mdn = 4) than IMSLP (U_I = 22.35, M = 3.37, Mdn = 4) in finding information, and a Mann-Whitney test shows that FIRM had a significantly higher rating than IMSLP, p = .012, r = .34. In addition, on the ease-of-use of finding answers, FIRM (U_F = 34.07, M = 4.04) received a median rating of 4, whereas IMSLP (U_I = 20.93, M = 2.96) had a median of 3. The participants tended to rate FIRM significantly higher than IMSLP, p = .002, r = .43. The average ranks of IMSLP (M = 3.59, Mdn = 4) and FIRM (M = 4.30, Mdn = 4) in being satisfied with obtaining information were 22.06 and 32.94, respectively, and the result of the test was significant, p = .002, r = .36. The mean rank of users' satisfaction with obtaining answers in FIRM (M = 4.30, Mdn = 5) was 33.87 and that of IMSLP (M = 3.41, Mdn = 3) was 21.13. The participants' perception of FIRM was significantly higher than IMSLP, p = .002, r = .42

This study found that the high knowledge group placed similar ratings in their level of ease-of-use and satisfaction with the low knowledge group, notably on the ease-of-use of finding information and answers, and the satisfaction with obtaining answers. The average rank of finding information in FIRM (N = 45, *M* = 3.91, *Mdn* = 4) was 50.62, whereas that of IMSLP (N = 45, *M* = 3.47, *Mdn* = 4) was 40.38. Repeated measures in a Mann-Whitney test indicated a significant difference, $p = .049$, $r = .21$. They also gave higher ranks to FIRM ($U_F = 55.36$, *M* = 4.13, *Mdn* = 4) than IMSLP ($U_I = 35.64$, *M* = 3.36, *Mdn* = 3) in finding answers. A Mann-Whitney test revealed a significant difference, $p < .000$, $r = .40$. In their satisfaction level of obtaining answers, FIRM ($U_F = 51.11$, *M* = 4.09, *Mdn* = 4) received a significantly higher score than IMSLP ($U_I = 39.89$, *M* = 3.67, *Mdn* = 4), $p = .03$, $r = .23$.

Table 5.25 Subjective Measurements by Knowledge Group between Systems

Group	Measurements	Mann-Whitney U	Z	p
Low Knowledge Group	Find Page	269.5	-1.732	.083
	Find Info	225.5	-2.500	.012*
	Find Answer	187	-3.166	.002**
	Obtain Info	217.5	-2.673	.008**
	Obtain Answer	192.5	-3.117	.002**
High Knowledge Group	Find Page	867.5	-1.235	.217
	Find Info	782	-1.967	.049*
	Find Answer	569	-3.777	.000***
	Obtain Info	906	-.931	.352
	Obtain Answer	760	-2.173	.030*

This study also examined users' overall perceptions of ease-of-use in finding entity and relationship information between the systems within each knowledge group. Wilcoxon signed

tests were adopted to examine the significances between systems (Table 5.26). The median of the high knowledge group's rating on the relationship description in FIRM was 4 (N = 15, $W_+ = 63$), and the median of IMSLP was 3 (N = 15, $W- = 3$). A Wilcoxon test indicated that there was a significant difference between systems, $p = .007$.

While the higher knowledge group had a significant difference between the systems only in relationship information, the low knowledge group's perceptions of all entities and relationship information between systems were significantly different between the systems. In work, FIRM received a median of 4 (N = 9, $W_+ = 28$) and the median for IMSLP was 3 (N = 9, $W- = 0$), and a Wilcoxon signed test revealed a significance, $p = .015$. In expression (performance) information, the sum of ranks in FIRM (*Mdn* = 5) and IMSLP (*Mdn* = 3) were 15 and 0, respectively. A Wilcoxon signed test found a significant difference, $p = .038$. The medians of the participants' perception on manifestation (sound recording) to FIRM ($W_+ = 21$) was 5 and that of IMSLP ($W- = 0$) was 3, and a Wilcoxon signed test indicated a significant difference, $p = .026$. In addition, FIRM (*Mdn* = 5) received the sum of ranks of 21 where IMSLP (*Mdn* = 3) had 0 in the ease-of-use of finding person. The test showed the significance, $p = .026$. Finally, the perception on relationship information was also significant as the median of FIRM ($W_+ = 42.5$) was 4 and that of IMSLP ($W- = 0$) was 3, $p = .039$.

Table 5.26 Perception Analyses between Systems by Knowledge Groups

knowledge		Work	Expression	Manifestation	Person	Relationship
Low	Z	-2.428	-2.070	-2.232	-2.232	-2.060
	Sig	.015*	.038*	.026*	.026*	.039*
High	Z	-1.836	-1.947	-1.294	-1.725	-2.708
	Sig	.066	.052	.196	.084	.007*

From the measurements, it was found that the participants' knowledge of classical music generally did not make a significant difference in their search performance and subjective ratings within each system, although there was a significant difference in the success rate in IMSLP between the groups. Both groups did have significantly different perceptions in ease-of-use and satisfaction between the systems, although the logs of search performances were not very different. The low-knowledge group's overall perception, especially on the ease-of-use of finding entity in FIRM, was significantly higher than with IMSLP. It can be concluded that, regardless of their knowledge level of classical music, FIRM received higher ratings than IMSLP, but the participants' knowledge was not an influential factor when they searched in the same system.

5.4.2.3 Impact of Music Search Skill

Previous studies have found that search skill is an important factor for measuring search performance (Hargittai, 2002) and this study examined how music search skill impacts users' performance and perceptions in FIRM and IMSLP. The participants were asked to rate their music search skill using a 5-point Likert scale (1= very poor; 5 = very good) during the pre-experiment survey. Twelve participants (50%) rated their music search skill as poor or fair, and the remainder (N=12) of participants answered they were good or very good at searching music (Table 5.10). There was no participant who rated their music search skill as very poor; therefore, this study only used 4 values from the Likert scale. This study examined whether the participants' search performance and perception of the music search systems were influenced by their search skills. Again, Mann-Whitney tests were run to determine if there were significant differences. Table 5.27 shows the outcomes of the search skill groups based analysis.

In IMSLP, there was no significant difference in performance and perception between the skill groups. However, the high search skill group ($U_{H=}$ 34.54, *M* = 4m09s, *Mdn* = 3m49s) spent less time than the low search skill group (U_L = 38.46, *M* = 5m27s, *Mdn* = 4m59s) in FIRM. A Mann-Whitney test indicated there was a significant difference in time spent between the groups, p = .18, r = .28.

Table 5.27 Measurements betwen Music Search Skill Groups

	System	Measurements	Mann-Whitney U	Z	Sig
Performance	IMSLP	Search	608.5	-.565	.572
		Page	641.5	-.074	.941
		Time	577.5	-.794	.427
		Success	597.5	-.912	.362
	FIRM	Search	626	-.327	.744
		Page	535.5	-1.3	.194
		Time	438	-2.365	.018*
		Success	629.5	-.602	.547
Subjective	IMSLP	Find Page	572	-.891	.373
		Find Info	576.5	-.844	.399
		Find Answer	603	-.524	.600
		Obtain Info	597.5	-.605	.545
		Obtain Answer	572.5	-.890	.373
	FIRM	Find Page	421	-2.770	.006**
		Find Info	491	-1.868	.062
		Find Answer	370	-3.340	.001**
		Obtain Info	441.5	-2.505	.012*
		Obtain Answer	384	-3.187	.001**

In user perception of FIRM, Mann-Whitney tests found several instances of a significant difference between groups. The low skill group (U_L = 30.19, M = 3.97, Mdn = 4) rated significantly lower on finding page than the high skill group (U_H = 42.81, M = 4.36, Mdn = 5), p = .006, r = .33. Also, low skill group's rating (U_L = 28.78, M = 3.81, Mdn = 4) on finding answer was significantly lower than that of the high skill group (U_H = 44.22, M = 4.42, Mdn = 5), p = .001, r = .39. In addition, the rating of the satisfaction in obtaining information was significantly different between low skill group (U_L = 30.76, M = 3.94, Mdn = 4) and high skill group (U_H = 42.24, M = 4.28, Mdn = 5), which a Mann-Whitney test indicated as significant, p = .012, r = .30. In FIRM, the mean rank of the high skill groups' rating in satisfaction of obtaining answer was 43.83 (M = 4.44, Mdn = 5), whereas the low skill group's mean rank was 29.17 (M = 3.89, Mdn = 4) and repeated measures in a Mann-Whitney test showed a significant difference, p = .001, r = .38. Based on the observation between the two skill groups, it was found that the high skill group's performance in time spent and perception was significantly higher than those of the low skill group in FIRM, where two groups did not have differences in IMSLP. It may be inferred that FIRM is more helpful when better-skilled music seekers are searching classical music information.

I conducted another measurement of Mann-Whitney tests in order to examine the difference between the search systems in each skill group (Table 5.28). In the performance analyses, the Mann-Whitney test revealed that the high skill group viewed significantly less additional pages in FIRM (U_F = 27.58, M = 1.5, Mdn = 1) than in ISMLP (U_I = 45.42, M = 3.47, Mdn = 3), p < .000, r = .43. Also, the high skill search group spent notably shorter time in FIRM (U_F = 29.35, M = 4m09s, Mdn = 3m49s) than in IMSLP (U_I = 43.65, M = 5m42s, Mdn = 5m01s). A Mann-Whitney test found a significant difference between the systems, p = .004, r = .34.

The perceptions toward FIRM were rated higher than toward IMSLP by the high skill search group. A median of finding information in IMSLP was 4 (U_I = 32.4, M = 3.31), and FIRM received a median of 5 (U_F = 40.6, M = 4.17). The test results indicated a significant difference between systems, p = .002, r = .37. Also, the high skill group had a much higher mean rank for FIRM, 47.14, (M = 4.42, Mdn = 5) in finding answers than IMSLP, 25.86 (M = 3.14, Mdn = 3). A Mann-Whitney test revealed a very significant difference, p < .000, r = .53. In terms of obtaining information, the high skill group rated a median of 5 in FIRM (U_F = 42.28, M = 4.28) where IMSLP (U_I = 28.75, M = 3.81) received 4 as a median. Repeated measures in a Mann-Whitney test showed a significant difference, p = .012, r = .30. The mean rank of FIRM from the high skill group's satisfaction of obtaining answer was 44.25 (M = 4.44, Mdn = 5) and that of IMSLP was 28.75 (M = 3.64, Mdn = 4). The test result revealed a significant difference between FIRM and IMSLP, p = .001, r = .39.

Table 5.28 Measurements by Search Skill Group between Systems (continue).

Group	Measurements	Mann-Whitney U	Z	Sig
	Search	620	-.400	.689
Low Search	Page	480.5	-1.653	.056
Skill Group	Time	522	-1.419	.156
	Success	561.5	-1.699	.089
	Search	636	-.178	.858
High Search	Page	327	-3.673	.000***
Skill Group	Time	390.5	-2.900	.004**
	Success	593.5	-1.393	.164

Group	Measurements	Mann-Whitney U	Z	Sig
Low Search Skill Group	Find Page	544	-1.253	.210
	Find Info	558	-1.089	.276
	Find Answer	461	-2.223	.026*
	Obtain Info	556.5	-1.115	.265
	Obtain Answer	479	-2.034	.042*
High Search Skill Group	Find Page	500.5	-1.798	.072
	Find Info	382.5	-3.106	.002**
	Find Answer	265	-4.488	.000***
	Obtain Info	440	-2.507	.012*
	Obtain Answer	369	-3.341	.001**

The low skill group's ratings on ease-of-use of finding answers in FIRM (U_F = 41.69, *M* = 3.78, *Mdn* = 4) and IMSLP (U_I = 31.31, *M* = 3.28, *Mdn* = 3) revealed a significant difference, p = .026, r = .26. In addition, the median scores of the satisfaction of finding answer in FIRM (U_F = 44.25, *M* = 3.89) and IMSLP (U_I = 31.31, *M* = 3.5) were 4 and 3, respectively. A Mann-Whitney test found a significant difference between two systems, p = .042, r = .24.

In addition, I examined users' overall perceptions of ease-of-use in finding entity and relationship information between the systems within each search skill group. Wilcoxon signed tests were adopted to examine the differences between FIRM and IMSLP (Table 5.29).

Table 5.29 Perception Analyses between Systems by Search Skill Groups

Music Search Skill		Work	Expression	Manifestation	Person	Relationship
Low	Z	-1.265	-1.732	-1.823	-2.271	-2.598
	Sig	.206	.083	.068	.023*	.009**
High	Z	-2.714	-2.420	-1.848	-1.903	-2.257
	Sig	.007**	.016*	.065	.057	.024*

The low skill group's sum of ranks of the CMFRBR-based relationship description in FIRM is 36 (N = 12, *Mdn* = 4) while that of IMSLP is 0 (N = 12, *Mdn* = 3). A Wilcoxon signed test indicated that the low group has a significantly different perception in rating the relationship description between FIRM and IMSLP, $p = .009$. In addition, person search in FIRM ($W+ = 36$, *Mdn* = 4) received higher ratings than that of IMSLP ($W- = 0$, *Mdn* = 4). A Wilcoxon signed test indicated a significance, $p = .023$.

In the case of the high skill group, Wilcoxon tests found significances in their perception of ease-of-use in finding work, expression, and relationship. A Wilcoxon signed test indicated that high groups ratings on work in FIRM (N = 12, $W_+ = 45$, *Mdn* = 5) and IMSLP (N = 12, $W_+ = 0$, *Mdn* = 3) were significantly different, p = .007. In expression, FIRM received a median of 5 ($W_+ = 34.5$) and the median for IMSLP was 3 ($W- = 1.5$), and a Wilcoxon signed test revealed a significance, $p = .015$. The sum of ranks of relationship information in FIRM (*Mdn* = 5) and that of IMSLP (*Mdn* = 3) were 34 and 1, respectively. A Wilcoxon signed test found a significant difference, $p = .024$.

Both groups' perceptions on FIRM were somewhat significantly higher than IMSLP. Remarkably, the higher search skill group's performance and perception in FIRM are significantly higher than IMSLP. It seems that the high skill groups' likes and dislikes between the systems were very clear. The high group's perception in FIRM is greatly higher than the low skill group, but their ratings are close to each other in IMSLP. It can be inferred that high skill group's strong preference for FIRM influenced the significant differences between the groups and systems.

5.4.2.4 Impact of Participants' Educational Level

As listed in Table 5.10, four occupation groups (librarians, graduate students, undergraduate students, and others) participated in the experiment. This study examined whether the participant groups, especially educational level, affected their search performance and perspective of the music search systems. The major participants groups were students (19 out of 24) from the University of Pittsburgh and Carnegie Mellon University. Due to the limited time and location of the experiment, this study did not recruit similar number of participants in each occupation group. Eleven graduate students and eight undergraduate students participated in the experiment. Two librarians and three other participants were excluded in this analysis since the sample size is too small to compare with other groups. Because the survey or interview did not ask participants' earned degrees, this study does not apply two librarians and three others to the undergraduate or graduate student group. Therefore, this section analyzes the two major groups' (undergrad students and graduate students) search performance and perception between the systems. Mann-Whitney tests were run to determine if there were significant differences.

This study did not find any significant differences between the undergraduate student group and graduate student groups in their search performances and perceptions within the systems. As seen on the Table 5.30, graduate student group placed similar ratings with undergraduate student group on the perception ratings of the ease-of-finding the entity information and satisfaction with their search performances in obtaining classical music information and answers.

Table 5.30 Measurements betwen Education Groups

	System	Measurements	Mann-Whitney U	Z	Sig
Performance	IMSLP	Search	317	-1.553	.120
		Page	297.5	-1.617	.106
		Time	321.5	-1.204	.229
		Success	360	-.882	.378
	FIRM	Search	336	-1.286	.198
		Page	316	-1.328	.184
		Time	330	-1.067	.286
		Success	389.5	-.272	.786
Subjective	IMSLP	Find Page	297	-1.684	.092
		Find Info	384	-.196	.845
		Find Answer	393	-.050	.960
		Obtain Info	303.5	-1.604	.109
		Obtain Answer	291	-1.778	.075
	FIRM	Find Page	289	-1.869	.062
		Find Info	301.5	-1.617	.106
		Find Answer	285.5	-1.909	.056
		Obtain Info	289	-1.869	.062
		Obtain Answer	300	-1.680	.093

Moreover, the search performance analysis did not reveal any significant differences. Thus, it is possible to conclude the participants' educational level did not affect their search performance for searching in both systems.

On the other hand, I examined whether each group has significant differences in the search performances and perception between FIRM and IMSLP. Table 5.31 presents the

outcomes of the Mann-Whitney tests of both groups' performance and perceptions between FIRM and ISLP.

Table 5.31 Performance Analyses between Systems by Student Groups

Group	Measurements	Mann-Whitney U	Z	Sig
Undergrad Students	Search	255.000	-.786	.432
	Page	239.500	-1.021	.307
	Time	261.500	-.546	.585
	Success	265.500	-.968	.333
Grad Students	Search	514.000	-.548	.584
	Page	233.000	-4.044	.000***
	Time	329.500	-2.757	.006**
	Success	461.000	-1.799	.072

Group	Measurements	Mann-Whitney U	Z	Sig
Undergrad Students	Find Page	242.500	-.991	.321
	Find Info	253.500	-.755	.450
	Find Answer	201.000	-1.870	.062
	Obtain Info	242.000	-1.008	.314
	Obtain Answer	190.500	-2.102	.036*
Grad Students	Find Page	486.000	-.818	.413
	Find Info	373.500	-2.297	.022*
	Find Answer	266.000	-3.725	.000***
	Obtain Info	435.500	-1.539	.124
	Obtain Answer	370.000	-2.396	.017*

There was no significant difference between FIRM and IMSLP among undergraduate students whereas graduate students' performances were significantly different in extra page view

and time spent. The graduate student group's number of pages viewed was significantly lower in FIRM (N = 33, U_F = 42.94, *Mdn* = 1) than IMSLP (N = 33, U_F = 24.06, *Mdn* = 4), $p < .000$, r = .5. In addition, the graduate students' task completion time in FIRM (N = 33, U_F = 40.02, *Mdn* = 3m50s) is significantly lower than IMSLP (N = 33, U_I = 26.98, *Mdn* = 6m08s). A Mann-Whitney test indicated that the graduate students spent significantly different time between the systems, p = .006, r = .34.

In the perception analyses, the undergraduate student group's ratings to satisfaction with obtaining answers in FIRM (U_F = 28.56, *Mdn* = 4) was significantly higher than that for IMSLP (U_F = 20.44, *Mdn* = 3). A Mann-Whitney test revealed that there is a significant differences between the systems, p = .036, r = .3.

Meanwhile, the graduate student group's ratings in FIRM were significantly higher than IMSLP's in terms of ease-of-use of finding information (p = .022, r = .28), answers ($p < .000$, r = .46) and the satisfaction of obtaining answers (p = .017, r = .29).

This study also examined users' overall perceptions of ease-of-use in finding entity and relationship information between the systems within the student group. I utilized the Wilcoxon signed tests to examine the significances between systems (Table 5.32). The median of the graduate student group's rating on ease-of-use in finding work in FIRM was 4 (N = 11, W_+ = 21), and the median of IMSLP was 4 (N = 11, W- = 0). A Wilcoxon test indicated that there was a significant difference between systems, p = .026. There were marginal significant differences between the systems in the ease-of-finding expression and relationship information between the systems within the graduate student group.

Table 5.32 Perception Analyses between Systems by Student Groups

Student Group		Work	Expression	Manifestation	Person	Relationship
Undergraduate Students	Z	-.828	-1.414	-1.134	-1.841	-2.271
	p	.408	.157	.257	.066	.023*
Graduate Students	Z	-2.232	-1.947	-1.715	-1.518	-1.903
	p	.026*	.052	.086	.129	.057

On the other hand, undergraduate student group did not have significantly different ratings to the ease-of-use in finding classical music entity information. However, the undergraduate student group's ratings to the ease-of-finding relationship information in FIRM (N = 8, $W_+ = 21$) was higher than in IMSLP (N = 8, $W_+ = 0$). A Wilcoxon signed tests revealed the significant differences between systems, $p = .023$.

To sum up, it was found that the participants' level of education did not make a significant difference in their search performance and subjective ratings within each system. In the search performances, undergraduate students did not have significant difference between FIRM and IMSLP, whereas graduate students performed significantly different in the time spent and extra page views. Meanwhile, graduate students' ratings for FIRM were significantly higher in terms of the ease-of-finding information and answers, and satisfaction with obtaining answers than for IMSLP.

5.4.3 Summary

This section concludes the results of the comparative study between FIRM and IMSLP. First, in overall measurements, participants' performances of search tasks in FIRM was significantly better than IMSLP, especially in time spent and success rate of finding correct answers. Users

also perceived it to be easier to find relevant pages, information, and answers in FIRM, and they were more satisfied with their search performance in finding information and answers in the FIRM system than with IMSLP. Moreover, participants preferred to use FIRM when they sought music entities and relationship description of classical music information rather than IMSLP.

Second, in terms of the first-learned language of classical music, this study did not find significance in either performances or perceptions between the two groups in FIRM, but found that the two groups had significant differences in the time spent and ease-of-use of finding answers in IMSLP. This implies that FIRM is a reliable method to find information for both language groups. The perception ratings on both systems by each group conclude that the Non-English group's strong preference for FIRM influenced the differences between the systems. The English group, however, rated a similar score on both systems, so this study did not find differences between FIRM and IMSLP for them. In overall perception of relationship description, both groups gave significantly higher scores to FIRM than IMSLP, which indicated that the participants perceived better relationship description in FIRM than IMSLP, regardless of their initial music training languages.

Third, the participants' knowledge of classical music did not influence their search performance and subjective ratings of ease-of-use and satisfaction within each system, though it did affect the success rate in IMSLP between the groups. Both groups did, however, have significantly different perceptions of ease-of-use and satisfaction between the systems, although the logs of search performances were not very different. It can be concluded that FIRM received higher ratings than IMSLP regardless of participants' knowledge of classical music, but their knowledge was not an influence when they searched using the same search methods.

Fourth, participants' music search skills somewhat influenced their search performance and perceptions. Notably, the high search skill group's performance and perception in FIRM was significantly higher than in IMSLP. In addition, the high search skill group's perception in FIRM was significantly higher than the low skill group's but the ratings in IMSLP were close to each other. It is possible to deduce that the high search skill group's drastic inclination toward the FIRM-based search influenced the great differences found between groups and systems.

Finally, the participants' educational level did not impact their search and perception with in the systems. Undergraduate student group did not have significant different performances or perception ratings between the systems except their satisfaction with obtaining answers. However, graduate students' performances and perception ratings were significantly different between the systems.

Consequently, the first learned language of classical music, music knowledge, and the level of education did not influence finding music information in the same search system, but those groups' perceptions on each system had some significant differences. However, search skill somewhat effected the ratings for FIRM-based search, especially the high skill group, which perceived significantly higher ease-of-use and satisfaction in FIRM than in IMSLP.

Phase 3 made two contributions. First, it examined user experiences and system performance of music information retrieval using FIRM compared to IMSLP in multiple dimensions. Next, the entity and relationship model of CMFRBR in FIRM was evaluated on whether they were helpful to users in finding music information.

6. DISCUSSION AND CONCLUSIONS

In this chapter, the research questions are answered, and the conclusions of this study are presented. In addition I identify some important implications of the entire study. The previous three chapters (Chapters 3 - 5) presented the analytic results in response to each of the two main research questions and their sub-questions. Section 6.1 aims to conclude the answers for the research questions and provides a further comprehensive discussion of the results from the previous three chapters. Then in Section 6.2, the contributions and implications that can be drawn from the findings of this study are discussed. Limitations of this study are discussed in Section 6.3. Finally, Section 6.4 presents my conclusions and possible future work.

6.1 Discussion of Research Results

The previous three chapters (Chapter 3-5) presented the analytic results in response to each of the two main research questions and their sub-questions. In this section, the results of this dissertation research are discussed to answer the research questions.

6.1.1 Representation of CMFRBR in FIRM

This section focuses on RQ 1: “How can classical music information be represented in FRBR-based bibliographic systems?” and its two sub-questions.

6.1.1.1 Appropriate Attributes and Relationships for Classical Music in FRBR

The primary attributes of each entity and relationship description of CMFRBR were identified by representing the FRBR's entity relationship model in order to answer RQ 1.1*:* "What are the important features (attributes and relationship between entities) of FRBR to represent classical music?"

First, music seekers considered that the title, medium of performance, and the form of work were the primary attributes in work entity. For expression, it was found that the most important attributes include title of expression, medium of performance, language of performance (if applicable), and summarization of content.

Second, for corporate body, participants gave top ratings for name, biography, and place of corporate body. In person entity, the top rated attributes were name, biography and date of person (date of birth/death) which are similar to the findings of previous studies (Kim & Belkin, 2002; J. H. Lee & Downie, 2004). This indicates that those attributes are not only important search methods in FRBR-based music information search, but are also the most popular methods to represent music information. This calls for the involvement of additional attributes such as biography, which the CMFRBR model suggested, in addition the FRBR model.

Lastly, in terms of relationships, parent, sibling, and similar work relationships in work were newly adopted to CMFRBR. For expression, parent, sibling, and related expression were included. The participants were mostly interested in the parent/children relationship of work (e.g. "Spring" as one of "the Four Seasons") and the sibling relationship of expression (e.g. different performances of the same musical work). This implies that people would like to know the collection information, of which a work is a part, when they search for musical work

information. They were also interested in finding different performance information (by same or different performers) of a certain musical work.

To sum up, the most important attributes for music seekers searching for classical music in FRBR are: title, medium of performance, and form in work entity; title of expression, medium of performance, language of performance, and summarization of content in expression entity; name, biography, and place of corporate body; and name, biography and date of person in person entity. CMFRBR added the following relationships to the FRBR model: parent, sibling, and similar work in work; and parent, sibling, and related expression in expression entity. The addition of the new attributes and relationships in FRBR model would contribute in the following two aspects: 1) it helps better meet music seekers' information needs; 2) it represents FRBR's music entities in a better comprehensive way so that users can be aware of important related information.

6.1.1.2 FIRM as a Useful and Positive Aid to Music Search

In order to answer RQ 1.2: "Do users experience FIRM's attributes and relationships among entities as a useful and positive aid in satisfying their information needs? Moreover, does FIRM give users a better user experience when compared to IMSLP?", the usability characteristics were utilized to measure usefulness and positive point of view of music search methods. When explicitly asking users whether FIRM's attributes and relationships among entities was a useful and positive aid in satisfying their information needs and provided a better user experience, users' responses revealed their positive views in searching for classical music information in FIRM.

Effectiveness

In usability characteristics, the metrics of effectiveness of this study were 1) percentage of completion, 2) percentage of correct answers, and 3) self-assessment of the outcomes of interactions. This study did not analyze the percentage of task completion as only one task by one individual was not completed within the given time.

With respect to the rate of correct answers, the participants had significantly higher success rate in finding correct answers in FIRM. Although the difference in the users' average success rate between two systems was only .022, this was statistically significant ($p = .027$). In self-assessment of the outcome of interactions, users gave higher ratings to FIRM than IMSLP on the satisfaction of their search performance in finding information, and answers.

In terms of the correct answer rate and self-assessments, FIRM effectively provided the bibliographic information of classical music for its users, as users' responses and performance logs showed better outcomes than with IMSLP, which answers a portion of RQ 1.2.

Efficiency

The measurements of efficiency used in this study included, 1) the number of queries the user issued in the task, 2) the time spent on each task and 3) the number of additional pages viewed in the task. All the efficiency measurements are computed from the participants' search performance in the user experiment. No significant difference was found between systems in the number of queries issued because most participants issued only one or two queries to find answers in each task. In the time spent, the participants spent significantly less time using FIRM to complete their task than IMSLP, even though they had to view more required pages in FIRM (a minimum of four pages) than IMSLP (a minimum of two pages). In addition, the participants viewed significantly fewer extra pages in FIRM to complete tasks than IMSLP.

This demonstrates that FIRM is an efficient system in that users spent less time and less effort to find appropriate classical music information as asked by RQ 1.2. It implies that a CMFRBR-based classical music representation can help music seekers, so that FIRM or similar systems should be implemented in Web-based search systems to enhance the findability of classical music information by users.

Satisfaction

User satisfaction was measured from the following three dimensions: 1) ease of completing a task, 2) overall satisfaction in each system and 3) participants' preference for a search platform.

First, I discovered that users had significantly different perceptions in finding entity information and relationship between the two systems, and FIRM received higher ratings in the ease-of-use of finding entity information than IMSLP. User ratings to relationship descriptions of FIRM were also more highly positive than IMSLP.

Second, the participants were more likely to select FIRM rather than IMSLP when they sought classical music information in entity search. Their preference for using FIRM in finding work, manifestation, and person was higher than 80%. Remarkably, all of the participants preferred to use FIRM to search or browse relationship descriptions among entities.

Lastly, users highly agreed that their satisfaction with the information organization in FIRM was better than IMSLP's, and they strongly believed that FIRM's representation of relationship would help its users to understand the relationships between entities.

In summary of the usability of FIRM, based on the users' responses, it was found that FIRM was a positive aid to the classical music search method, as FIRM received more selections for the classical music search method than IMSLP. These results provide positive answers RQ 1.2 supporting that FIRM provides a better organized description of classical music information

and is a more useful method to help music seekers find appropriate bibliographic information of classical music that they might need.

6.1.2 CMFRBR-based FIRM as a Classical Music Search System

This section discusses RQ 2: "Can a FRBR-based classical music representation provide better help for users to find music?" and its four sub-questions.

The answers to the first two sub-questions (RQ 2.1 and RQ 2.2) were discovered from real users' questions about classical music bibliographic information. The questions were collected from Yahoo! Answers, a social Q&A website. The study found that CMFRBR's model can provide general users' needs for classical music information by providing attributes and relationship information. RQ 2.3 and RQ 2.4 will be addressed in the later section. This study does not limit the usage of CMFRBR and its representation system, FIRM, to Web-based systems. As many previous FRBR related studies within the library systems, this study actually extended the search environment to the Web. It means that the study not only examined the usefulness of FRBR in what could be a standalone library setting, but also in a meaningful information delivery method on the Web.

6.1.2.1 Classical Music Information from Social Q&A Sites

RQ 2.1: What is the general public's information need (e.g., entities, attributes, and relationship) of classical music on the Web?

In the Yahoo! Answers dataset, I found that there are several questions sought to find sources of sound recordings or video clips that they could obtain. This reveals an important information need in Yahoo! Answer – obtaining and listening to music. In addition to the URL

source, I also found that the users were also interesting in finding the physical location, particularly for the manifestation.

Besides, users in Yahoo! Answers were also interested in finding different performances of a musical work, which CMFRBR defined as a sibling expression of the same work. In addition, they sought different music performances of the same musician or music groups; CMFRBR describes this relationship as performance of person/corporate body. This implies that music seekers also try to find music information related to certain persons or works.

To sum up, I discovered that the access address (i.e. URL or physical location) of manifestation is one of the most important entities that a search system can provide to its users to meet their information needs. In addition, the general public often seeks classical music information based on the relationships. Finally, the title of work and name of person/corporate body were also frequently asked in Yahoo! Answers.

RQ 2.2: What change in the FRBR-based classical music representation should be made to help the general public on the Web to find classical music information?

From the observation of the user's question set in Yahoo! Answers, I discovered that people usually have a limited range of question types for asking, which include the title of work, the background of work, music era, medium of performance in expression, date of expression, access address of manifestation, form of carrier, person's name and biography, etc. Based on users' questions in Yahoo! Answers, it implies that CMFRBR can have a significant role in providing proper bibliographic information of classical music. CMFRBR includes various attributes and relationship descriptions which can answer many of the most frequently asked bibliographic questions from the classical music category in Yahoo! Answers. CMFRBR provides organized information with attributes of each entity and can draw relationship between

entities. In addition, based on the relationship description, users can browse music information based on their information needs from work or person entity to expression and manifestation information, which allows users to use the knowledge they have to find the information they seek in CMFRBR.

CMFRBR, therefore, adds relationship information and additional bibliographic attributes to the FRBR model.

6.1.2.2 Objective and Subjective Outcomes in FIRM

RQ 2.3: Can the attributes and the relationships of the CMFRBR representation in FIRM provide the user with a superior objective and subjective experience when searching for classical music information compared to IMSLP?

The participants' perceptions toward the ease-of-use in finding classical music pages, information, and answers were significantly higher in FIRM than in IMSLP. Their satisfactions with their search performance of obtaining information and answers in FIRM were also significantly higher than in IMSLP. Especially, ease of finding answers and satisfaction of obtaining answers were statistically significant at the $p < 0.001$ level. It further implies that the participants have a superior experience when using FIRM to find classical music information.

It was also discovered that users preferred FIRM when they sought music information by entities. More than 80% of the participants selected FIRM as their preferred search method when they sought for work, person, and manifestation. Remarkably, all the participants selected FIRM over IMSLP when asked what their preferred system was to find relationship information. This implies that FIRM presents perceptually easier and in a more satisfactory way to acquire music information than IMSLP, especially when finding a specific piece of music information based on entity's attributes and relationship information.

This study answered the research question whether FIRM can provide better subjective experience. Indeed, FIRM enhanced users' perception on the ease-of-use in finding classical music information and their search satisfaction.

Objective outcomes were measured by the following measurements, which included 1) percentage of task completion, 2) number of search query, 3) number of additional page views from the minimum requirement, 4) the time spent, and 5) correct answer rate.

The first measurement, percentage of task completion, was excluded since 99.3% of tasks were completed within given time. I did not find significant differences of the number of search queries between the systems because most participants issued two or fewer queries in each task.

The rest of the observations of objective measurements revealed significantly different outcomes between the two systems. The participants viewed significantly more additional pages and spent longer time in IMSLP to reach to the answers than FIRM. Although the participants spent more time and viewed more extra pages than required in IMSLP, their success rates of finding correct answers were significantly lower than FIRM. This result implies that CMFRBR's entity relationship model as implemented in FIRM provides a better search and browsing interface to find classical music information and is easier to use to find relevant information and answers about classical music. In addition, it is important to note that the study results do not imply that CMFRBR model and its retrieval system, FIRM, are better than other classical music search system on the Web. This study compared the differences between implemented FRBR-based classical music search system, FIRM, and FRBR-like music search system (IMSLP).

Thus, this study supports RQ 2.3 that the FIRM provided a superior performance experiences for its users to search and browse classical music information.

6.1.2.3 Users' Internal Factors of Music Information Retrieval

RQ 2.4: Which internal factors (independent variables: language, music knowledge, education level, and search skills) influence the users' search performance and subjective experience?

This section discusses how users' internal factors (language, music knowledge and search skill) influenced their music search in the two systems, and answers RQ 2.4.

First Classical Music Learned Languages

I analyzed the experiment results based on the participants' first learned language (English and other languages) to find whether their initial classical music training language influenced search performance and perception. It was discovered that the participants of different language groups did not have significant differences in their search performance and perceptions in FIRM, which indicated that FIRM provided a stable search interface for both language groups. On the other hand, the two groups had significant differences in the time spent and in ease-of-use in finding answers in IMSLP. Because the Non-English group spent significantly more time to find answers in IMSLP, it influenced the group to give significantly lower ratings to ease-of-use of finding answers. This implies that music seekers, whose initial trained language of classical music is not English, need more time and effort to find music information in plain text-based music description than the English group, whereas a more organized interface of music information representation allows an easier retrieval process for the Non-English group users.

This study also discovered several significant differences in the search performances and users' perceptions between FIRM and IMSLP within the language groups. For the English group, they viewed significantly more extra pages in IMSLP. Their ratings of ease-of-use in finding answers and satisfaction with obtaining answers in FIRM were significantly higher than

those for IMSLP. Meanwhile, the Non-English group's search performances in viewing extra pages and the time spent in FIRM were significantly lower than those in IMSLP. Moreover, their ratings of the ease-of-use in finding information and answers, and satisfaction with obtaining information and answers in FIRM were significantly higher than IMSLP. Within the Non-English group, I discovered the participants, who are not familiar with the classical music terms, assigned strong preference for using FIRM as their classical music search method, and this result caused very significant differences between the two systems.

These results imply that the participants' first learned language of classical music did not noticeably affect their searching when they searched for classical music information within the same search interface, particularly in FIRM. Furthermore, I discovered that regardless of the first learned language of classical music, the participants perceived FIRM as easier and were more satisfied with the system than with IMSLP. Both groups also exerted significantly less effort to find music information with FIRM than with IMSLP. Finally, FIRM can help the Non-English group more easily find classical music information, especially for people who are not familiar with the terminology of classical music.

Classical Music Knowledge

Between the two classical music knowledge groups, I did not find significant differences in either objective or subjective measures within the same search system, except for the success rate in IMSLP (p = .049) in which the lower music knowledge group had a lower success rate than the high music knowledge group. This does not mean that the knowledge of classical music never influenced their music search performance and perception, because this study was conducted based on known-item search from pre-defined task sets. Its results could be different if users perform an exploratory search on unknown classical music resources.

Between the two search platforms, this study revealed significant differences from the high music knowledge group's performance. They viewed significantly fewer extra pages and spent less time in FIRM than IMSLP, whereas the low music knowledge group did not have any significant differences between the two systems. This shows that FIRM is a better to system to save time and effort in finding classical music if people's knowledge of classical music is relatively good. Although this study did not find performance differences within the low music knowledge group, it revealed that there are perceptually significant differences between the two systems. The low music knowledge group's ratings of ease-of-use in finding music information and answers, and satisfaction with obtaining information and answers in FIRM were significantly higher than in IMSLP. Similarly, the high music knowledge group's ratings in FIRM to ease-of-use in finding information and answers, and satisfaction with obtaining answers were significantly higher than IMSLP.

Similar to the results for the language groups, this implies that the participants' knowledge levels of classical music did not influence their search performance and perception when they searched for classical music information within the same search system, especially in FIRM. It did, however, find in both groups that the participants' perceptions of ease-of-use and satisfaction with their search performance between FIRM and IMSLP were significantly different. FIRM provided an easier and more satisfied search experience for both groups.

Music Search Skill

This study discovered that in FIRM, the search performance of the high search skill group in the time spent was significantly less than that of the low search skill group, whereas there is no significant difference between the groups in IMSLP. In addition, it revealed that the high search skill group's perception of ease-of-use and satisfaction with their performances in FIRM are

significantly higher than the low group's ratings, but there was not any significant difference between the two skill groups in IMSLP. This is because the participants in the high search skill group gave very high ratings to FIRM, which dominated their ratings to IMSLP and the low search skill group's ratings for both FIRM and IMSLP. From this result, it can be implied that the high search skill group has a stronger positive perceptions of FIRM than that of the low search skill group.

On the other hand, the high search skill group's performances in FIRM with respect to the viewing of additional pages and the time spent were significantly better than in IMSLP, whereas the low search skill group did not have any significant differences between the two systems. In user perception, similar to the performance logs, the high search skill group gave significantly higher ratings to FIRM than IMSLP, while the low search skill group gave similar ratings to both systems. Therefore, FIRM is a better search system for the high search skill group to search for classical music than IMSLP, but FIRM did not differentially help the low search skill group find classical music information compared to IMSLP. This implies that FIRM is a somewhat suitable system for music seekers whose music search skill is higher than the average.

Educational Level

This study analyzed the results to find whether participants' educational levels influenced their search performance and subjective perception. It is found that there is no significant difference in either objective (performances) or subjective (perception) measures within the same search system.

Between two classical music information platforms, this study revealed significant differences from the graduate student group's performance. They viewed significantly less extra pages and spent less time in FIRM than those in IMSLP, whereas the undergraduate student

group did not have any significant differences between the two systems. This tells that FIRM is a better to system to save time and effort in finding classical music for graduate level students regardless their fields. Additionally, graduate student group's subjective ratings to FIRM were significantly higher than IMSLP, especially in ease-of-use of finding information and answers and satisfaction with obtaining answer is their search performances. Undergraduate student groups' rating on the satisfaction with obtaining answer was the only significant difference between FIRM and IMSLP. This implies that FIRM is a somewhat useful system for graduate student level.

To sum up, in order to answer the research question, I examined which internal factors influenced the users' search performance and subjective experience. This study discovered that all internal factors (first learned language of classical music, music knowledge, educational level and search skill) generally did not effect on their search performance when they search within the same system in both IMSLP and FIRM. Similarly, their perception toward ease-of-use and satisfaction with their search performance within the system, in general, were not significantly different between the language groups and the knowledge groups, but there were significantly different perceptions between the search skill groups. This implies that search skill is a factor associated with significant differences in the users' perceptions of ease-of-use in finding music information and their satisfaction.

The Non-English group, the high knowledge groups, graduate student group, and the high search skill group's performances in FIRM were somewhat significantly better than in IMSLP, as these groups viewed fewer extra pages and spent less time in FIRM. This implies that FIRM is a helpful system to find classical music information for these groups. Moreover, in general, it is found that all the groups, except the low search skill group, perceived that FIRM is a somewhat

better system in terms of ease-of-use and satisfaction. Therefore, search skill is the only factor to differentiate user performance within the system, but most groups generally performed and perceived better in FIRM than in IMSLP. This implies that regardless of internal factors FIRM generally enhanced users' perceptions and performances toward classical music search.

6.2 Implications and Contributions

6.2.1 For FRBR Research Communities

The findings of this study indicate that the FRBR model functions are not only a bibliographic record relationship model in library settings but can equally function in any search system. The main emphasis of previous FRBR research focused on modeling FRBR in library catalog, but there were fewer studies discussing the application of FRBR in people's daily web search on unstructured web pages and the usability evaluations for constructed FRBR schema. The lack of focus on user task and usability test is important since it results in failure to investigate users' inquiries of information display and organization. Therefore mixed usability and FRBR user task studies will be potential future directions to improve FRBR research. This study includes usability testing of the FRBR model and is the first example of such testing in the classical music field.

Next, another important message from this study is that the studies of music search in FRBR should not only be concerned with the efficiency and effectiveness of search, in terms of usability, but also be concerned with users' perception of their search experiences, particularly with their satisfactions. This study included instruments to measure users' perception of search

experience and satisfaction, which can also easily to be applied in any other FRBR or even non-FRBR settings.

Finally, FRBR's entity relationship model can be used to create a search system which can be effectively used by the general community (i.e. non-expert) to obtain information they seek. This dissertation also demonstrates the feasibility of building a FRBR–based system that provides general users with an accessible classical music information system. The users of different language groups, different levels of search skill and classical music knowledge were all able to effectively use the implemented entity relationship model to find answers to questions that real Web users ask for, taken from a social Q&A site. Users specifically liked relationship information presented in the FRBR model. This indicates that relationships are significant cognitive concepts for general users and may provide sufficient contextual information for users to navigate in/out any music entities. Further study on the most effective of relationship information is necessary as is what relationships are the most important in different domains.

6.2.2 For Music Information Retrieval Research Community

The CMFRBR model adds more attributes and entities in the traditional music representation schema. Known that normal users usually care about certain music entities and relationships, MIR research can use CMFRBR model in two ways: 1) reconsiders the representation of music information in the backend of music IR systems; 2) provide different types of facets of attributes of entities and relationships in a faceted music search system to make users more controllable in their search process.

The findings of this study suggest that music information retrieval researchers may study various groups' internal factors related to their music search which could influence their search

process and results. Although I did not include the professional level of classical music knowledge group in this study, the outcomes of the search results and their perception were quite different among the groups. It will be an interesting research when comparing the usability of professional group's internal factors or between professional and non-professional groups as the groups may have different strategies and search behavior to find classical music information. It is also important that FRBR researchers explore other measurements that can examine the benefits of information organization.

6.2.3 For the Design of Classical Music Search systems

The findings of this study have several implications for the design of classical music information retrieval systems in order to better support its general users.

First, the study results suggest that when the general public seeks to find certain information they need, they frequently browse through related music entities such as works and persons for additional music information using an unspecified relationship model. This implies that the FRBR model can be implemented in music search systems and that the designers of classical music information search systems should initially consider drawing upon all possible relationships among classical music information elements. The FRBR-based relationship description is complex but it is important to define the most important relationships (e.g., parents, sibling, etc.) which are potentially useful to general users of their specific classical music search system. Users of FIRM in this study clearly preferred using relationship information when answering some of the study tasks and commented on lack of such information in IMSLP.

Second, the findings in this study can provide useful guidance for the interface design of a classical music information search system. Each page should describe the attributes and

relationships of a single entity and the pages should be linked by the relationships as FIRM presented based on the CMFRBR model. In an entity page, it would be beneficial to separate attributes and relationship information in multiple panels (or frames) in the display to enable users search, browse and explore the relationships among entities. Users in this study preferred an interface design that had more focused information contents in each page rather than pages with a lot of information. Even to the extent of having to view a larger number of pages being preferred when it is easier to find desired information on each page. Explicitly in FIRM the minimum number of pages required to achieve some tasks was four while the minimum number in IMSLP was two, however, users still preferred to use FIRM even with the additional required pages. Although in general fewer page clicks is considered to be better than more page clicks, this experiment showed that is not always true.

Third, in implementing a system with FRBR model, it is important to be aware of the needs for learning process with FIRM-based search. In this user experiment, users initially had some difficulties in using FIRM in order to find answers. The major reason for the difficulties was trying to understand CMFRBR's terminologies and classical music terms. This implies that the search system should use easier terms on the end user side rather than technical FRBR terminology. For example, users initially had difficulties with understanding terms such as "manifestation", "medium of performance", etc. In addition, the implementation of FIRM for this study only provided keyword-based search without any advanced search options. It would be beneficial to add advanced search options which could include entity based search or filtering option by entities. In addition, to prevent the length of the page from becoming too long, it would be beneficial if users could interact with the display employing expansion of filtering affordances

such as +/- signs in relationship description. Other researchers have similar findings in evaluating FRBR-based music catalog systems (Salaba & Zhang, 2012).

Fourth, from the observations and surveys, FRBR not only can provide bibliographic information of a certain musical object but also can function as a classical music information provider for students who learn classical music. For example, it could be implemented as an educational system for classical music in K-12 schools. Such FRBR-based music search system can assist music teachers in not only searching for music products but also to provide background or history of music to their students.

Lastly, as most of the previous FRBR studies only focused on FRBR's conceptual model in libraries' catalog setting, it is now necessary to investigate the feasibility of the FRBR conceptual model in Web-based search systems. Some studies have done this with a general FRBR model, but only a small number of these studies were done in the music domain especially in the classical music field. CMFRBR's representation can serve as an alternative database schema for obtaining classical music information on the Web so that users can do one-stop searching from classical music work information to related musical representations, such as sound recordings, music scores, and books. In order to enhance the usage of libraries, it is also important that the destination and access information for obtaining pieces of classical music manifestation should be included, such as libraries' URLs or the physical location of a library.

6.3 Limitations of the Study

There are several limitations of this study. First, although significant parts of the Functional Requirements for Bibliographic Records model is considered and examined for classical music

resources representation and retrieval, the model was not fully tested. This study focuses only on Groups 1 and 2 of the Functional Requirements for Bibliographic Records among the three groups (Groups 1, 2, and 3). However, some entities in Group 3 have been merged as attributes into the entities of Groups 1 and 2. Moreover, the "Item" entity in Group 1 is excluded in this study because this study relies more heavily on Web-based music information retrieval, and the manifestation level can provide enough information of embodied expression in media.

In the second study, I sampled 500 classical music related questions from Yahoo! Answers to categorize the types of questions general Web users ask related to classical music. However, there may be different types of information needs than those samples or questions may be different in other platforms. In addition, the study did not include the analyses of FRBR's user task which is to find, identify, select, and obtain the entity information from the Yahoo! Answers question set. This process will be done in the near future.

The majority of participants in the final experiment were college students representing members of the general public whose educational background is higher than undergraduate. However, the participants' music search skill and knowledge are not necessarily higher than those of the general public outside of academia. There was an age bias to an under 30 category.

Finally, this dissertation only focuses FRBR's feasibility of the classical music bibliographic records. In CMFRBR, the records contains only the musical sound-based information in expression and manifestation, which does not include printed material such as books, music scores, etc. In this study, only classical music information including work, performance and its recorded materials was investigated; all other music genres like jazz, pop, dance, etc., were excluded.

6.4 Conclusions and Future Work

This study had three purposes. First, it was intended to determine the important attributes and relationships to describe classical music information. The second purpose was to identify users' real information needs for finding bibliographic records on the Web. The final purpose was to understand how people search and find classical music information in given music search systems with different types of support.

The phase of the study successfully identified classical music attributes in entities and established the relationships between entities in FRBR. The results of the survey in the first phase implied that attributes of each entity can enrich descriptions of musical bibliographic information, and these attributes help users find improved music information.

In the second phase of the study, it was found that the general public tended to ask about bibliographic classical music information when they were not explicitly seeking opinions about which composer/symphony/orchestra is better. Based on the users' questions in Yahoo! Answers, the study indicated that FRBR can play a significant role in identifying entities and attributes of information from questions in social Q&A sites. The FRBR model provides a proper framework to represent classical music information in a manner that general users can understand and use to obtain their desired information on the Web.

Finally, for the CMFRBR-based classical music information representation and its retrieval system, FIRM, the usability test was performed. To my knowledge, this study is the first to examine the usefulness of a FRBR-based classical music representation model for retrieval of bibliographic records. The results demonstrate that a FRBR-based classical music search system can provide the bibliographic information to users in a format they prefer over the baseline system (IMSLP) as far as organization and representation are concerned. The survey results also

pointed out that users can easily search for specific information in FIRM which significantly improved users' satisfaction.

The entire study results conclude that general web users are interested in finding classical music information and would like to use a better organized music search system. Therefore this study contributed in indicating that a FRBR-based system such as FIRM, the implemented FRBR classical music search system use for this study, can help users find appropriated classical music information they needed.

I plan to conduct future studies in the following directions. First, it is necessary to expand the datasets to include various types of media format such as books, scores, etc. This will provide a larger benefit to classical music seekers to find not only sound recordings of music out but also additionally related information of classical music. Second, a larger scale analysis of users' classical music information needs can indicate additional information needs in topics or platforms. For the current study, I only sampled 500 questions from Yahoo! Answers which can be extended. Finally, further in-depth analysis, such as analysis based on FRBR user task, can provide a better understanding of the diversity of users' classical music information retrieval experience.

REFERENCES

Ayres, M.-L. (2005). Case Studies in implementing Functional Requirements for Bibliographic Records [FRBR]: AustLit and MusicAustralia. *Australian Library Journal, 54*(1), 43-54.

Ayres, M.-L., Kilner, K., Fitch, K., & Scarvell, A. (2002). Report on the successful AustLit: Australian Literature Gateway implementation of the FRBR and INDECS event models, and implications for other FRBR implementations. *IFLA Conference Proceedings*, 1-8.

Bainbridge, D., Cunningham, S. J., & Downie, J. S. (2003). *How people describe their music information needs: A grounded theory analysis of music queries.* Paper presented at the Proceedings of the International Symposium on Music Information Retrieval.

Beitzel, S. M., Jensen, E. C., Chowdhury, A., Grossman, D., & Frieder, O. (2004). *Hourly analysis of a very large topically categorized web query log.* Paper presented at the Proceedings of the 27th annual international ACM SIGIR conference on Research and development in information retrieval.

Bennett, R., Lavoie, B. F., & O'neill, E. T. (2003). The concept of a work in WorldCat: an application of FRBR. *Library Collections, Acquisitions, and Technical Services, 27*(1), 45-59.

Bentley, F., Metcalf, C., & Harboe, G. (2006). *Personal vs. commercial content: the similarities between consumer use of photos and music.* Paper presented at the Proceedings of the SIGCHI conference on Human Factors in computing systems.

Bosma, M., Veltkamp, R. C., & Wiering, F. (2006). Muugle: A music retrieval experimentation framework. *M. Baroni, AR Addessi, R. Caterina, M. Costa*.

Bowen, J. (2005). FRBR: Coming Soon to Your Library? *Library Resources & Technical Services, 49*(3), 175-188.

Buchanan, G. (2006). *FRBR: enriching and integrating digital libraries.* Paper presented at the Proceedings of the 6th ACM/IEEE-CS joint conference on Digital libraries.

Byrd, D., & Crawford, T. (2002). Problems of music information retrieval in the real world. *Information processing & management, 38*(2), 249-272.

Casey, M. A., Veltkamp, R., Goto, M., Leman, M., Rhodes, C., & Slaney, M. (2008). Content-based music information retrieval: Current directions and future challenges. *Proceedings of the IEEE, 96*(4), 668-696.

Chang, N., Tsai, Y., Dunsire, G., & Hopkinson, A. (2013). Experimenting with implementing FRBR in a Chinese Koha system. *Library Hi Tech News, 30*(10), 10-20.

Chapman, A. (2010). The case of AACR2 versus RDA. *Legal Information Management, 10*(3), 210-213.

Chen, Y.-X., & Butz, A. (2009). *Musicsim: integrating audio analysis and user feedback in an interactive music browsing ui.* Paper presented at the Proceedings of the 14th international conference on Intelligent user interfaces.

Classical. (2015). In Merriam-Webster.com.

Cunningham, S. J., Jones, M., & Jones, S. (2004). Organizing digital music for use: an examination of personal music collections.

Cunningham, S. J., & Laing, S. (2009). An analysis of lyrics questions on Yahoo! Answers: Implications for lyric/music retrieval systems. *ADCS 2009, 18*, 137.

Cunningham, S. J., Reeves, N., & Britland, M. (2003). *An ethnographic study of music information seeking: implications for the design of a music digital library.* Paper presented at the Proceedings of the 3rd ACM/IEEE-CS joint conference on Digital libraries.

Delsey, T. (2002). *Functional analysis of the MARC 21 bibliographic and holdings formats*: Network Development and MARC Standards Office.

Dickey, T. J. (2008). FRBRization of a Library Catalog: Better Collocation of Records, Leading to Enhanced Search, Retrieval, and Display. *Information Technology & Libraries, 27*(1), 23-32.

Downie, J. S., & Cunningham, S. J. (2002). Toward a theory of music information retrieval queries: System design implications.

Duggan, G. B., & Payne, S. J. (2008). *Knowledge in the head and on the web: Using topic expertise to aid search.* Paper presented at the Proceedings of the SIGCHI conference on Human factors in computing systems.

Dunn, J. W., Byrd, D., Notess, M., Riley, J., & Scherle, R. (2006). Variations2: Retrieving and using music in an academic setting. *Communications of the ACM, 49*(8), 53-58.

Encelle, B., Jessel, N., Mothe, J., Ralalason, B., & Asensio, J. (2009). BMML: Braille Music Markup Language. *Open Information Systems Journal, 3*(1), 123-135.

Futrelle, J., & Downie, J. S. (2002). *Interdisciplinary Communities and Research Issues in Music Information Retrieval.* Paper presented at the ISMIR.

Gromko, J. E. (1993). Perceptual differences between expert and novice music listeners: A multidimensional scaling analysis. *Psychology of Music, 21*(1), 34-47.

Hanrath, S., & Kottman, M. (2015). Use and Usability of a Discovery Tool in an Academic Library. *Journal of Web Librarianship*(ahead-of-print), 1-21.

Hardesty, J., Harris, S., Coogan, A., & Notess, M. (2012). Scherzo Usability Test Report.

Hargittai, E. (2002). Beyond logs and surveys: In-depth measures of people's web use skills. *Journal of the American Society for Information Science and Technology, 53*(14), 1239-1244.

Hemmasi, H. (2002). *Why not MARC?* Paper presented at the In Proceedings of the Third International Conference on Music Information Retrieval (ISMIR 2002), Paris, France.

Hickey, T. B., & O'Neill, E. T. (2005). Frbrizing oclc's worldcat. *Cataloging & Classification Quarterly, 39*(3-4), 239-251.

Hickey, T. B., O'Neill, E. T., & Toves, J. (2002). Experiments with the IFLA functional requirements for bibliographic records (FRBR). *D-Lib Magazine, 8*(9), 1-13.

Hider, P., & Liu, Y.-H. (2013). The Use of RDA Elements in Support of FRBR User Tasks. *Cataloging & Classification Quarterly, 51*(8), 857-872.

Hornbæk, K. (2006). Current practice in measuring usability: Challenges to usability studies and research. *International journal of human-computer studies, 64*(2), 79-102.

IFLA Study Group on the Functional Requirements for Bibliographic Records, & International Federation of Library Associations and Institutions. Section on Cataloguing. Standing Committee. (1998). Functional requirements for bibliographic records : final report *UBCIM publications* (pp. viii, 136 p.). München: K.G. Saur.

International Organization for Standardization. (1998). ISO 9241-11: Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs): Part 11: Guidance on Usability.

Isaacson, E. (2002). Music IR for Music Theory. *The MIR/MDL Evaluation Project White paper Collection*, 23-26.

Jahnke, N. (2010). Language complexity and usability. *Usability of Complex Information Systems: Evaluation of User Interaction*, 47-66.

Kelly, D. (2009). Methods for evaluating interactive information retrieval systems with users. *Foundations and Trends in Information Retrieval, 3*(1—2), 1-224.

Kilner, K. (2005). The AustLit gateway and scholarly bibliography: A specialist implementation of the FRBR. *Cataloging & Classification Quarterly, 39*(3-4), 87-102.

Kim, J.-Y., & Belkin, N. J. (2002). *Categories of Music Description and Search Terms and Phrases Used by Non-Music Experts.* Paper presented at the ISMIR.

Laplante, A. (2010). *Users' Relevance Criteria in Music Retrieval in Everyday Life: An Exploratory Study.* Paper presented at the ISMIR.

Le Boeuf, P. (2005a). FRBR: Hype or Cure-All? *Cataloging & Classification Quarterly, 39*(3/4), 1-13.

Le Boeuf, P. (2005b). Musical Works in the FRBR Model or "Quasi la Stessa Cosa": Variations on a Theme by Umberto Eco. *Cataloging & Classification Quarterly, 39*(3-4), 103-124. doi: 10.1300/J104v39n03_08

Lee, J. H. (2010). Analysis of user needs and information features in natural language queries seeking music information. *Journal of the American Society for Information Science and Technology, 61*(5), 1025-1045.

Lee, J. H., & Downie, J. S. (2004). *Survey Of Music Information Needs, Uses, And Seeking Behaviours: Preliminary Findings.* Paper presented at the ISMIR.

Lee, J. H., Downie, J. S., & Cunningham, S. J. (2005). Challenges in cross-cultural/multilingual music information seeking.

Lee, S., & Jacob, E. K. (2011). An integrated approach to metadata interoperability: construction of a conceptual struture between MARC and FRBR. *Library Resources and Technical Services, 55*(1), 17-32.

Lehtiniemi, A., & Holm, J. (2011). *Evaluating a cube-based user interface for exploring music collections.* Paper presented at the Information Visualisation (IV), 2011 15th International Conference on.

Lehtiniemi, A., & Holm, J. (2013). Designing for music discovery: Evaluation and comparison of five music player prototypes. *Journal of New Music Research, 42*(3), 283-302.

Library of Congress. (2012). U.S. RDA Implementation Updates from the U.S. RDA: Test Coordinating Committee.

Madison, O. M. A. (2006). Utilizing the FRBR Framework in Designing User-Focused Digital Content and Access Systems. *Library Resources & Technical Services, 50*(1), 10-15.

Maxwell, R. L. (2008). *FRBR : a guide for the perplexed*. Chicago: American Library Association.

McGill, T. M. (2011). Report of the ALCTS FRBR Interest Group Meeting, American Library Association Annual Conference, Washington, DC, June 2010. *Technical Services Quarterly, 28*(3), 346-349.

Merčun, T., Švab, K., Harej, V., & Žumer, M. (2013). Creating better library information systems: the road to FRBR-land. *Information Research, 18*(3), paper C07. doi: http://InformationR.net/ir/18-3/colis/paperC07.html

Merčun, T., & Žumer, M. (2009). Visualizing FRBR. *Libraries in the Digital Age, LIDA 2009, May 25-30 2009, Dubrovnik and Zadar Croatia*, 209-215.

Miletto, E. M., Pimenta, M. S., Bouchet, F., Sansonnet, J.-P., & Keller, D. (2011). Principles for music creation by novices in networked music environments. *Journal of New Music Research, 40*(3), 205-216.

Minibayeva, N., & Dunn, J. W. (2002). *A digital library data model for music.* Paper presented at the Proceedings of the 2nd ACM/IEEE-CS joint conference on Digital libraries.

Mortensen, E. R. (2014). E-Resource Round Up: Opportunities for Digital Scholarship in Music. *Journal of Electronic Resources Librarianship, 26*(4), 294-298. doi: 10.1080/1941126X.2014.971679

Mullin, C. A. (2010). International Music Score Library Project/Petrucci Music Library (review). *Notes, 67*(2), 376-381.

Nachar, N. (2008). The Mann-Whitney U: a test for assessing whether two independent samples come from the same distribution. *Tutorials in Quantitative Methods for Psychology, 4*(1), 13-20.

Notess, M., & Dunn, J. (2004). *Variations2: improving music findability in a digital library through work--centric metadata.* Paper presented at the Proceedings of the 4th ACM/IEEE-CS joint conference on Digital libraries.

Notess, M., Dunn, J. W., & Hardesty, J. L. (2011). *Scherzo: A FRBR-Based Music Discovery System.* Paper presented at the International Conference on Dublin Core and Metadata Applications.

O'Neill, E. T. (2002). FRBR: Functional Requirements for Bibliographic Records: application of the entity-relationship model to 'Humphry Clinker'. *Library Resources & Technical Services, 46*(4), 150-159.

Oliver, C., & Curran, M. (2004). FRBR Is Everywhere, But What Happened to the Format Variation Issue? Content versus Carrier in FRBR. *Serials Librarian, 45*(4), 27-36.

Ontopia home page, n. d.). Retrieved March 20, 2015, from http://www.ontopia.net

Orio, N. (2006). *Music retrieval: a tutorial and review* (Vol. 1): now publishers Inc.

Patton, G. E., & IFLA Working Group on Functional Requirements Numbering of Authority Records. (2009). Functional requirements for authority data: a conceptual model (Vol. 34.; 34). München: K. G. Saur.

Picco, P., & Ortiz Repiso, V. (2012). The Contribution of FRBR to the Identification of Bibliographic Relationships: The New RDA-Based Ways of Representing Relationships in Catalogs. *Cataloging & Classification Quarterly, 50*(5-7), 622-640.

Pisanski, J., Pisanski, T., & Žumer, M. (2013). A new approach to complex web site organization. *Journal of Information Science, 39*(6), 805-814.

Pisanski, J., & Zumer, M. (2007). Functional requirements for bibliographic records: an investigation of two prototypes. *Program, 41*(4), 400-417.

Pisanski, J., & Zumer, M. (2010a). Mental models of the bibliographic universe. Part 1: mental models of descriptions. *Journal of Documentation, 66*(5), 643-667.

Pisanski, J., & Zumer, M. (2010b). Mental models of the bibliographic universe. Part 2: comparison task and conclusions. *Journal of Documentation, 66*(5), 668-680.

Pisanski, J., & Zumer, M. (2012). User verification of the FRBR conceptual model. *Journal of Documentation, 68*(4), 582-592.

Rajapatirana, B., & Missingham, R. (2005). The Australian National Bibliographic Database and the Functional Requirements for the Bibliographic Database (FRBR). *Australian Library Journal, 54*(1), 31-42.

Riley, J. (2008). *Application of the Functional Requirements for Bibliographic Records (FRBR) to Music.* Paper presented at the Ninth International Conference on Music Information Retrieval.

Riley, J., Hunter, C., Colvard, C., & Berry, A. (2007). Definition of a FRBR-based metadata model for the Indiana University Variations3 Project. *Bloomington, IN: Indiana University*.

Riley, J., & Mayer, C. A. (2006). *Ask a Librarian: The Role of Librarians in the Music Information Retrieval Community.* Paper presented at the ISMIR.

Riley, J., Mullin, C., & Hunter, C. (2009). Automatically batch loading metadata from MARC into a work-based metadata model for music. *Cataloging & Classification Quarterly, 47*(6), 519-543.

Riva, P. (2007). Introducing the Functional Requirements for Bibliographic Records and Related IFLA Developments. *Bulletin of the American Society for Information Science & Technology, 33*(6), 7-11.

Riva, P., & Oliver, C. (2012). Evaluation of RDA as an Implementation of FRBR and FRAD. *Cataloging & Classification Quarterly, 50*(5-7), 564-586.

Sadeh, T. (2008). User experience in the library: a case study. *New Library World, 109*(1/2), 7-24.

Salaba, A., & Zhang, Y. (2012). Searching for music: End-user perspectives on system features. In D. R. Neal (Ed.), *Indexing and Retrieval of Non-Text Information* (pp. 137-159). Munich: De Gruyter Saur

Scherle, R., & Byrd, D. (2004). *The Anatomy of a Bibliographic Search System for Music*. Paper presented at the ISMIR.

Seikel, M. (2013). General Notes in Catalog Records versus FRBR User Tasks. *Cataloging & Classification Quarterly, 51*(4), 420-427.

Smiraglia, R. P. (2001). *Musical Works as Information Retrieval Entities: Epistemological Perspectives.* Paper presented at the ISMIR.

Smiraglia, R. P. (2012). Be Careful What You Wish For: FRBR, Some Lacunae, A Review. *Cataloging & Classification Quarterly, 50*(5-7), 360-368.

Song, Y., Ma, H., Wang, H., & Wang, K. (2013). *Exploring and exploiting user search behavior on mobile and tablet devices to improve search relevance.* Paper presented at the Proceedings of the 22nd international conference on World Wide Web.

Takhirov, N., Aalberg, T., Duchateau, F., & Žumer, M. (2012). FRBR-ML: A FRBR-based framework for semantic interoperability. *Semantic Web, 3*(1), 23-43.

Takhirov, N., Aalberg, T., & Žumer, M. (2011). *An XML-based representational document format for frbr.* Paper presented at the Web Information Systems Engineering–WISE 2010 Workshops.

Taniguchi, S. (2012). Viewing RDA from FRBR and FRAD: Does RDA Represent a Different Conceptual Model? *Cataloging & Classification Quarterly, 50*(8), 929-943.

Tarango, A. (2008). *FRBR for Serials: Rounding the Square to Fit the Peg.* Paper presented at the CONSER Operations Meeting.

Tillett, B. (2005). What is FRBR? A conceptual model for the bibliographic universe. *Australian Library Journal, 54*(1), 24-30.

Yee, M. M. (2005). FRBRization: a Method for Turning Online Public Finding Lists into Online Public Catalogs: American Library Association.

Zhang, Y., & Salaba, A. (2009a). *Implementing FRBR in libraries : key issues and future directions*. New York: Neal-Schuman Publishers.

Zhang, Y., & Salaba, A. (2009b). What Is Next for Functional Requirements for Bibliographic Records? A Delphi Study. *Library Quarterly, 79*(2), 233-255.

Zhang, Y., & Salaba, A. (2012). What Do Users Tell Us about FRBR-Based Catalogs? *Cataloging & Classification Quarterly, 50*(5-7), 705-723.

Žumer, M., Salaba, A., & Zhang, Y. (2012). User Verification of the FRBR Conceptual Model and Testing of FRBR Prototypes *The Outreach of Digital Libraries: A Globalized Resource Network* (pp. 148-151): Springer

APPENDIX A

CMFRBR ATTRIBUTES AND RELATIONSHIPS

- **Work**

Work Attributes		
Title	Form (Musical Form/Genre)	Date String
Place	Other Distinguishing (Variant Name/Title)	Context (movements/parts/acts)
Nature of Work (Background/History)	Purpose of Work (Dedication/commission)	Medium of Performance (Musical Instrument)
Language (of Music)	Numeric Designation (Opus Number/Music Catalog Number)	Music Period (Music Style/Music Era)
Intended Audience	Genre	Key
Duration (Playing Time)	Subject Locator	

Relationships with Work	
Performance (Realized in) of the Work :Expression	Composer: Person or Corporate Body
Librettist/Lyricist/Poet/Writer: Person or Corporate Body	Arranger: Person or Corporate Body
Has Work of Work (Parent Work): Work of Work	Sibling Work(s) under Same Parent Work: Work
Arrangement of Work	Successor/Succeed: Work
Involved Sound Recordings: Manifestation	

- **Expression**

Expression Attributes		
Title	Title	Title
Place	Place	Place
Extensibility of Expression	Extensibility of Expression	Extensibility of Expression
Context (movements/parts/acts)	Context (movements/parts/acts)	Context (movements/parts/acts)
Medium of Performance (Musical Instrument)	Medium of Performance (Musical Instrument)	Medium of Performance (Musical Instrument)
Relationships with Expression		
Original Music of the Performance (Realization of): Work	Performer: Person or Corporate Body	
Conductor: Person or Corporate Body	Director/Producer: Person or Corporate Body	
Arranger: Person or Corporate Body	Sponsor: Person or Corporate Body	
Related Expressions (Expressions under Expression of Expression): Expression	Sibling Expression (Performances of Same Music work): Expression	
Has Expression of Expression (Entire event information): Expression of Expression	Recordings of This Performance (Embodied in): Manifestation	

- **Manifestation (continue)**

Manifestation Attributes		
Title	Statement of Responsibility	Edition/Issue designation
Place of Publication/Distribution	Date of Publication/Distribution	Fabricator/ Fanufacturer
Series Statement	Form of Carrier	Extent of the Carrier
Physical Medium	Capture mode	Dimensions of the Carrier
Access Restrictions on the Manifestation	Source for Acquisition/Access Authorization	Terms of Availability
Publication Status (Serial)	Numbering (Serial)	Playing Speed (Sound Recording)
Groove Width (Sound Recording)	Kind of Cutting (Sound Recording)	Tape Configuration (Sound Recording)
Kind of Sound (Sound	Special Reproduction	Polarity (Microform or

Recording)	Characteristic (Sound Recording)	Visual Projection)
Generation (Microform or Visual Projection)	Presentation Format (Visual Projection)	System Requirements (Electronic Resource)
File Characteristics (Electronic Resource)	Mode of Access (Remote Access Electronic Resource)	Access Address (Remote Access Electronic Resource)
Relationships with Manifestation		
Performances in This Recording (Embodiment) : Expression	Original Music Works/Contributor (Related Name): Work	
Alternate Media format Manifestation: Manifestation	Publisher: Person/Corporate Body	
Series: Manifestation		

- **Person**

Person Attributes		
Name	Date of Birth	Place of Birth
Date of Death	Place of Death	Other Designation (Variant/Alternative Name)
Occupation (Profession)	Biography	Subject Locator
Relationships with Person		
Composition(s): Work	Libretto/Lyric/Poem/Write: Work	
Performance: Expression	Conduction: Expression	
Direction/Production: Expression	Music Work Arrangement in concert: Expression	
Sponsored: Expression	Has family: Person	
Is member of Corporate Body: Corporate Body	Affiliated with Corporate Body: Corporate Body	
Publisher/Distributor: Manifestation	Involved Sound Recordings: Manifestation	

- **Corporate Body**

Corporate Body Attributes		
Name	Number Associated with Corporate Body	Other Designation (Variant/Alternative Name)
Biography	Address	Place
Date	Subject Locator	
Relationships with Corporate body		
Composition(s): Work	Libretto/Lyric/Poem/Write: Work	
Performance: Expression	Conduction: Expression	
Direction/Production: Expression	Music Work Arrangement in concert: Expression	
Sponsored: Expression	Has member: Person	
Affiliated with person: Person	Publisher/Distributor: Manifestation	
Involved Sound Recordings: Manifestation		

- **Role Types (Person and Corporate Body)**

Role types (Person and Corporate Body)		
Composer	Librettist/Lyricist/Poet/Writer	Conductor
Performer	Contributor	Director
Arranger	Sponsor	Publisher/Distributor

- **Work of Work**

Work of Work Attributes		
Title	Other Distinguishing (Variant Name/Title)	Date of composition of whole series
Place	Summarization (History/Background)	
Relationships with Work of Work		
Children Works: Work	Composer: Person or Corporate Body	
Librettist/Lyricist/Poet/Writer: Person or Corporate Body	Arranger: Person or Corporate Body	
Performance (Realized in) of the Work: Expression		

- **Expression of Expression**

Expression of Expression Attributes		
Title	Other Distinguishing (Variant Name/Title)	Date
Place	Summarization (Event Information)	
Relationships with Expression of Expression		
Performer: Person or Corporate Body	Conductor : Person or Corporate Body	
Director/Producer : Person or Corporate Body	Arranger : Person or Corporate Body	
Sponsor : Person or Corporate Body	Children Expressions: Expression	
Recordings of This Performance (Embodied in): Manifestation		

APPENDIX B

SURVEY QUESTIONNAIRES IN PHASE 1

Q1 Which of the following best describes your occupation?

- ❍ Music Expert/Musician
- ❍ Music Librarian
- ❍ Music Student
- ❍ Music Scholar
- ❍ Others _____

Q2 How often do you use a music catalog? (E.g. PittCat)

- ❍ Daily
- ❍ 2-3 Times a Week
- ❍ Once a Week
- ❍ 2-3 Times a Month
- ❍ Once a Month
- ❍ Several Times a Year
- ❍ Once a Year or Less
- ❍ Never

Q3 How would you rate your skills in searching for and finding musical resources? (in on-line and cataloging systems)

- ❍ Poor
- ❍ Fair
- ❍ Neutral
- ❍ Good
- ❍ Excellent

Q4 Are you satisfied with current music library cataloging systems utility in searching for music information resources?

- ❍ N/A
- ❍ Very Dissatisfied
- ❍ Dissatisfied
- ❍ Neutral
- ❍ Satisfied
- ❍ Very Satisfied

Q5 Please specify which functions you are not satisfied with. (Check all that apply)

- ❑ Difficulty in search function
- ❑ Difficulty in finding similar items
- ❑ Difficulty in identifying the item I intend to find
- ❑ Difficulty in finding appropriate media format
- ❑ Others _____

Q6 Based on your previous experiences with music catalog and search systems, what improvements would you suggest? Please provide detailed examples or cases of the features and functions. (E.g. indicating duplications show the redundancy: same album in different media format, similar items, etc.) *These examples can be used in your answer

Q7 Are you familiar with FRBR (Functional Requirements for Bibliographic Records)?

Yes No

Q8 If Yes to Question 7, please rate your expertise in FRBR.

Regretful Poor Neutral Good Excellent

Q9 Do you agree that "Title of Work" (A word, phrase, or group of characters naming the work. e.g. Wiegenlied, D. 498) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q10 Do you agree that "Form of Work" (The class to which the work belongs. E.g. Concerto) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q11 Do you agree that "Date of Work" (e.g. Composition date or Premiered date) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q12 Do you agree that "Other distinguishing of Work" (Any characteristic that serves to differentiate the work from another work with the same title. e.g. moonlight sonata, Piano Sonata No. 14 op. 27, No. 2) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q13 Do you agree that "Nature of Work" (The general character of a work. E.g. Classical Cradle song) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q14 Do you agree that "Purpose of Work" (The purpose for which the work was created, e.g. dedicate to someone) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q15 Do you agree that "Intended audience of Work" (The class of user for which the work is intended. e.g. young children) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q16 Do you agree that "Context of Work" (The historical, social, intellectual, artistic or other context within which the work was originally conceived) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q17 Do you agree that "Medium of Performance" (The instrumental, vocal, and/or other medium of performance for which a musical work was originally intended. e.g. piano, orchestra, men's voices) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q18 Do you agree that "Numeric Designation" (A serial number, opus number, or thematic index number assigned to a musical work. e.g. D. 498, Op. 98, No. 2) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q19 Do you agree that "Key" (The set of pitch relationships that establishes a single pitch class as a tonal centre for the work as originally composed. e.g., D major) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q20 Do you agree that "Language of Work" (Original language of the opera or song. e.g. Germany) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q21 Do you agree that "Place of Work" (e.g. Composition or Premiered place) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q22 Do you agree that "Genre of Work" (Lists of Form of Work. A representative genre subject describe in Form of work, otherwise all other genres state here. E.g. Concerto, for voice, piano; for voices with keyboard; Scores featuring the voice; German language...) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q23 Do you agree that "Piece Style of Work" (Classical Music Era. e.g. Romantic, Classical) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q24 Do you agree that "Duration of Work" (The playing time of original work) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q25 Do you agree that "Creator(s) of Work" (e.g. composer, librettists) attribute in Work Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q26 If you were to provide feedback for music FRBR, what additional attributes in Work entity would you suggest?

Q27 Do you agree that "Title of Expression" (A word, phrase, or group of characters naming the expression. e.g. Concerto) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q28 Do you agree that Form of Expression (The means by which the work is realized. e.g. in this study, form is always Musical Sound) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q29 Do you agree that Date of Expression (The date the expression was created) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q30 Do you agree that Language of Expression (The language or languages in which the work is expressed. e.g. sung by German) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q31 Do you agree that "Other Distinguishing of Expression" (Any characteristic of the expression that serves to differentiate the expression from another expression of the same work) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q32 Do you agree that "Extensibility of Expression" (The expectation that the expression will have additional intellectual or artistic content added to it) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q33 Do you agree that "Revisability of Expression" (The expectation that the intellectual or artistic content of the expression will be revised) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q34 Do you agree that "Summarization of Content" (A list of chapter headings, songs, parts, etc. included in the expression. e.g. Movement 1 in Piano sonata No. 14, Op. 27, No. 2) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q35 Do you agree that "Context for Expression" (The historical, social, intellectual, artistic or other context within which the expression was realized) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q36 Do you agree that "Critical Response to Expression" (The reception given to the expression by reviewers, critics, etc., as encapsulated in an annotation. e.g., “critically acclaimed for its use of ….”) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q37 Do you agree that "Use Restrictions on Expression" (Restrictions on access to and use of an expression. e.g., copyright restrictions, license restrictions) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q38 Do you agree that "Medium of Performance in Expression" (The instrumental and/or vocal medium of performance represented in the expression of a musical work. e.g., two pianos, soprano and alto) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q39 Do you agree that "Place of Expression" (The place of the performance and/or recording) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q40 Do you agree that "Key of Expression" (The set of pitch relationships that establishes a single pitch class as a tonal centre for the expression. It could be different from original work. E.g. A minor) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q41 Do you agree that "Duration of Expression" (The playing time of expression) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q42 Do you agree that "Contributor of Expression" (e.g. performer, conductor, sponsor, etc.) attribute in Expression Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q43 If you were to provide feedback for music FRBR, what additional attributes in Expression Entity would you suggest?

Q44 Do you agree that "Name of Person" (A word, character, or group of words and/or characters by which the person is known. Includes forenames (or given names), matronymics, patronymics, family names (or surnames), sobriquets, dynastic names, etc.) Attribute in Person Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q45 Do you agree that "Dates of person" (Dates associated with a person. Includes precise or approximate date of birth and/or death. Born in mm/dd/yyyy, died in mm/dd/yyyy) attribute in Person Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q46 Do you agree that Title of person (A word or phrase indicative of rank, office, nobility, honor, etc., in this study, title refers occupations. e.g. composer, instrumentalist) attribute in Person Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q47 Do you agree that Other Designation Associated With Person (A numeral, word, or abbreviation indicating succession within a family or dynasty, or an epithet or other word or

phrase associated with the person. In this study, Nickname, other language, or different name of the Person other than Name of Person) attribute in Person Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q48 Do you agree that Biography/History of Person (Information pertaining to the life or history of the person) attribute in Person Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q49 Do you agree that "Place of Person" (e.g. born/ death place) attribute in Person Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q50 If you were to provide feedback for music FRBR, what additional attributes in Person Entity would you suggest?

Q51 Do you agree that Name of Corporate Body (A word, character, or group of words and/or characters by which the body is known. e.g. New York Philharmonic) attribute in Corporate Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q52 Do you agree that "Number Associated With Corporate Body" (A numerical designation sequencing a meeting, conference, exhibition, fair, etc. that constitutes one of a series corporate body of related meetings, conferences, exhibitions, fairs, etc.) attribute in Corporate Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q53 Do you agree that Place Associated With Corporate Body (A city, town, or other designation of location in which a meeting, conference, exhibition, fair, etc., was held, or the location with which the corporate body is otherwise associated. e.g. The New York Philharmonic at Lincoln Center’s Avery Fisher Hall in New York City) attribute in Corporate Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q54 Do you agree that Date Associated With Corporate Body (A date or range of dates on which the corporate body is associated. e.g. the date of its found/incorporation) attribute in Corporate Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q55 Do you agree that Other Designation Associated With Corporate Body (A word, phrase, or abbreviation indicating incorporation or legal status of the body, or any term serving to differentiate the body from other corporate bodies, persons, etc. In this study, nick name or different name of the corporate body other than Name of Corporate Body) attribute in Corporate Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q56 Do you agree that Address attribute (The address of the corporate body. Includes postal address, electronic communications address, location code, etc.) in Corporate Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q57 Do you agree that "Bibliography/history of Corporate Body" (Information pertaining to the life or history of the corporate body) attribute in Corporate Entity for music FRBR is important?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q58 If you were to provide feedback for music FRBR, what additional attributes in Corporate Body Entity would you suggest?

Q59 In terms of understandability, how easy do you think you can understand the entity relationships of Music FRBR?

• Very Difficult • Difficult • Neutral • Easy • Very Easy

Q60 How much do you think the relationship representation "has sibling Work" in Work is important?

• Not at all Important • Very Unimportant • Neither Important nor Unimportant • Very Important • Extremely Important

Q61 How much do you think the relationship representation "has similar Work" in Work is important?

- Not at all Important
- Very Unimportant
- Neither Important nor Unimportant
- Very Important
- Extremely Important

Q62 How much do you think the relationship representation "has successors" in Work is important?

- Not at all Important
- Very Unimportant
- Neither Important nor Unimportant
- Very Important
- Extremely Important

Q63 How much do you think the relationship representation "has super-work" in Work is important?

- Not at all Important
- Very Unimportant
- Neither Important nor Unimportant
- Very Important
- Extremely Important

Q64 Among the relationship representations of Work entities, please rank the importance of the relationships.
____ has related Work ____ has similar Work ____ has successors ____ has super work

Q69 In terms of relationship representations, what additional relationship description between Work Entities would you suggest?

Q65 How much do you think the relationship representation "has related expression" in Expression is important?

- Not at all Important
- Very Unimportant
- Neither Important nor Unimportant
- Very Important
- Extremely Important

Q66 How much do you think the relationship representation "has similar expression" in Expression is important?

- Not at all Important
- Very Unimportant
- Neither Important nor Unimportant
- Very Important
- Extremely Important

Q67 How much do you think the relationship representation "has super-expression" in Expression is important?

• Not at all Important	• Very Unimportant	• Neither Important nor Unimportant	• Very Important	• Extremely Important

Q68 Among the relationship representations of Expression entities, please rank the importance of the relationships.
_____ has related expression _____ has similar expression _____ has super-expression

Q70 In terms of relationship representations, what additional relationship description between Expression Entities would you suggest?

Q71 Do you agree that an expression data (e.g. Yo-Yo Ma performed Cello Sonata No. 1 in F major, Op. 5/1 with other music and published CD in 1987) will help to describe a single piece of music manifestation (e.g. single mp3 file from the complete album) better than traditional music catalog?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q72 Do you agree that FRBR relationship representation will help music searchers to find the useful information (e.g. related expressions of the same concert, or similar expressions of the same work) between Work and Expression easily?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q73 Do you agree that FRBR relationship representation will help music searchers to understand the relationship between Work/Expression and Person/Corporate Body easily (e.g. Beethoven's role in Sonata No. 1 is composer, and the role of Yo-Yo Ma and/or New York Philharmonic in Beethoven's Sonata No. 1 is performer)?

• Strongly Disagree • Disagree • Neither Agree nor Disagree • Agree • Strongly Agree

Q74 If music work contains librettos or lyrics, do you agree that librettists would be one of the creators?
Yes No Others _____

Q75 If certain part(s) of a musical work are represented at the expression level, do you agree that the piece(s) of music can be regarded as the same music work?
Yes No Others _____

Q76 Please provide any comments regarding Music FRBR representations

APPENDIX C

EXPERIMENTAL TASK SETS IN PHASE 3

Training Set: You have heard Mozart's "The Magic Flute" somewhere and now you want to search for information about this musical work.

1. What musical instruments (medium of performance) were intended to be used?
2. Who was the librettist (lyricist) of the opera? When and where was s/he born?
3. Find other music written by the same librettist.
4. What is the vocal type (for example, soprano) of the role "The Queen of the Night"?
5. Identify the performer's name of the performance entitled "Overture", and find the birth (or established date) of the performer.
6. Find the published date and publisher of "Overture"

Task 1 Statement: You are listening to the opera Aida, composed by Giuseppe Verdi.

1. What musical instruments (medium of performance) were intended to be used?
2. Identify all the roles whose voice type is Bass.
3. Who was the librettist (lyricist) of the opera? When was s/he born?
4. Find Pottier's performance information and identify his voice type.
5. Who is the publisher of the performance above and when was the performance published?

Task 2 Statement: You have listened to Beethoven's Symphony No. 9, and would like to know when and why it was composed.

1. What period of music history was Beethoven - Symphony No.9?
2. Is there a special name for Beethoven's Symphony No. 9 because it involves a choir?
3. Did composers write the words for the symphonies? If not, who is lyricist? When was

s/he born?

4. Identify the instruments that Papalin used for the performance of this work.
5. When Papalin's performance published and which format is it?

Task 3 Statement: Antonio Vivaldi composed 4 violin concertos called "Four Seasons".

1. What instruments are used in Vivaldi's Winter (from Four Seasons)?
2. These four concertos were published as part of a set of twelve concertos. Find the title and opus number of the set.
3. When Antonio Vivaldi was born and died?
4. Benjamin Intartaglia performed Vivaldi's Spring. Where did he perform?
5. Identify the permanent link of the sound recording of Intartaglia's performance.

Task 4 Statement: Bach composed Six Brandenburg Concertos as a set.

1. What are the instruments in Bach's Brandenburg Concerto No.3?
2. When (years) were the concertos composed?
3. Identify composer's Variant Name (Alternative Names/Transliterations).
4. When and where did Cambridge Concentus Perform Concerto No.3?
5. Identify the Permanent Link of Cambridge Concentus' Sound Recordings.

Task 5 Statement : The Requiem Mass in D minor (K. 626) by Wolfgang Amadeus Mozart was composed in Vienna in 1791

1. Was Mozart's requiem actually written by Mozart? (Entire work) If not, find the name and reason.
2. How Old Was Mozart When He Died?
3. Name the movements of Mozart's Requiem in order?
4. What musical instruments (medium of performance) were intended to be used, and what musical instruments Papalin used for his performance?
5. When was Papalin's performance published and which format is it?

Task 6 Statement: You are listening to "Siegfrieds Tod" by Wagner

1. This is the last part of "Der Ring des Nibelungen (The Ring of the Nibelung)". Find the remaining parts of this musical work.
2. What is the purpose of the music composition (i.e. dedication)?
3. What musical instruments (medium of performance) were intended to be used?

4. Identify the Conductor’s name that performed with University of Chicago Orchestra entitled Siegfried's Rhine Journey?
5. Find the publisher of the sound recording of the performance above.

APPENDIX D

BACKGROUND SURVEY QUESTIONNAIRE

Q1. Which of the following best describes your occupation?

- ❍ Music Related Profession
- ❍ Librarian
- ❍ Grad Student
- ❍ Undergrad Student
- ❍ Others _____

Q2. How would you rate your knowledge of Classical Music?

- ❍ Very Poor
- ❍ Poor
- ❍ Fair
- ❍ Good
- ❍ Very Good

Q3. How often do you search for music information in a Library Cataloging System (e.g. PittCat)

- ❍ Never
- ❍ Less than Once a Month
- ❍ Once a Month
- ❍ 2-3 Times a Month
- ❍ Once a Week
- ❍ 2-3 Times a Week
- ❍ Daily

Q4. How would you rate your skills in searching for and finding musical resources? (in on-line and cataloging systems)

- ❍ Poor
- ❍ Fair
- ❍ Good
- ❍ Very Good
- ❍ Excellent

Q5. Which of the following would be your starting point, if you are looking for a particular music recording by specific musicians (performer, composer), or the information about a specific piece of music. (Check all that apply)

- ❑ Google
- ❑ YouTube
- ❑ Library Catalog
- ❑ iTunes
- ❑ Naxos Music Library
- ❑ Other _____

Q6. Did you first learn classical music in English?

- ❍ Yes
- ❍ No

Q7. Did you first learn classical music in Western Europe?

- ❍ Yes
- ❍ No

Q8. Are you familiar with classical music description in English? (E.g. Movement, Key, Opus number, etc.)

- ❍ Yes
- ❍ No

Q9. Are you familiar with FRBR (Functional Requirements for Bibliographic Records)?

- ❍ Yes
- ❍ No

Q10. If you answered Yes to Question 7, please rate your expertise with FRBR.

- ❍ Poor
- ❍ Fair
- ❍ Good
- ❍ Very Good
- ❍ Excellent

APPENDIX E

POST-TASK, POST-SYSTEM QUESTIONNAIRE

Post-Task Questionnaire

Q1. Did you know about this topic before you performed the search?

- ❍ Yes, I know all answers about the topic
- ❍ I know the most answers about the topic
- ❍ I know a little answers about the topic
- ❍ No, I have no idea about the topic

Q2. Please rate the level of difficulty of finding the following:

	Very Difficult	Difficult	Neutral	Easy	Very Easy
Finding Relevant Page	❍	❍	❍	❍	❍
Finding Relevant Information	❍	❍	❍	❍	❍
Finding Answers	❍	❍	❍	❍	❍

Q3. Please rate the level of your satisfaction with your search results.

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Obtaining Relevant Information	❍	❍	❍	❍	❍
Obtaining Answer	❍	❍	❍	❍	❍

Post-System Questionnaire

Q1. Overall, how would you rate searching for information about musical works on the FIRM/IMSLP?

❍ Very Difficult
❍ Difficult
❍ Neutral
❍ Easy
❍ Very Easy

Q2. Overall, how would you rate searching performance information on the FIRM/IMSLP?

❍ Very Difficult
❍ Difficult
❍ Neutral
❍ Easy
❍ Very Easy

Q3. Overall, how would you rate searching Sound Recording information on the FIRM/IMSLP?

❍ Very Difficult
❍ Difficult
❍ Neutral
❍ Easy
❍ Very Easy

Q4. Overall, how would you rate searching person/corporate body information on the FIRM/IMSLP?

❍ Very Difficult
❍ Difficult
❍ Neutral
❍ Easy

❍ Very Easy

Q5. Please rate your satisfaction with the organization of information about musical works/performance/sound recording and composers/librettists/performer on the FIRM/IMSLP.

❍ Very Dissatisfied
❍ Dissatisfied
❍ Neutral
❍ Satisfied
❍ Very Satisfied

APPENDIX F

POST-EXPERIMENT QUESTIONNAIRE

Q1. Overall, do you agree that FRBR provides more organized information about musical works than the IMSLP?

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neither Agree nor Disagree
- ❍ Agree
- ❍ Strongly Agree

Q2. Do you agree that FRBR relationship representation will help music finders to understand the relationship between entities easily (e.g. Beethoven's role in Symphony no 9 is composer, and Friedrich Schiller's role in Beethoven's symphony no. 9 is librettist)?

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neither Agree nor Disagree
- ❍ Agree
- ❍ Strongly Agree

Q3. Which search option is better to find answers about:

	Select the system you prefer	
	IMSLP	FRBR
Finding Work Information	❍	❍
Finding Performance Information	❍	❍
Finding Sound Recording Information	❍	❍
Finding Person/Corporate Body Information	❍	❍
Finding relationship of musical work and person	❍	❍

Q4. If this FRBR system were available on the Web, would you be willing to use this system to find music-related information?

❍ Very Unlikely
❍ Unlikely
❍ Somewhat Unlikely
❍ Undecided
❍ Somewhat Likely
❍ Likely
❍ Very Likely

Q5. Do you agree that 1 page long information in IMSLP would be an advantage?

❍ Disagree
❍ Neutral
❍ Agree

Q6. Was the English-based description barrier to find appropriate page/information/answer?

	Select your Answer		Please comment about your barrier
	Yes	No	Skip if you answered "NO"
Page	❍	❍	
Information	❍	❍	
Answer	❍	❍	

APPENDIX G

INTERVIEW QUESTIONS

1. You selected IMSLP/FIRM to find Work information for your preference, please explain.
2. You selected IMSLP/FIRM to find Performance information for your preference, please explain.
3. You selected IMSLP/FIRM to find Sound Recording information for your preference, please explain.
4. You selected IMSLP/FIRM to find Person information for your preference, please explain.
5. You selected IMSLP/FIRM to find Relationship information for your preference, please explain.
6. How did you like 1 page long IMSLP presentation and separated pages in FIRM?
7. Any other comments from the study?