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The difficult task of finding digitized music manuscripts in online library collections

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Abstract: Music researchers are seldom at the center of attention as a user group within LIS. Thus, investigations of search possibilities for digitized music manuscript collections with a user perspective are lacking. Here, three digitized music manuscript collections (the *Schrank II* collection in Dresden, the *Utile Dulci* collection in Stockholm, and the *Düben* collection in Uppsala) are examined with regard to the accessibility of their contents to the target user group in two steps: First, music researchers are asked about their information seeking process and queries. They are observed in surveys, interviews, and think-aloud protocols. Second, the three retrieval systems are subjected to a performance evaluation by means of precision, recall, and F_1 measures. The results show that music researchers are seeking information either with *known-item searching*, *browsing*, or *subject search*, yet the latter with considerably different subjects than, for example, in the domain of literature. In addition, while music researchers are expressing their satisfaction with the discovery systems, the observations from protocol analysis and the performance evaluation show that all three have issues in retrieving relevant documents for music-specific queries.

Keywords: digitized music manuscript collections, music researchers, accessibility, information seeking behavior, query formulation, performance evaluation, music information retrieval

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1 Introduction

During the past twenty years, the field of music information retrieval has gained in attention. Great efforts have been made to discover ways of finding music in digital collections, especially by members of the International Society for Music Information Retrieval (ISMIR, see https://www.ismir.net/). Their focus lies, however, mainly on the retrieval of music recordings, the actual sound, or on the optical recognition of music symbols. When it comes to the discovery of digitized historical music manuscripts, the field is almost completely outside public attention. Yet, the members of the RISM (*Répertoire International des Sources Musicales*, see http://www.rism.info/home.html) committee are actively researching retrieval matters concerning older sources of music. They state:

> Standard practices for cataloging instrumentation of music scores are well documented. To our knowledge, searching scores by instrumentation, on the other hand, has not been covered by dedicated studies (Pugin & Zitellini, 2013, p. 195-196).

To my knowledge, this statement is still true, not only for searching by instrumentation, but even other facets of music manuscript discovery.

Since I am a music historian concerned with music manuscripts from the 17th century, I am frequently experiencing information retrieval problems. In my work, I have to find music that has not been recorded, edited, played, or sometimes even looked at for hundreds of years – it is preserved in old manuscripts only. A music researcher like me might use those old manuscripts for exploring musical practices of that time, or for producing modern sheet music editions of the pieces contained in those manuscripts, to make them accessible to musicians for playing the music. Those old manuscripts often do not provide all the necessary information for a complete set of metadata that would allow a successful search - some lack title, composer, or text, the parts might be spread out in different places, and music historians like me work hard to collect information about scribes or provenance. At the present state, many pieces could only be made searchable by encoding the music manually, which is not happening to a larger extent, since it would require a lot of resources. In addition, digitized music manuscripts in different collections are found through many different platforms and search interfaces, many of which are not meeting my user needs well. In library and information science (LIS), it is a known fact that "music materials pose unique demands that must be considered for successful discovery. There is exciting potential for new discovery interfaces to ease the difficulties users face when searching for music materials. However, in reality, the specialized discovery needs arising from music materials are often overlooked" (Newcomer et al., 2013, p. 494).

This neglect of discovery needs in digitized music manuscript collections has dire consequences for music research, which potentially could be made much easier with all the new digital possibilities of our times. Both music researchers and libraries could profit from giving the matter more attention:

> When discovery interfaces work well, everyone benefits: the library's collections are more fully exposed, and users do not have to adhere to nor

> struggle with complicated search vocabularies and strategies. Discovery is optimized (Newcomer et al., 2013, p. 494).

It seems that I am not the only music researcher experiencing problems. However, music researchers are not often the subjects for studies within Library and information science (LIS), although they are the main target audience for digitized music manuscript collections. In this context, I mean by “music researchers” not only musicologists or music scholars, but also music editors or musicians within the field of historically informed performance practice. They all have in common that they are requiring the ability to read and analyze music materials that are mostly illegible to people without the necessary kind of special training.

Publications on musically trained people’s way of finding music in all forms (scores, recordings, or other manifestations) are generally rare. Even when it comes to the general ways how people search for music on the Internet, there has not been done much research yet:

> One of the major issues in current music information retrieval (MIR) research is the lack of empirical studies of real-life users and their music information seeking and retrieval processes (Lee, 2010, p. 1025).

Because I have been working with the digitization of music manuscripts myself, I felt the urge to shed light on this matter. Last autumn, within my courses at Borås University, I conducted a small study about music researchers’ use of digitized music manuscript collections, which showed that many of them today rely on such collections. However, my approach then was quite general, the sample size was too small to draw generalizing conclusions, and almost every library has its own discovery system for digitized collections. I still lacked scientific facts about information retrieval problems within different systems. This is why I decided to go further in this master’s thesis.

I use the term *discovery system,* meaning the systems for finding digitized music manuscripts in a collection, rather than *information retrieval (IR) system*, because the objects that are retrieved are images that do not per se contain the information that is searched for. The images are pixels only. Some information about the pieces of music found in those pixels is described in metadata, but not all of it; it takes the trained eyes of music researchers to extract the actual music from the images. Thus, the system is enabling the user to discover musical sources without retrieving the actual information contained in the images. The *search interface* is the part of the system that makes it possible for the user to interact with it: the visible parts (websites, search screens, result lists) and the underlying matching algorithms. It does not contain the catalogue, the descriptive metadata, or the classification schema.

1.1 Problem formulation

Since so little is known about the ways in which music researchers are searching for music materials, and libraries seldom collaborate with music researchers when planning their digitization projects and discovery systems (Laplante & Fujinaga, 2016, p. 47), we cannot actually be sure that the systems designed for this special target user group match their queries and information seeking behavior.

Therefore, I ask the following questions:

1. How are music researchers searching for digitized music manuscripts?
2. What queries do they use for finding digitized music manuscripts in library collections?
3. How well are the online access systems for collections in three different libraries suited to give answer to those queries?

1.2 Aim and purpose

Answering these questions is necessary if libraries with digitized music manuscript collections in future shall be able to know how to design their user interfaces. My aim is to provide some of the information they need about music researchers' information seeking behavior within such collections and the experiences they create with different kinds of search interfaces for digitized music manuscripts. I feel urged to do this, because detailed studies in this field are lacking so far. The purpose of this thesis is to generate knowledge about the ways music manuscripts are searched for and the effectiveness of existing discovery systems in relation to music researchers' information needs.

2 Previous Research

Here, I give an overview on previous research in related fields to my research questions: Literature about discovery system and search interface evaluation concerning music (chapter 2.2) is concerning research questions two and three. While little is known about the information seeking behavior of music researchers, there are some studies considering other related user groups, which are accounted for in chapter 2.3. Since part of the problems occurring in the search for music materials are due to issues in music classification, I mention a few important works in that area in chapter 2.4. Because the whole undertaking has its place within the field of MIR, I start with describing that area of research (chapter 2.1).

2.1 Music information retrieval (MIR)

The research field of Music information retrieval (MIR) has been focusing on developing digital ways of finding music in different manifestations for many years. There are three main areas that are in the center of attention: Computers need to be enabled to identify music from sound recordings, to identify music from written scores or sheet music, as well as to notate music in machine-readable code.

Quite early, MIR researchers explored the possibilities offered by automatic sound recognition. Already in 2003, Pardo, Shifrin, and Birmingham developed a system for music search and retrieval based on a sung query, a melody provided by the user. Their system compared the query to music files in a database by means of a Forward algorithm, which means that all music in the system was manifested in recorded sound (Pardo et al., 2004). Others have been working on possibilities to transform the musical sound into different forms of music notation (for example Duggan & O'Shea, 2011; Sarnatskyi et al., 2017; Sleep, 2017). Quite a few of these research results have been implemented in search engines for music materials, for example in the smartphone apps "Shazam" (https://www.shazam.com/) or "Tunepal" (https://tunepal.org/). When it comes to music represented in old manuscripts preserved in library collections, sound recognition would only help if combined with a technique to make the manuscripts machine-readable.

Such a technique is called Optical Music Recognition (OMR). It is comparable to OCR techniques for texts written in letters, but much more complicated, because the meaning of musical symbols in traditional music notation from the Western world to a large extend is depending to their relation with other symbols in their surroundings, and because music notation contains several more dimensions than text. Quite a few researchers have made efforts to develop and improve technical solutions for automatically translating notated music scores into machine-readable code (for example Nhat & Lee, 2014; Padilla et al., 2014; Calvo-Zagaroza et al., 2017; Attwenger, 2015). The outcome of such automatic recognition can result in MusicXML code, which can be used for analyzing music in different ways (see for example Arora, 2011; Bahraini & Tilevich, 2019). One group of researchers has been making progress in developing a cloud-based tool for utilizing OMR in information retrieval systems (Fujinaga et al., 2014). Yet, so far even the most elaborate systems for transcribing the contents of old music manuscripts into modern notation or MusicXML are not working precisely enough to give accurate retrieval results.

Another problem is that implementing these techniques costs a lot of money and resources, which is why they are developed mainly for large user groups like listeners of popular music with smartphone access (for example https://www.shazam.com/), or musicians in general (for example Bahraini & Tilevich, 2019). Music researchers who are interested in old music manuscripts are not a large user group, and often they are not able to invest larger sums of money in the development of new research tools. A lot more development would yet be needed, though, to get the technical solutions to work properly on music manuscripts from all ages. So, while a combination of sound recognition for query formulation, OMR techniques for identifying music from manuscripts, and encoding the music in MusicXML would indeed facilitate finding music manuscripts in digitized collections, such a solution remains until now, and quite likely even in the nearest future, utopia.

Since libraries now are stuck with the technical solutions available today, many digitized music manuscript collections are still searchable by means of the same categories that have been used in library catalogues for ages. Until this is about to change, it certainly would pay to examine the systems that are in use concerning their functionality.

2.2 Discovery system and search interface evaluation

As mentioned, previous research in the specific area of music manuscript discovery is rare. One evaluation was performed by members of the Swiss RISM committee on their own system (Pugin & Zitellini, 2013). They are describing the properties of two search functions in the RISM-online database, and how they have been improved by the latest changes: searching for instrumentation, the musical *medium*, and searching for part of a melody in the beginning of a piece, the so called *incipit*. Their way of using test queries and counting true positive, false positive, as well as false negative results is a methodic model for my experiments, even if they are not calculating precision and recall, which I do (see chapter 3.2). In an earlier article, Pugin, Hankinson, and Fujinaga (2011) are giving more information on the technical background and history of the RISM-online database. Here, they are describing their strategies and experiences without examining the database from the user's perspective. Their thoughts and statements in both articles are of considerable importance, being nearly the only reference point in literature so far. Some of their arguments are strengthened by the results of my experiments.

That the search for music materials can cause problems within online catalogues has been known for quite some time. Already in 1995, Henigman and Burbank conducted a survey among librarians about the appropriateness of their systems for the use of musical symbols in search queries. The problem they are addressing is that some music titles contain the symbols for “sharp” (#), “flat”, or “natural” when indicating the key of a piece, for example “Symphony in A# major”. Because the # symbol is available on a standard keyboard, users might add it to a query when consulting an online catalogue about a piece of music. Discovery systems generally do not handle this well. Yet, while Henigman and Burbank (1995) are identifying this as a problem, and so do most of the librarians who answered their survey, they are neither providing any solution, nor examining the matter from a user’s perspective. In my study, I do not focus on this particular issue, because in other languages than English, key signatures are expressed without the use of such symbols (in German, for example, the symphony in A# major would be called “Sinfonie in Ais-Dur”). In addition, the work of Pugin and Zittellini (2013) induced me to focus rather on the musical medium. Still, using the key signature as a query is indeed problematic and would call for a separate study.

Thomas (2011) is examining a search interface and the improvements that it can add to existing Online Public Access Catalogue (OPAC) systems so that they perform better when retrieving music materials. His study is the only one I found focusing on a search interface for music and including users in the evaluation. Thomas is asking music students about the search interface he has been developing. He shows how he is able to make life easier for them without larger investments of time and money into a new discovery system. His results are especially interesting for libraries who are integrating the search for music materials into their main OPAC, as one of my chosen collections does. Yet, the examined materials are not old music manuscripts, but all modern materials, which has to be considered.

A performance evaluation of a music retrieval system is executed by Bahraini and Tilevich (2019) when they are presenting their search engine for music scores, *Ask Toskanini!*, which is making use of MusicXML. Their evaluation is not considering whether retrieved documents are relevant or not, but rather measuring the time it takes the system to extract information from the MusicXML files. Since this approach is specific to the new system in question, it is not applicable as a method in the present study.

Better suited as a methodological model are the experiments conducted by Fluhr et al. (2006), even if they are not concerned with a system for music manuscript discovery, but for multimedia information retrieval. They are including users in the evaluation by letting them determine the relevance of the retrieved documents and perform the tests. I did not have that possibility, but otherwise my approach is leaning on theirs.

While those articles could give me an idea on how some evaluation methods can be used in practice, I needed a broader work for being able to form my evaluation experiments in a valid way. For this purpose, I have been using the second edition of “*Modern Information Retrieval*” by Baeza-Yates and Ribeiro-Neto (2011), who are describing both the technologies involved in information retrieval and the methods for evaluating retrieval systems in a comprehensive way.

2.3 Information seeking behavior concerning music

Fully focusing on the user is Lee (2010) in an empiric study about real-life queries in music information retrieval. This study is about people in general and their music queries in common search engines like Google. Lee's study shows, if compared to the results of my surveys and interviews, that the information seeking behavior of music researchers is a completely different matter than those of ordinary people searching the Internet for a song they have heard. This is due to the circumstance that, normally, people searching for music have the goal to be entertained, to find something they like. To music researchers it does not matter if they like the music they find, or what mood it represents, they are asking for research objects, which alters the requirements for the search results. The findings of any study concerning music as entertainment are not transferable on music researcher's information behavior in music manuscript collections.

When it comes to the information seeking behavior of music researchers, there is not much previous literature to consider. Brown (2002) wrote an article about the research process of music scholars, at a time when digitized music manuscript collections almost did not exist. Still, the resulting insights and her model of different phases in the research process provide valuable background information. Her model consists of six stages: *idea generation*, *background work*, *preparing and organizing*, *analyzing*, *writing and revisio*n, and *dissemination* (Brown, 2002, p. 79). According to Brown (2002), most of the work with finding and reading music sources is done during the second and third stage, while the sources often are re-visited for double-checking and deepening through all stages but the last. She gets to those results by combining a quantitative survey with qualitative interviews, asking music scholars directly after their experiences and proceedings.

Dougan (2012) presents another study on music students, not researchers. She examined what kind of materials music students were searching for on the Internet, and which repositories they used to acquire the music materials they need. For that, she conducted an online survey and analyzed group discussions. While there are some parallels between music students and researchers interested in music manuscripts, it becomes apparent in Dougan's study that both still are completely different user groups, which is not surprising. Utilizing music manuscripts requires a level of training and experience that music students seldom reach, while at the same time historically informed performance practice is a quite narrow field of musical occupation, as is philological research on music manuscripts within musicology. Thus, Dougan's results are not applicable to music researchers.

A report on a meta-level on different previous studies about people's ways of using OPAC-systems while searching for music is provided by King (2007), not without pointing out that such studies are scarce. He does not draw conclusions on digitized collections, yet the compilation is highly useful for comparison and making general assumptions. While the users in the mentioned studies are not all specifically musicians or music scholars, we still can make the comparison, because not many other people have a purpose to search for music materials in library OPACs. In addition, most of the cited studies were performed at music conservatories and universities.

While all the mentioned studies provide information on the research methods that have been used, sometimes with detailed descriptions of the proceedings, I needed an overview on all the available methods for being able to choose surveys, interviews, and think-aloud protocols for this study as the best methods for solving my research problem. For that purpose, I relied on the book *Social Research Methods* (Bryman, 2012).

Marchionini (1995) provides a theoretical framework for the information seeking process in general. He identifies six different factors that have an impact on information seeking:

1. *Information seeker*, the person searching for information, with all her capabilities, experiences, and expectations.

2. *Task*, the manifestation of a problem driving information-seeking actions.

3. *Search system*, a source for knowledge, providing tools to access that knowledge. The system is divided into the *database*, containing the knowledge, and the *interface*, providing access.

4. *Domain*, the body of knowledge, in case of this thesis the music manuscripts and everything that is known about them.

5. *Setting*, elsewhere called *context* or *situation*, describes the circumstances in which the search is taking place, including social and environmental aspects.

6. *Outcomes* are the results of using an information system.

Those factors are applicable on all information seeking processes, not only within music. I use them to determine necessary methodological steps and, as a theoretical background, for analyzing the results.

2.4 Music classification and digitization

While user studies are remarkably underrepresented in previous literature about music discovery, there are quite a few contributions about issues concerning music classification and digitization. Here are some of those that are of considerable interest for the present study, because they help to explain the problems that music researchers are facing when searching for digitized music manuscripts:

Music classification is the subject in articles by Inskip and McFarlane (2007) as well as Lee and Robinson (2017). While the former articulate considerations about the meaning of music, its *aboutness*, and resulting problems for music information retrieval from the user’s perspective, the latter are describing the complexity of music classification concerning the facet of musical *medium*, which are the instruments and/or voices needed to perform the music. Both publications provide important thoughts on the complicated issue of music classification and help to explain the results of my experiments.

The library's point of view is taken by Laplante and Fujinaga (2016), who through interviews with library employees and directors of music digitization projects have been examining the problems libraries are facing when digitizing music manuscripts or prints: lack of funding, lack of proper planning, necessity of very detailed metadata, lack of skilled staff and/or technical support, as well as lack of user involvement. Most of the problems they point out have also been issues in at least one of the three collections I am investigating. Keeping those difficulties in mind is essential when assessing the evaluation results of my experiments.

When reading about all those potential complications, practical ones as well as matters of classification or interface design, one might ask for a guide on how to make digitized music manuscript collections as accessible as possible. Such a guide, or at least some guidelines, have been attempted by Newcomer et al. (2013). They are combining the results of existing studies with their own thoughts and experiences into lots of advice. Since this is meant as a reference guide, not as independent research, they are not presenting any new study results. In the discussion of my findings and their consequences for libraries, though, it would not be advisable to leave out their suggestions, since they provide possible explanations for some of the issues I discovered.

3 Methods and material

In this chapter, I describe the methods I used for my study (chapters 3.1 and 3.2), ethical considerations (3.3), and the three collections I chose for examination (3.4).

There are two different sides to evaluating a search interface:

> Technological evaluation aims at establishing a hierarchy between automatic processing technologies usually based on effectiveness measured by Precision/Recall. On the other hand, user-oriented evaluation considers the systems as used by end-users. In such evaluations, one must consider aspects such as the quality of the user interface, the ease of use of interactive tools, response time, indexing time, and time needed to adapt the system to a new domain (Fluhr et al., 2006, p. 302).

If I want to establish how well different discovery systems for digitized music manuscripts are functioning in relation to the information seeking behavior of music researchers, I need to attempt a combination of both aspects, because an ineffective system is equally unfit for this purpose as a bad user interface.

Because there are many different access systems to music materials to be found on the Internet, and I cannot examine them all, I focus on three well-known collections containing digitized music manuscripts from the 17th and 18th century. I chose that era, because there is a significantly larger number of music manuscripts preserved than from earlier ages and, thus, a greater amount of digitized material available, yet the percentage of pieces without a known composer, which should be the most difficult to retrieve, is still much higher than in later ages. The results should be transferable to classical music in the Western world from later ages, though, because the main developments in our musical system, like for example keys, harmonics, beats, and measures, happened in the end of the 16th and beginning of the 17th century. In addition, my own expertise as a musicologist lies within that research field, which is why I am able to assess the relevance of retrieved documents - a compulsory detail when there is not any research team available.

Since not enough is yet known about how music researchers behave in a digital environment and what queries they use, a necessary step is to find out more in that matter. Afterwards, I can evaluate the systems in a meaningful way. This is why I have designed this study in two stages: First, I examine the behavior of music researchers and the queries they use when searching for digitized music manuscripts online. This is achieved by means of surveys and interviews, as described in chapter 3.1. Then, I use the results of stage one to design queries for an experimental evaluation of the three chosen search interfaces, which I then run through the systems, calculating precision, recall, and F_1 measure, as described in chapter 3.2.

3.1 Stage 1: Surveys and interviews

For the purpose of examining the information seeking behavior of the target user group, music researchers, I conducted two qualitative, anonymous online surveys with mainly open-ended questions, collecting as many of the participants' thoughts and experiences around the collections as possible. I have tried a quantitative approach in my previous work, which has proven problematic; the number of music researchers working with digitized music manuscript collections is not very large to begin with, and if they not all are willing to participate in the surveys, the sample size will be too low as to get conclusive results. In addition, the qualitative approach provides richer and deeper insights into specific problems within the collections.

The first anonymous survey was aimed at users of the three chosen collections and containing questions concerning those collections only; people who had not been using at least one of those collections were not allowed to answer the questions. They were asked about their reasons for searching for music manuscripts, the frequency how often they have been visiting the collection during the past twelve months, their aims when searching the collection, the queries they used, if they found what they were looking for, and which problems they encountered (see Appendix I). Those open-ended questions were designed to give insight on the reasons for the users to search the collection, what they were looking for, and the user experience - if it was easy to find what they needed, if problems occurred, if they were satisfied. The survey was built with *Sunet Survey & Report* (see https://www.sunet.se/tjanster/survey/) and spread via different channels to reach as many music researchers as possible: E-mail lists for musicologists, especially those specialized in older music materials, early music, music editing, and historically informed performance practice; Facebook groups for music researchers; the involved libraries' user contacts; and private e-mail contacts. Due to the narrow research field that was covered, a low response rate was to be expected, and low it surely was - in total, I received ten answers for all three collections together. At the end of this survey, the participants were invited to volunteer for an online interview, which six participants did, one of whom not progressing to the actual interview.

Because those specific three collections are thematically very narrow, used only by a few patrons each, I complemented this first online survey with another one, directed towards music researchers who have been using any collection of digitized music manuscripts online. The second survey was designed to get a broader view on music researchers' preferred queries, containing one open-ended question only: "When you use digitized music manuscript collections online, what queries do you use? Please name as many examples as you can think of or remember." It was directed to users of any digitized music manuscript collection, not just the chosen three. I did this to broaden my view on music researchers' queries in general, as well as to validate the results from the first survey, which could be strongly biased due to the low number of participants. It was spread via the same channels as the previous survey, but not the involved libraries, and returned 16 answers.

The answers collected from both surveys were subjected to a qualitative analysis, in which different subject areas were grouped around the themes *research motives and purposes*, *search process*, *queries*, and summarized.

Surveys with open-ended questions can shed light on several aspects of the search process. Yet, for getting the full picture, a survey is not sufficient, especially when the response rate is expected to be low. A useful tool to study the search process is what King calls *protocol analysis*:

> (...) protocol analysis is one of the most useful methods of studying user search strategy, as it more closely monitors the person's thinking while the search is going on (King, 2007, p. 3-4).

What is analyzed in the process is a think-aloud protocol: When I'm listening to the participant's thoughts, at the same time observing their actions, I can see whether the issues a person is experiencing are caused by the *search system*, or whether they rather are concerning the *information seeker*, for example when the person lacks understanding of the search functions. Thus, I had online meetings with five music researchers in two parts, where the first part consisted of a semi-structured interview, the second part in a protocol analysis of several search instances, which I observed via shared screen, while the participants talked me through their thoughts and considerations throughout the search. The meetings were recorded and later analyzed.

Four of the five semi-structured interviews were held via the online platform *Zoom*. The fifth participant did not have the technical equipment for an online interview at home, and could not get to his workplace due to COVID-19 lockdown, which then just had started in his home country. He answered my questions in writing, which he preferred to the phone. The interviews included some questions about the researchers' background, but then allowing the participants to speak freely about their experiences with one of the examined collections (interview guide see Appendix II). After speaking and answering a few follow-up questions, three of the participants (one for each collection) shared their screen with me and conducted several search occurrences in one of the three collections while I was watching and they talked me through their thoughts and intentions. The whole process was recorded, so that I could focus on listening and observing, and analyze everything later. Only three interview participants could be observed, because one did not have access to the necessary technical equipment (see above), and one lacked the technical knowledge to share her screen or to find the collection by herself (when searching the collection previously, she had received help by a colleague and a librarian); since I took the role of an objective observer, I couldn't help her too much.

From the interviews, I determined as much information as possible about the *information seeker* and the *setting* of the individual information seeking process, as well as the basis for the evolving *tasks*. The protocol analysis was guided by several questions, put to answer matters of *task* and *outcomes* according to Marchionini (1995):

- How did the user find the collection in question?

- What were the user's intentions at the beginning of the search process?
- Which queries were used?
- How easy to use was the search interface?
- Which difficulties occurred?
- In what ways was the search successful or not?

3.2 Stage 2: Technical evaluation

One aspect of *outcomes*, according to Marchionini's model, is the evaluation of a search system's effectiveness. Outcomes have a great impact on the search process, because they determine, whether the goal of the task is reached or not (Marchionini, 1995, p. 48). This is why the technical evaluation is a necessary step in this study.

For conducting a performance evaluation that means anything in this context, I need to use queries that are relevant to music researchers.

> Query formulation involves matching understanding of the task with the system selected. (...) Query formulation requires two kinds of mappings: a semantic mapping of the information seeker's vocabulary used to articulate the task onto the system's vocabulary used to gain access to the content, and an action mapping of the strategies and tactics that the information seeker deems best to forward the task to the rules and features that the system interface allows (Marchionini ,1995, p. 53).

I used the knowledge about the information seekers and their actions that I had gathered in surveys, interviews, and protocol analysis in stage 1, specifically those concerning search queries preferred by music researchers and the strategies they used while searching, to develop a set of test queries to evaluate the information retrieval systems for the different collections. For obtaining a good mapping, I took the vocabulary used in the mentioned queries into account and compared it to the contents of all three collections. I also tried to keep in mind which queries could prove problematic in one way or another, as Pugin and Zitellini (2013, p. 197) have done in their evaluation.

Then, I went through a list of documents in all three collections and determined which documents are relevant for which query. The *Schrank II* collection (see chapter 3.4) contains 1 792 documents, the *Utile Dulci* collection 794 documents. Because of the size of the *Düben* collection, which is showing 2,843 entries in the database, and because of the special requirements in the search for text-free instrumental music, which is the main contents of the other two collections, I focused here on the instrumental music only, which includes 629 documents. Due to the *exact match* retrieval system, a larger number would not have had much impact on the resulting precision and recall measures.

The test queries were then run through the search interfaces mentioned in chapter 3.4. In the list of retrieved documents, I counted true positives (TP – relevant documents shown in the hit list), false positives (FP – documents shown in the hit list that are not relevant to the query) and false negatives (FN – documents that are relevant to the query, but not shown in the hit list), which enabled me to calculate precision, recall, and F_1 measure for the different discovery systems (Baeza-Yates & Ribeiro-Neto, 2011, pp. 135-139).

The precision value is calculated by dividing the number of TP by the sum of TP and FP, describing "the fraction of the retrieved documents (…) which is relevant" (Baeza-Yates & Ribeiro-Neto, 2011, p. 135). The more documents in the hit list for a query are relevant, the higher is the precision.

The recall value is calculated by dividing the number of TP by the sum of TP and FN, describing "the fraction of the relevant documents (…) which has been retrieved" (Baeza-Yates & Ribeiro-Neto, 2011, p. 135). The more of the relevant documents are appearing in the hit list, the higher is the recall.

The F_1 measure is used for comparing the performance of different systems. Is is combining precision P and recall R into a single measure, according to this formula (Baeza-Yates & Ribeiro-Neto, 2011, p. 144):

$$F_1 = \frac{2}{\frac{1}{R} + \frac{1}{P}}$$

Because only two of the three systems apply ranking, the technical evaluation is not considering rank and thus not resulting in curves, but more alike classifier evaluation (Baeza-Yates & Ribeiro-Neto, 2011, p. 327): Each query is assigned with one number each for precision, recall, and F_1, representing the total number of retrieved documents. Another reason for this approach is the finding that music researchers often want to examine the collection as a whole, which means that they are interested in finding all the relevant documents, not just a few of them that are ranked highly. Thus, the whole number of retrieved documents has to be examined. Under those circumstances, the recall for a successful search should be 100%.

When a large number of documents is retrieved, the ranking, on the other hand, has to be taken in account: "(...) the quality of the first documents in a retrieval set is much more important that the quality of the rest of the list" (Fluhr et al., 2006, p. 302). In those cases, I indicate and discuss the number of false positives among the first 20 hits.

The results of this experimental performance evaluation are analyzed and finally set in relation to the results of surveys and interviews, to discuss the capabilities of each discovery system regarding the fulfillment of music researchers' information needs.

3.3 Ethical considerations

To maintain good research ethics, the participants of surveys and interviews were informed of the purposes of my research at all times. Since the surveys were anonymous, I did not collect personal data of the participants in a traceable form. In those cases when I had to, for example when requesting e-mail addresses for interviews, I built in an informed consent form (Bryman, 2012, p. 131) into the survey, in which I described the terms and conditions of data use and storage according to GDPR and current standards at Borås University. Without agreeing, the participants could not enter their e-mail addresses. Both surveys started with a clearly structured, informative introduction about my thesis project and me (see Appendix I). I had this checked by several people who have not been involved in my study at any point. To be sure that every participant could understand the conditions, as well as to enable them to phrase their thoughts, as accurately and unambiguously as possible, the surveys were available in three languages: English, German, and Swedish. The participants chose their preferred language themselves.

The interviews could not be held anonymously. Here, the emphasis lies on confidentiality. True names of the candidates are not mentioned in this thesis, and any information that might be traceable to a person is anonymized. The interview participants have all been informed again about the study's purpose via e-mail and signed another informed consent form in advance. Before starting the recording of the interview, I asked them for their consent again and told them about the possibility to end the interview at any point, if they should feel uncomfortable about anything. Even the interviews were held in the language preferred by the participant.

Thus, I ensured that all participants of surveys and interviews did so of their own free will, knowing at all times what the information they provided would be used for. During the experimental stage, no other person but me was involved. All three libraries have agreed to the undertaking of this study and assisted in distributing the first survey to their users.

3.4 Objects of investigation

There are many different online access systems in use for digitized music manuscript. I chose to study three of them:

- Searching the collection "*Schrank II*" at *Sächsischen Landesbibliothek - Staats- und Universitätsbibliothek Dresden* (SLUB) via the library's online catalogue for digital collections (https://digital.slub-dresden.de/kollektionssuche/)[1].

- Searching the collection "*Utile Dulci*" at *Musik- och teaterbiblioteket Stockholm* (MTB) via the library OPAC (https://discover.musikverket.se/cgi-bin/koha/opac-

[1] This link might not lead to the right collection. See chapter 3.1 for explanation.

search.pl?q=utile+dulci#_ga=2.223028382.48251460.1583231391-1824306627.1582019325).

- Searching the *Düben collection* at *Uppsala University Library* (UUL) via The Düben Collection Database Catalogue (DCDC, https://www2.musik.uu.se/duben/Duben.php).

I chose those three collections, because they each represent a type of discovery system that is commonly used by libraries for digitized music manuscripts: One where the collection is included in a discovery system for different digitized materials, one where the collection is included in the library's general OPAC, and one specially developed for that specific collection only. Each approach has advantages and disadvantages on an organizational level, but that is not the subject of this thesis. In addition, all three collections have been catalogued according to RISM standards in their metadata categories (http://www.rism.info/en/organisation/rism-for-libraries.html), which allows me to compare their search functions properly.

> The search system supports information seeking by structuring knowledge and constraining access. The way that knowledge is organized and made available affects the way that information seekers are able to access this knowledge and thus their information-seeking performance (Marchionini, 1995, p. 38).

Because of this impact of the search system on the information seeking process, I will first describe how a user will approach the three collections, giving an overview on the design and search possibilities of all three discovery systems. By that, I hope to give you an impression of the different approaches music researchers are confronted with in their task of finding digitized music manuscripts. The user is "most concerned with the content of a database" (Marchionini 1995, p. 39) and not the physical *container* (Marchionini 1995, p. 41), which is why the technological solutions have not been in focus, even if I mention them in the description to give a complete view. Emphasis was on following questions, which I phrased to depict desirable and undesirable aspects within the interactive design according to Rogers et al. (2015, p. 22ff):

- How many clicks does it take to find the search interface on the library's website? While the number is giving some indication on the effort it takes to find the collection, it is not the whole truth. Possibilities to choose the wrong path are therefore also named.

- How clear is the design of the search interface? Here, the main aspect is visibility of the important features, which is seen in combination with the amount of distraction on the page.

- Which search possibilities are there? This aspect is both a matter of design and technical solutions. In this description, the focus lies on the availability of functions like a free text field, the possibility to exclude things from the search, and the ways in which queries can be expressed.

- How are the results presented? Since the results are the goal of the whole search process, it is most important which information is shown to the user, what contents are available, if and in what form ranking is applied, and how easily identifiable the music manuscripts are.

3.4.1 *Schrank II* Dresden

The collection *Schrank II* is named after a cabinet from the time of the Polish-Saxon union (1697-1763) in the court church at the royal castle in Dresden. In this cabinet, music manuscripts containing mainly instrumental music by internationally and locally known composers, intended for being played from by the court chapel, were kept. The cabinet is long gone, but the music manuscripts have been integrated into the music collections at the royal library and later into the collections of the SLUB. In 2008, a project financed by the *Deutsche Forschungsgesellschaft* (DFG) was launched to explore and digitize the *Schrank II* collection. For metadata capture according to RISM standards, the software *Kallisto* has been used, and for Internet presentation the software *Goobi*, developed by Göttingen University and SLUB specifically for the presentation of high-resolution images in combination with rich metadata (Bemmann & Voss, 2020). Goobi, which is an entirely open-source software, based on METS and MODS XML standards, has in the meantime changed name and is now found under *Kitodo* (http://www.kitodo.org/).

When entering the library website (https://www.slub-dresden.de/startseite/), the user can find a clearly visible link to the digital collections, and there gets to a nice overview over the library's digital collections with inviting images (see figure 1, https://digital.slub-dresden.de/kollektionen/). One of the images, showing a violin, is captioned "Musik", but when you choose that link, it leads you directly to all the music in the library; there, you would have to enter "Instrumentalmusik der Dresdner Hofkapelle" in the search field to get to the right collection, entering "Schrank II" doesn't produce any hits.

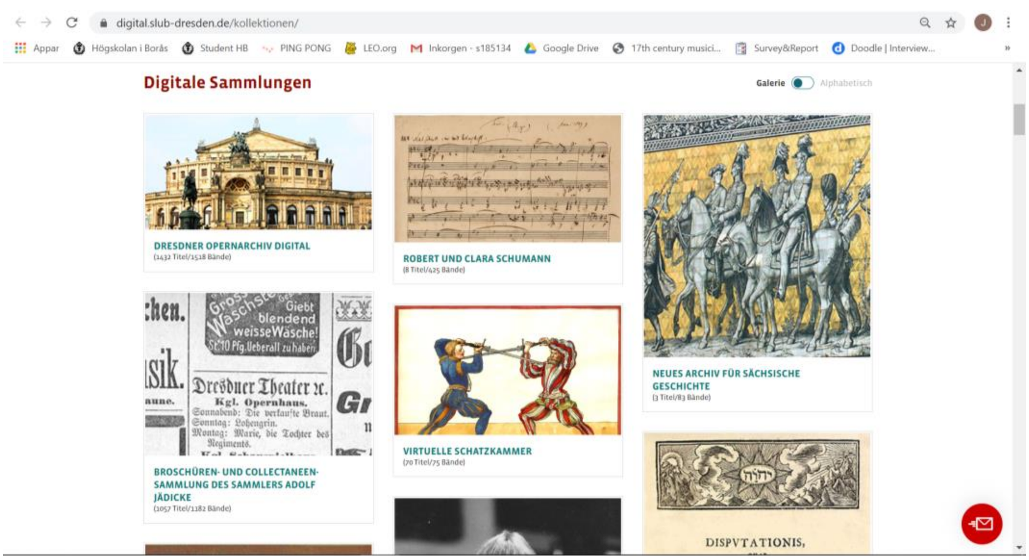


Figure 1: Screenshot from the website for digital collections at SLUB, taken from https://digital.slub-dresden.de/kollektionen/ 2020-05-10.

Back to the overview page on digital collections, there is an image showing four gentlemen ready to play a string quartet, captioned "Instrumentalmusik der Dresdner Hofkapelle". This is the right link to follow when you want to search the *Schrank II* collection. If you know where to look, it takes two clicks to get to the right place. On the downside, a user could easily get confused and follow the wrong link, even more so because the images and links on the overview page are changing place each time you visit the page. Saving the link to the search page for the *Schrank II* collection (https://digital.slub-dresden.de/kollektionssuche/) unfortunately is not a helpful way of creating a shortcut, because it automatically leads you to the last digital collection you have been visiting, not always to the *Schrank II* collection. If you are using different digital collections at the library, there is no way of bookmarking this specific one. If you have not been visiting any of the collections before, the link will show an empty result page within the SLUB collection search.

If you choose "Sammlungen" in the main menu and then follow the link "Musik" in the drop-down menu, you get to a list of music collections (https://www.slub-dresden.de/sammlungen/musik/). The link "Hofmusik" is leading to the *Hofmusik* project page (https://hofmusik.slub-dresden.de/), in which "Schrank II" is one of three possibilities to move further. Via that link, you get to the *Schrank II* project website (https://hofmusik.slub-dresden.de/themen/schrank-zwei/). If you click on "Recherche" in the main menu, you find a description of all the possibilities how to search the collections (https://hofmusik.slub-dresden.de/recherche/). Within this text, a link named "Schrank II" is found, which leads you to the search interface (https://digital.slub-dresden.de/kollektionssuche/). This way, you need four or five clicks to get to the search interface for the collection.

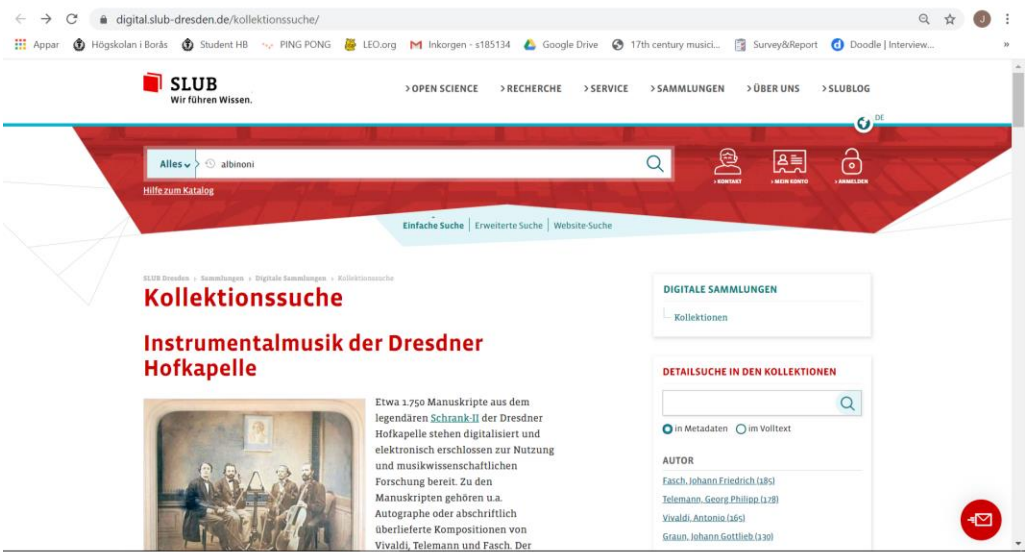


Figure 2: Screenshot from the website for digital collections at SLUB, taken from https://digital.slub-dresden.de/kollektionssuche/ 2020-05-10.

On the search page (figure 2), you have to be careful not to use the catalogue search field on top of the page, or your search will be conducted within all documents in the entire library. In the right-hand menu, there is a specific search field for the collection, captioned "Detailsuche in den Kollektionen". Here, you can search the collection by means of a free-text field. As soon as you enter the third letter, a drop-down menu with suggestions, all starting with those three letters, appears. The field allows combinations of search terms. Boolean queries, which would make it possible to exclude things from the search results, seem at first glance possible. A quick test reveals, though, that exclusion does not work; if I search for "(vl 1) AND (vl 2) NOT (ob)" ("vl" being the standard abbreviation for violin, "ob" for oboe), there are still pieces listed that contain oboe parts. The number of hits does not change, no matter whether I use Boolean operators or not. If I use quotation marks instead of brackets, there are not any hits at all.

The search results are presented in a list (figure 3), which can be sorted according to the user's preferences. The default setting is ranking by relevance. How the relevance of the hits is established is not immediately obvious, but since the algorithm in the open-source software has been developed for all kinds of digitized documents, not specifically music, it does not surprise that the ranking is not according to any musical aspects. For each hit, the list is showing a thumbnail image of the front cover or, in case there is none, the first scanned page, beneath a heading, consisting of basic content information and the library signature, as well as some more bibliographic information. It becomes clear that this view wasn't designed for music manuscripts in the first place, as the shown categories in the bibliographic information contain, besides the author, publication place (not relevant for manuscripts) and date (often hard to estimate), as well as license information (not relevant for older materials) and the type of material (in this collection mostly manuscripts). Except for the genre information in the heading and the abbreviation "Mus." in the signature, nothing is telling the user that this manuscript is containing music.

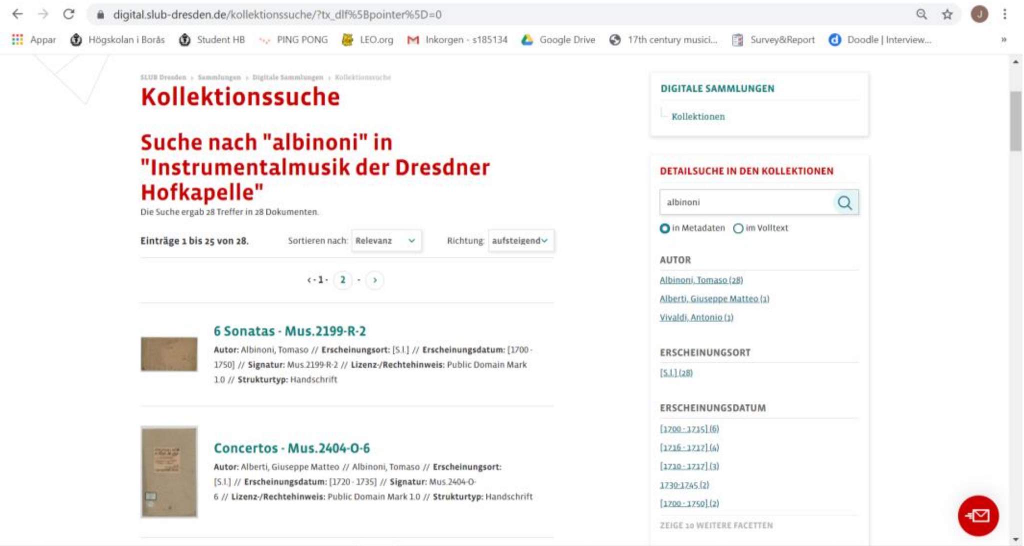


Figure 3: Screenshot from the website for digital collections at SLUB, taken from https://digital.slub-dresden.de/kollektionssuche/ 2020-05-10.

When one hit is chosen, the view is nice and clear, with impressive possibilities to zoom in on the high-resolution images (figure 4). On the left side, metadata is shown, followed by a list of contents, which allows the user to navigate directly to different parts of the manuscript. That is extremely helpful. On the other hand, even here, the metadata categories are not well adapted to music materials; information about instrumentation or opus and work catalogue numbers is gathered under the rubric "Untertitel". This information is not shown in the hit list, which is potentially problematic. Some composers of that era (like Telemann or Vivaldi) have been the authors of a great number of pieces from the same genre. For example, the first 49 hits in a search for Vivaldi are all called “Concertos”, followed by the library shelf number. What if I do not know the library shelf number of the piece I am looking for?

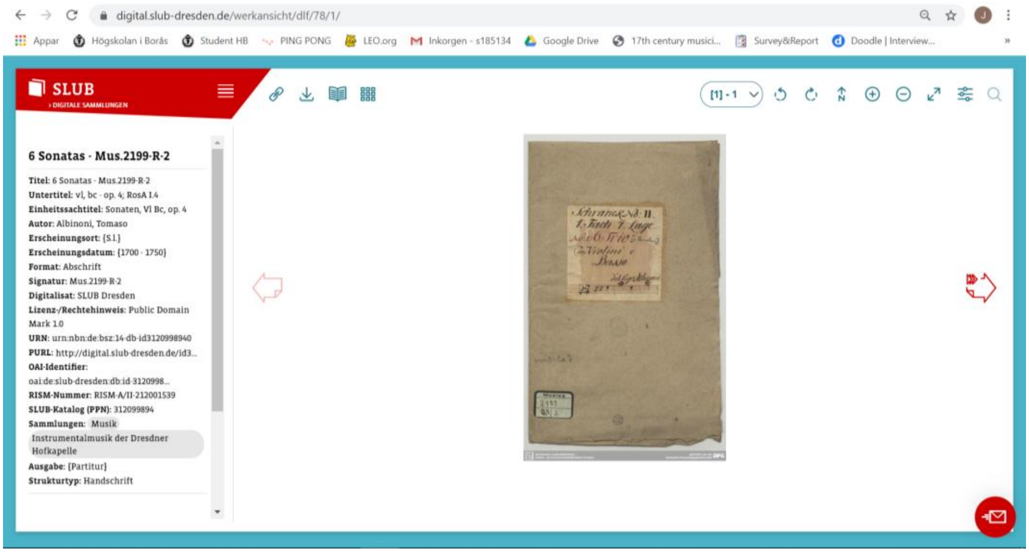


Figure 4: Screenshot from the website for digital collections at SLUB, taken from https://digital.slub-dresden.de/werkansicht/ 2020-05-10.

Overall, the design is rather clear and intuitive, though there are some major drawbacks when it comes to the specific properties of music materials, and there are a few issues that might be confusing when somebody is using the website for the first time. On the other hand, in the research instructions on the project website (https://hofmusik.slub-dresden.de/recherche/), the users are advised to search for the music materials via the RISM OPAC, which is designed specifically for older music sources and providing many detailed search alternatives (http://www.rism.info/de/service/opac-suche.html). There, all the music materials at SLUB are contained and can be reached directly from the RISM post via link.

3.4.2 *Utile Dulci* Stockholm

The collection *Utile Dulci* at MTB Stockholm contains the remains of the cultural society with the same name, which was founded in Stockholm in 1766. This society, active within the fields of music and poetry, had the aim to combine usefulness with pleasure, as the Latin name indicates, and consisted mainly of upper-class amateur poets and musicians. The music manuscripts and prints used in the music division of the society were collected in a music library that, presumably around 1806, was incorporated into the library of the Royal Academy of Music, which later became one of the components of the MTB (see Heintz, 2011).

When the collection first was digitized, a special database and retrieval system was designed in PHP and MySQL, which was published a few years prior to 2011 (Heintz, 2011, p. 15). This system, though, is not available anymore, due to data security and data preservation issues; it was taken offline in 2019. Instead, the materials are now found via the MTB's general OPAC, which is based on the open-source library software *Koha* (https://koha-community.org/). While I, who has been in contact with librarians and the developer of the original system, know this, information about the digitization process is otherwise nowhere to be found.

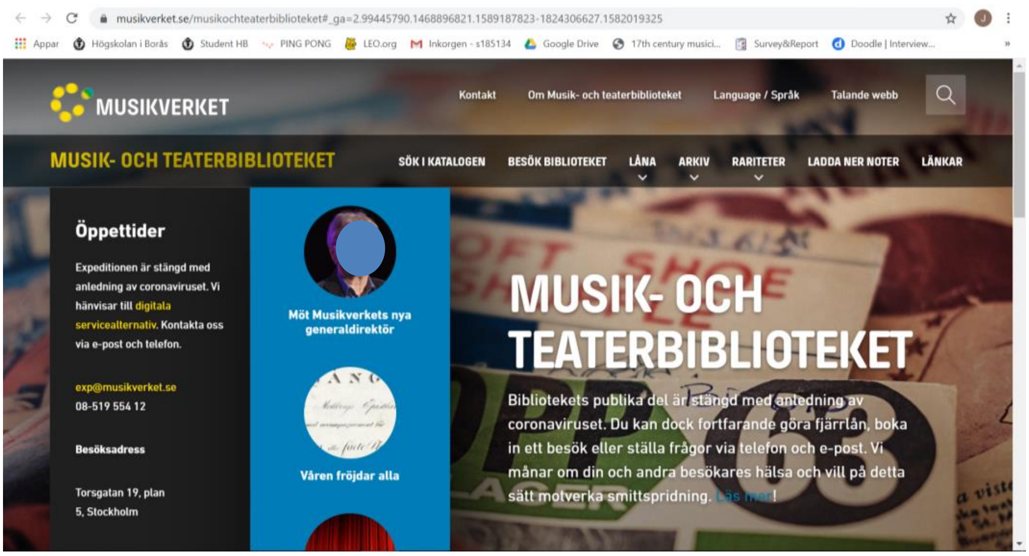


Figure 5: Screenshot from the website for MTB, taken from https://musikverket.se/musikochteaterbiblioteket 2020-05-10.

When the user enters the MTB website (figure 5), there are two possible ways of finding the *Utile Dulc*i collection. You can press "Sök i katalogen" (Search the catalogue) and enter the search term "utile dulci" in the catalogue search field (figure 6), or you can choose "Ladda ner noter" (Download sheet music) and find four images, one of them with the caption "Utile Dulci" and a little information about the collection. Clicking that link, you will get to the same search interface as via the link "Sök i katalogen", with the search term "utile dulci" already inserted, showing the results in a list ranked by relevance (figure 8).

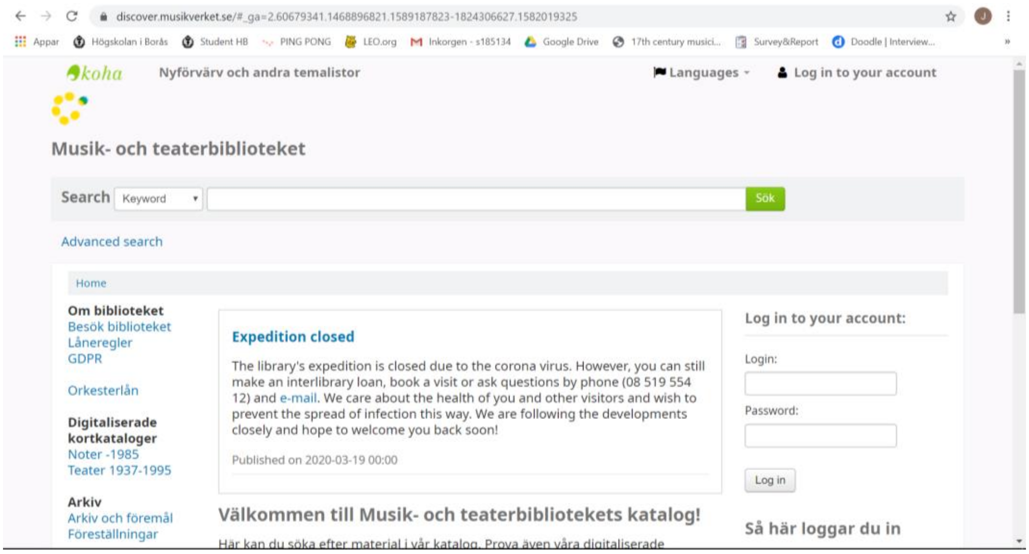


Figure 6: Screenshot from the MTB OPAC catalogue, taken from https://discover.musikverket.se/ 2020-05-10.

If you know what to look for, it takes you only two clicks, or one and the right search term, to reach the collection. Note, though, that it is not possible to find the collection via the link "Rariteter" (Rare materials). Since the materials in the Utile Dulci collection mainly are rare, some of them even unique, I find this rather confusing. In addition, the link found under "Ladda ner noter" only works in the Swedish version of the website. Change the language to English, and "Search the Catalogue" is your only option, because the link under "Download Sheet Music" is not up to date, still linked to the old database address.

The search interface is clearly structured, with a rather uninspired, yet intuitive design. One drawback for English-speaking users is that some words, links, and headings have not been translated from Swedish. There is the possibility to use the free text field, which does not allow Boolean operators, but will automatically combine search terms with AND, if you write in several. Truncating words with * or ? is not possible, which implies that some kind of *exact match* strategy is applied in the retrieval process, but that doesn't become clear from the user interface. You can also choose the option "Advanced search", where a structured search is available, offering the combination of terms with "and" only. There is no way of excluding things from the search. The structural options are *Keyword*, *Subject*, *Title*, *Author*, *Publisher*, *Publisher location*, *ISBN*, and *Barcode*. The results can also be limited to certain types of material. Although the catalogue belongs to a library specialized in music, there are no search options for musical facets, and the structural options are to a large part irrelevant or not existing for music manuscripts (figure 7).

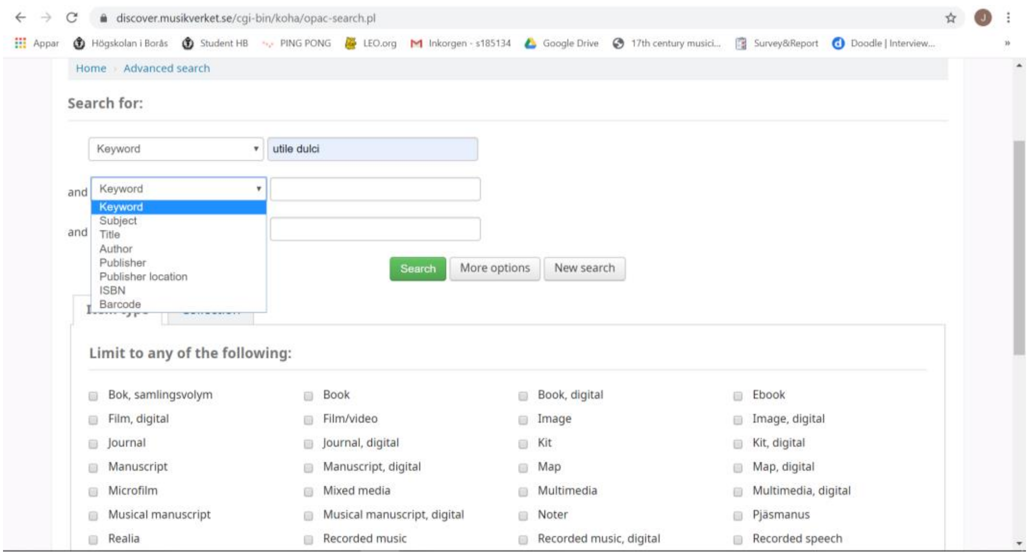


Figure 7: Screenshot from the MTB OPAC catalogue, taken from https://discover.musikverket.se/cgi-bin/koha/opac-search.pl 2020-05-10.

The results are shown in a ranked list that can be sorted according to the user's own preferences. The default ranking is by relevance; even here, an algorithm not primarily developed for music materials distinguishes the relevance. Every position is containing a transcription of the original title and additional metadata put in square brackets, presumably to make it searchable (figure 8).

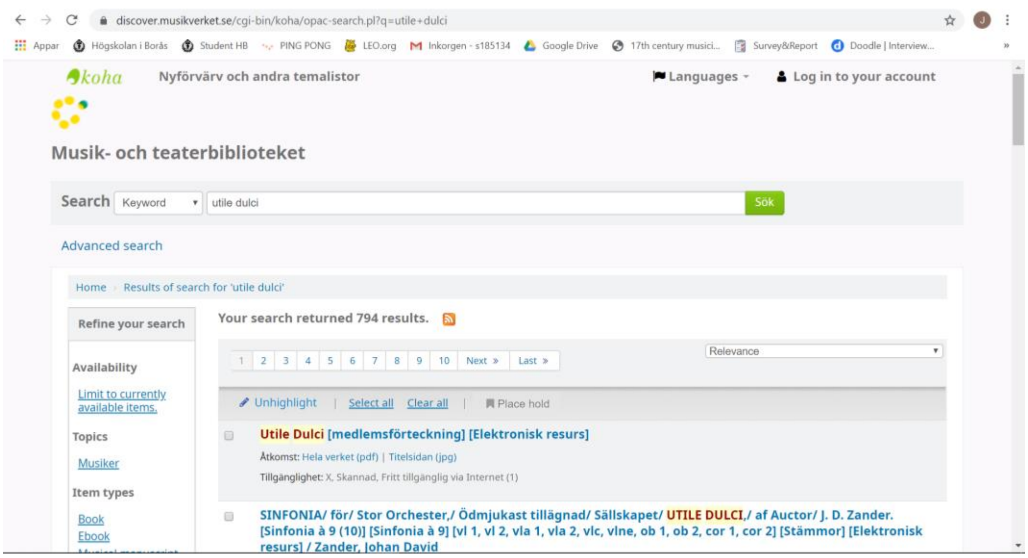


Figure 8: Screenshot from the MTB OPAC catalogue, taken from https://discover.musikverket.se/cgi-bin/koha/opac-search.pl?utile+dulci 2020-05-10.

If you click one of the links, you see that the information included in the title is about all you will get when it comes to metadata (figure 9). The statement that there are no physical items for this record is wrong, of course there are. All the physical items belonging to the *Utile Dulci* collection are in possession of the MTB. By searching this catalogue, you will only find the digital post, though. If you are interested in the actual physical item or need the shelf number for another reason, you have to conduct your search in another catalogue, found under the link “Digitaliserade kortkataloger: Noter -1985” (Digitized card catalogues: Music -1985, see figure 6), which is not available in English.

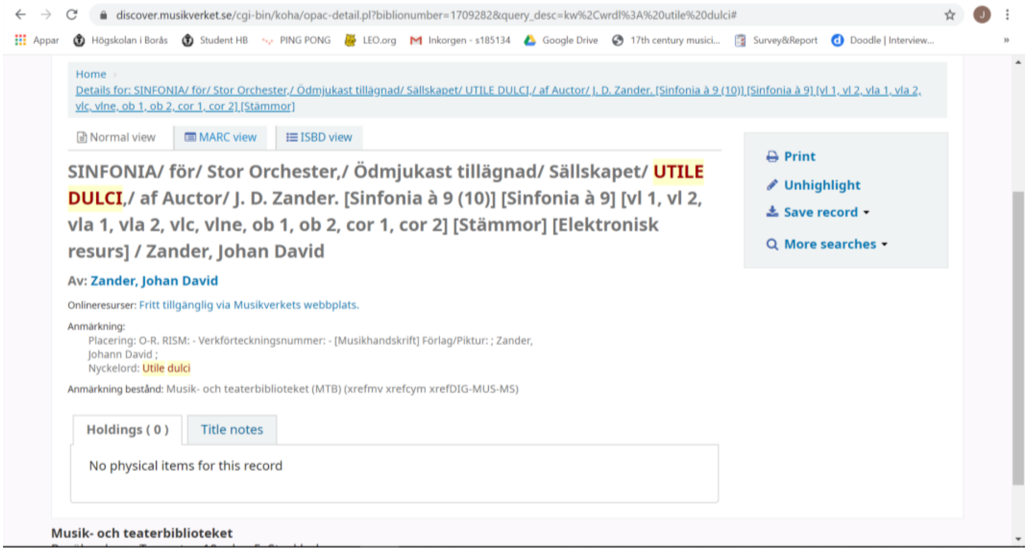


Figure 9: Screenshot from the MTB OPAC catalogue, taken from https://discover.musikverket.se/cgi-bin/koha/opac-detail.pl 2020-05-10.

The digitized material is found by clicking on the link “Fritt tillgänglig via Musikverkets webbplats” (Freely available via Musikverkets webspace; MTB is a part of what is called “Musikverket”). Here, you get a PDF file containing the scanned images, without further information or metadata (figure 10). The scans are made in black-and-white and become rather dotted when zooming in, which evokes the suspicion that they might have been made from Xerox copies, not the original material. This suspicion, though, cannot be proven, since there is not any information about image capture.

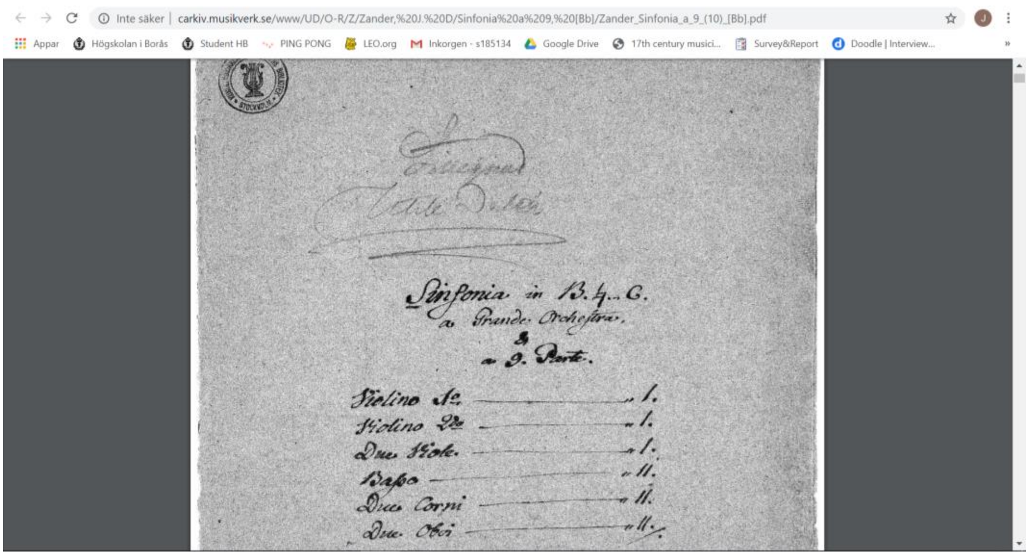


Figure 10: Screenshot from the MTB OPAC catalogue, taken from https://carkiv.musikverket.se/ 2020-05-10.

Summing it up, the search interface for the *Utile Dulci* collection has massive design issues. To the library’s defense, it has to be mentioned here that the present solution is a highly provisorical one. Since the old database had to be taken offline, the library has been applying for resources to rescan all the materials, as well as to develop a new digital catalogue system that is more fitting for their needs as a music library and providing a proper online presentation of the digital images. Funds have recently been granted, so that we can look forward to improvements within a near future (David Jansson, responsible librarian for digitization at MTB, in a telephone call 2020-02-14). That is not a full excuse, though, for the poor design of the website and the missing translations.

3.4.3 Düben collection Uppsala

A similar MySQL and PHP database to that once designed for the *Utile Dulci* collection still is in use when it comes to the Düben collection, showing that, from the user's perspective, oldest is not always worst. Court chapel master Gustav Düben has gathered this large collection of music manuscripts during the second half of 17th century at the royal court in Stockholm. In 1732, Gustav Düben's son Anders donated the collection to Uppsala University Library. Containing around 2.300 compositions, this manuscript collection is one of the largest preserved music collections from that era in the world (https://www2.musik.uu.se/duben/DubenCollectionInfo.php). Already in 1987, plans for a digital database catalogue of the collection were made, and in 1991, the project started as a cooperation between Uppsala University and Eastman School of Music, Rochester University. In 2006, the database was published in its present form and filled with further content until 2017. During the long time of construction, data was transferred from one technological system to another, starting with D-Base 3, Paradox, and Access, ending up in MySQL and PHP (https://www2.musik.uu.se/duben/DubenProjectInfo.php and Kjellberg, 2007).

The search interface for this collection has been designed to match the contents, not to be compatible with other contents or other systems. The target audience have always been music researchers (Kjellberg, 2007), which is why the level of metadata is very rich. Almost every kind of metadata is searchable in a content-and-structure (CAS) search, which means that not only the content of the query is defined, but also the part of the structure in which the query shall be applied; in this case, you can search for the composer's name in the field "Composer" only, for title words in the field "Title" only, for musical medium in the field "Scoring" only, and so on.

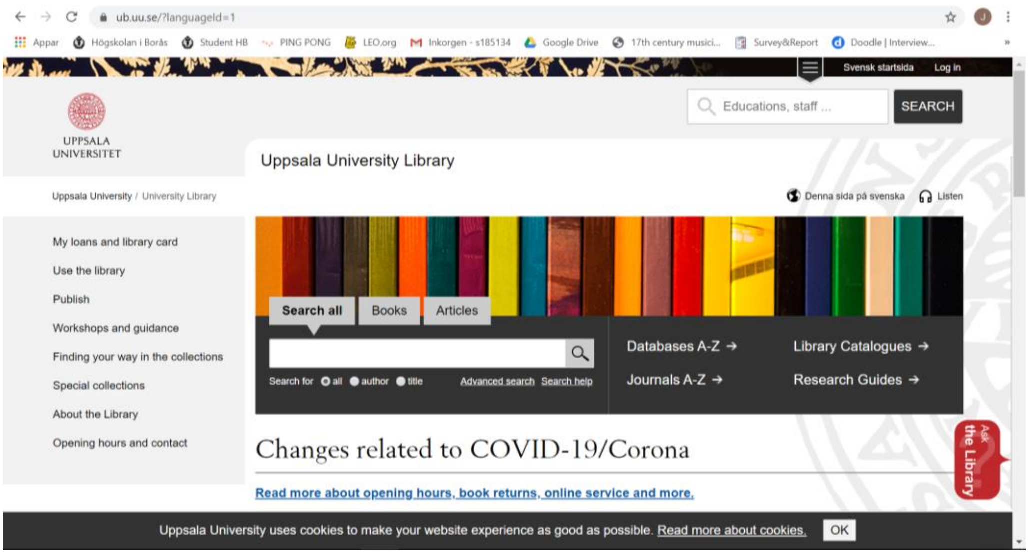


Figure 11: Screenshot from the UUB website, taken from https://ub.uu.se/languageid=1 2020-05-10.

When arriving at the website of the UUL (figure 11), it might not be completely obvious to the user where to go to find the Düben collection. Yet, if you try the link "Special collections", and from there "Digital collections", you get to a clearly structured overview page with captioned images and instructive headings. If you scroll down on the page, you find the link "Düben Collection" under the heading "Music" (figure 12). A click on the caption gets you directly to the website of the Düben collection, where the search interface is found in the left sidebar (https://www2.musik.uu.se/duben/Duben.php).

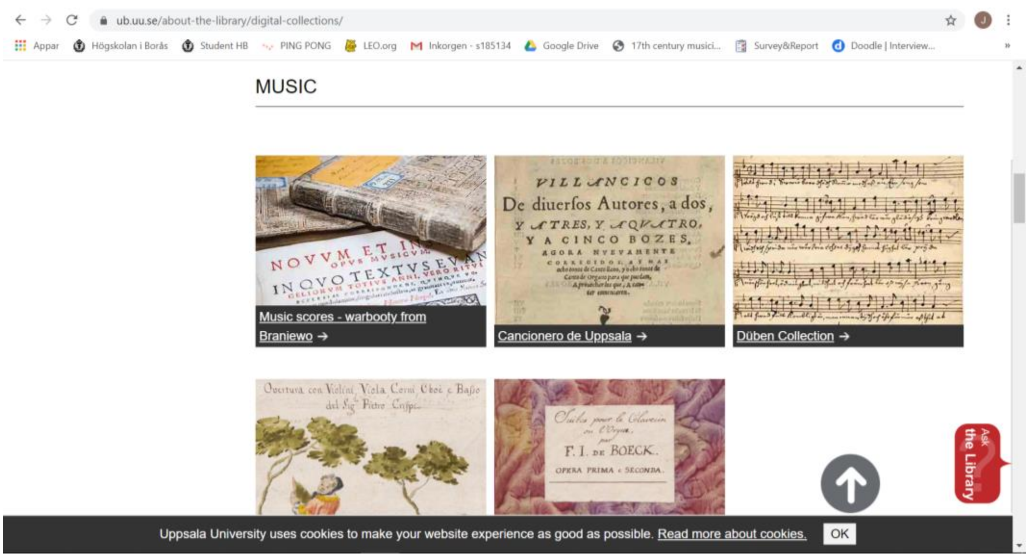


Figure 12: Screenshot from the UUB website for digital collections, taken from https://ub.uu.se/about-the-library/digital-collections/ 2020-05-10.

Even if you do not know where to start and choose a different path, you need the same number of clicks to get to the Düben collection: Pick "Finding your way in the collections", click on or scroll down to "Music", and "Düben Database" is the second link in the list. This way might be even faster, because you end up directly on the basic search page (figure 13), skipping the welcome message and "about" page that normally appears first when entering the Düben database. Either way, it takes three clicks to find the collection, which is a little more than on the other two library websites in this study, but on the other hand, the user cannot easily go wrong when not exactly knowing where to look.

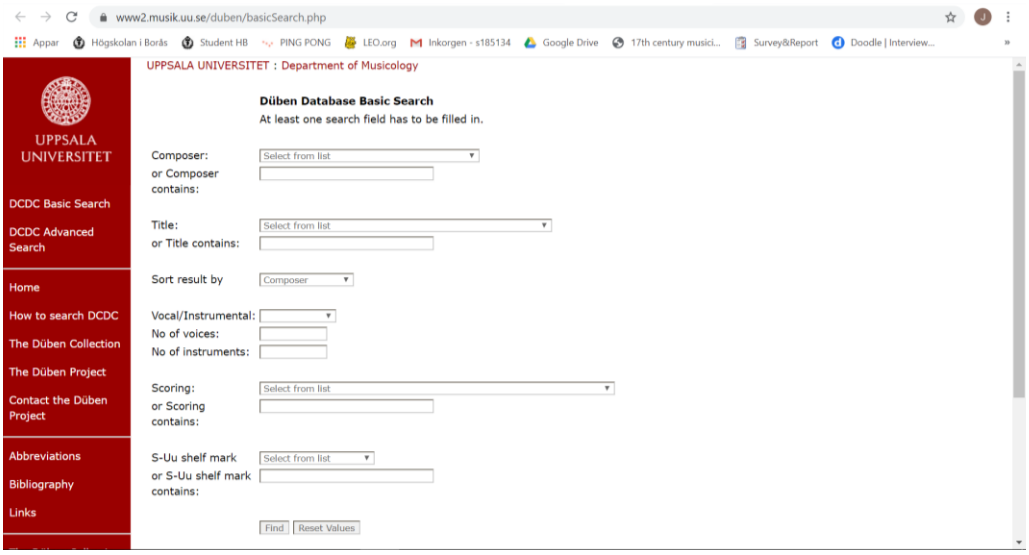


Figure 13: Screenshot from the Basic search interface for the DCDC, taken from www2.muik.uu.se/duben/basicSearch.php 2020-05-10.

This search interface gives a rather old-fashioned impression, reminding of libraries' online catalogues during the 1990s. There is no free-text search field, and you have to choose in the search step already how you want the results to be sorted. Here, sorting by relevance is not an option, only by composer, title, or shelf number; composer being the default setting. Each search option can either be written in a free-text field, or chosen from a drop-down list; within the drop-down list, you can jump to the right entry by typing the first letters. You can search by one option only or combine as many as you want. There is not any possibility to exclude things from the search, except via the fields "No of voices" or "No of instruments". If you want to search for pieces for one violin only, not all the pieces that contain a violin (which would be nearly all of them), you can set the "No of instruments" to 1, the "No of voices" to 0, and you will find all the pieces for only one violin. The function has a binary feel to it, without any attempt of ranking; either the document contains what you are looking for, and then it is retrieved, or it does not, and then it is not retrieved.

Already in this "basic" search, the options are clearly designed for the discovery of music and nothing else. If you choose "Advanced Search", there are so many fields that you have to scroll down to see them all (figure 14). Several of the search options would be comprehensible for researchers only, and some of them not even to them, if they are not well informed about the Düben collection already, for example "G Düben ink no". For most of the search options, you can choose if you want hits that begin with the text you enter, or if you want them to contain the text you enter, all within the given structural category. You also can choose to combine two search terms within the same category, either with the operator AND or OR. NO is not an alternative, so that the only way of excluding anything remains the procedure described above for the basic search.

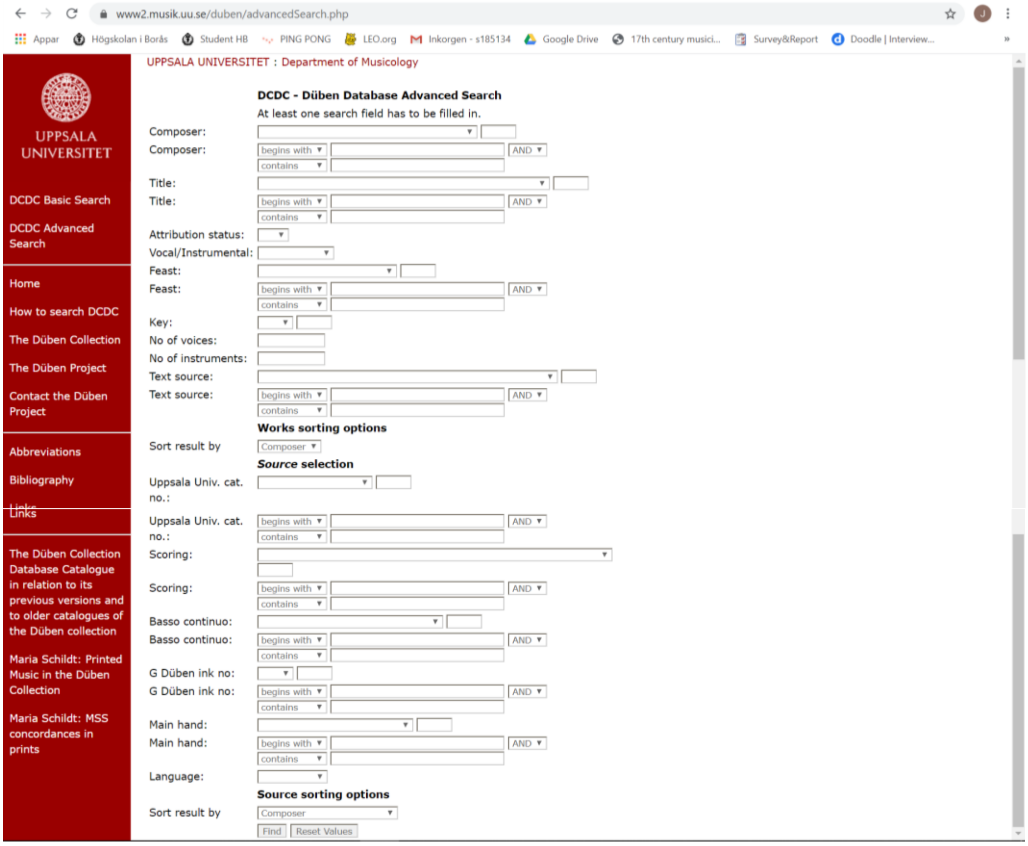
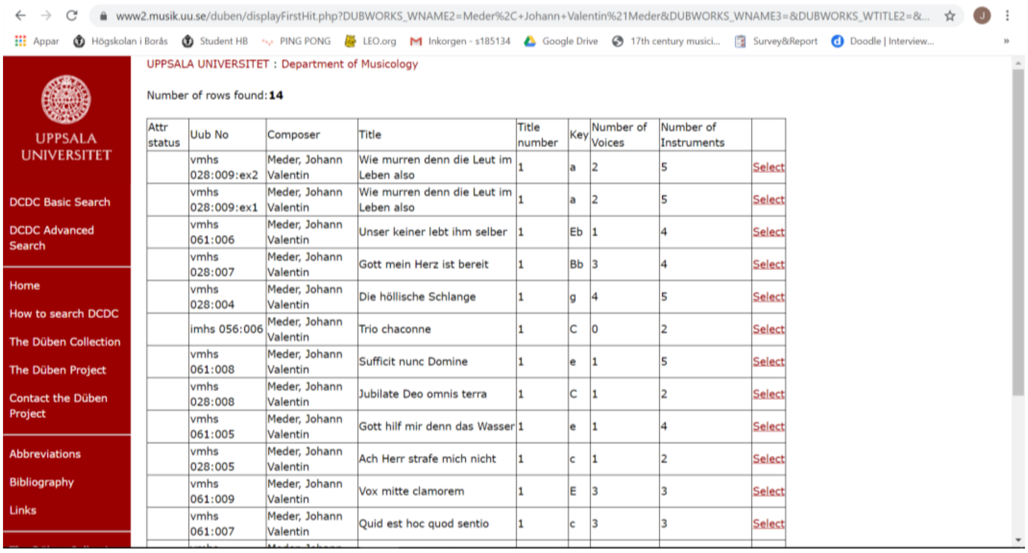


Figure 14: Screenshot from the Advanced search interface for the DCDC, taken from www2.muik.uu.se/duben/advancedSearch.php 2020-05-10.

When the search forms look old-fashioned, this goes even more for the presentation of the results. The hits are listed, sorted by the chosen category, in a plain table with a link marked "Select" at the end of each row. In addition to the composer and the title, the displayed information contains the key, the number of voices and instruments, as well as the shelf number (figure 15).



Attr status	Uub No	Composer	Title	Title number	Key	Number of Voices	Number of Instruments	
	vmhs 028:009:ex2	Meder, Johann Valentin	Wie murren denn die Leut im Leben also	1	a	2	5	Select
	vmhs 028:009:ex1	Meder, Johann Valentin	Wie murren denn die Leut im Leben also	1	a	2	5	Select
	vmhs 061:006	Meder, Johann Valentin	Unser keiner lebt ihm selber	1	Eb	1	4	Select
	vmhs 028:007	Meder, Johann Valentin	Gott mein Herz ist bereit	1	Bb	3	4	Select
	vmhs 028:004	Meder, Johann Valentin	Die höllische Schlange	1	g	4	5	Select
	imhs 056:006	Meder, Johann Valentin	Trio chaconne	1	C	0	2	Select
	vmhs 061:008	Meder, Johann Valentin	Sufficit nunc Domine	1	e	1	5	Select
	vmhs 028:008	Meder, Johann Valentin	Jubilate Deo omnis terra	1	C	1	2	Select
	vmhs 061:005	Meder, Johann Valentin	Gott hilf mir denn das Wasser	1	e	1	4	Select
	vmhs 028:005	Meder, Johann Valentin	Ach Herr strafe mich nicht	1	c	1	2	Select
	vmhs 061:009	Meder, Johann Valentin	Vox mitte clamorem	1	E	3	3	Select
	vmhs 061:007	Meder, Johann Valentin	Quid est hoc quod sentio	1	c	3	3	Select

Figure 15: Screenshot from the search result display for the DCDC, taken from www2.muik.uu.se/duben/displayFirstHit.php 2020-05-10.

From here, it is still quite a way to go until the user reaches the actual digital images. When clicking “Select”, you are first directed to a page about the work you selected, containing some information about the composition and a list of the sources in the collection for that particular piece of music (figure 16).

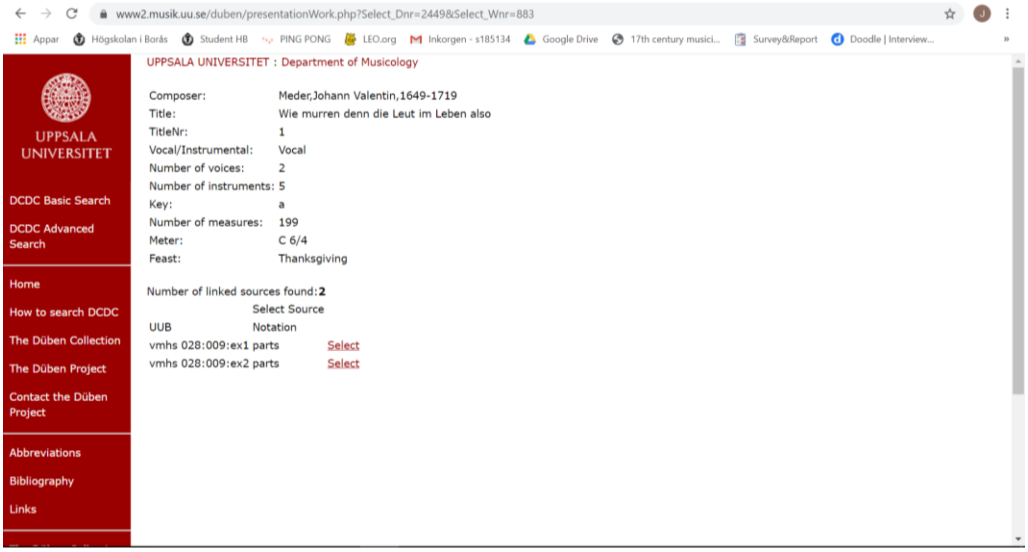


Figure 16: Screenshot from the search result display for the DCDC, taken from www2.muik.uu.se/duben/presentationWork.php 2020-05-10.

When choosing the source you want to see, you get all the metadata related to the specific source and a list of parts that belong to this source (figure 17).

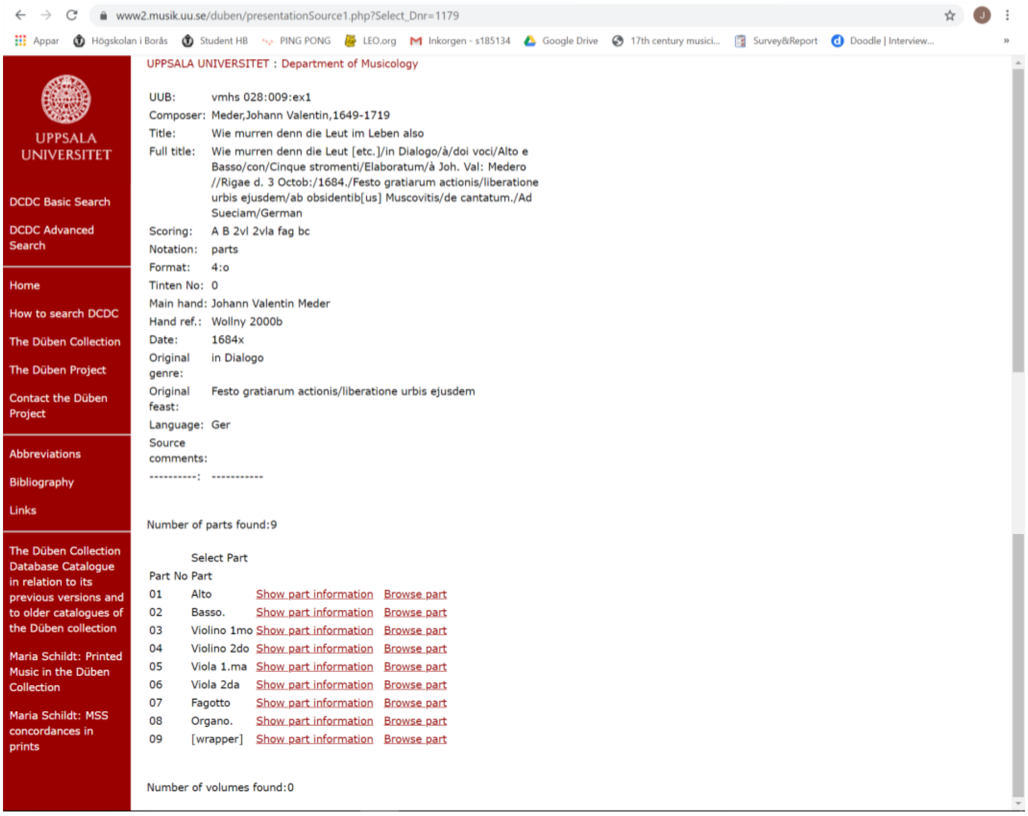


Figure 17: Screenshot from the search result display for the DCDC, taken from www2.muik.uu.se/duben/presentationSource1.php 2020-05-10.

Here, you can choose again - do you want to see all the part-related metadata, including copyist, watermark, page dimensions, and so on, for every single sheet? Then, click “Show part information”. Alternatively, do you want to get straight to the images? Then, click “Browse part”, and the images will finally be displayed (figure 18), not in a fancy viewer and not the whole source in one go, but equally plain and prosaic as the whole database is designed, each single part at a time. If you want to see all the pictures, it will take you more time, because you have to go back and forth between the “Source information” and the different parts, but if you want to see one specific part, you will find it much quicker than when the whole source is displayed in a fancy viewer. For zooming in or out, you have to download the image and open it in a picture viewer on your own device.

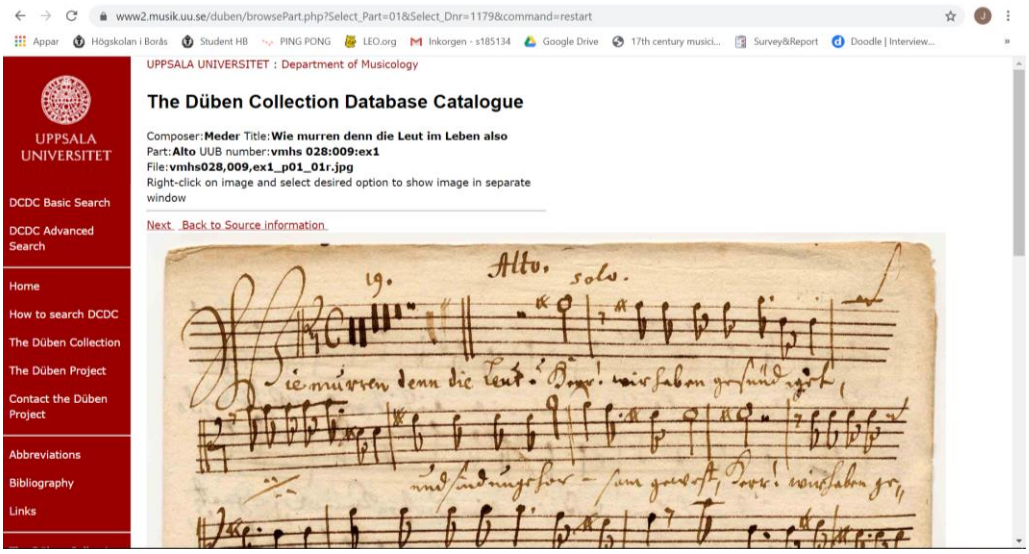


Figure 18: Screenshot from the image display for the DCDC, taken from www2.muik.uu.se/duben/browsePart.php 2020-05-10.

From the point you started your search in the collection to seeing the digital image, it takes four or five clicks, and that does not count those you need to find the collection in the first place. In addition, you have to put in quite some effort in learning how to handle the very specific search form. On the other hand, you receive a lot of information, and you can be entirely sure to find every document containing exactly what you entered as a search term, due to the binary function of the *exact match* system. The question is: Is this long and winding road worth the effort, from a music researcher’s point of view? Or do they prefer the quicker, less specific options in the other search interfaces?

4 Results and analysis

Here, the results of my surveys, interviews, and experiments are gathered and analyzed. First, I will present what the responses to my surveys and interviews could tell me about the information seeking behavior of music researchers and the queries they use when searching for digitized music manuscripts in online collections (chapter 4.1). Then, in chapter 4.2, the experiments I conducted for the technical evaluation of the three discovery systems are giving answers to the question how well the different systems are suited to fulfill those queries.

4.1 Stage 1: Surveys and Interviews

Because both surveys and interviews with protocol analysis were designed to explore the information seeking behavior of music researchers and the queries they use, I will analyze their results together (4.1.3). But first, I describe them separately: survey results in 4.1.1, interview and protocol analysis results in 4.1.2. The chapter is concluded by my thoughts on the appropriateness of the chosen methods.

4.1.1 Survey results

When it comes to research motives and purposes, three user groups can be identified from the first survey: musicologists who needed to explore the collections for research purposes, music editors who needed to find music sources for making editions, and musicians who needed to find music for concert projects. All of them found what they were looking for in the three collections, but some did encounter problems during the search: errors in metadata descriptions, getting used to the search interface (concerning the *Düben* collection), the search being “ponderous and not user friendly” (concerning *Utile Dulci*), and linkage problems. Two respondents were complaining about the circumstance that the old discovery system for the *Utile Dulci* collection had disappeared, which they experienced superior to the integrated catalogue search. One participant noted that the connection between the digitized *Schrank II* materials and the associated RISM catalogue post, where most of the music-related metadata is found, is hard to recognize.

When describing the search process, three different ways can be identified from the answers in the first survey. Some of the participants were looking for a specific piece of music, using the composer’s name and the work catalogue number or shelf number as a query. Others were interested in the collection as a whole, satisfied with seeing what it contained, which is why they stopped searching after having reached the collection and started browsing instead; one of them says that he or she is making use of the possibility to get informed about new additions to the collection via RSS feed. The third group were searching more thematically, mostly when trying to find music for playing in concerts. Then, they used different composers’ names or the ensemble size as a query. Two participants mention two of the three identified search processes, one searching either for a specific piece (not mentioning the query used) or for all the pieces by one composer in the collection, the other browsing the collection, sometimes examining trio sonatas only: "(...) jag har bläddrat i samlingen för att det är intressant att se vad som finns där, också inför ev. framtida konsertprojekt. Sen har jag stannat upp vid triosonater och plockat fram dem och kollat extra på dem."[2]

In the second survey, where the focus was entirely on search queries, it became clear that the *composer's name* is the most common search query for finding digitized music manuscripts: eleven of the 15 respondents account for using this query. Eight search for the *title of the piece*; four name the musical *genre* as a possible query. On the shared fourth rank of most mentioned search queries we find the musical *medium* (the instruments, voices, or ensembles required for playing the music), as well as *opus or work catalogue numbers*. Also appearing in the answers as possible search queries were *watermarks, date of origin, text language,* and *key*.

Even though the question was explicitly for search queries, several respondents used the open-ended field to comment on other facets of their search process, especially when they mainly browsed collections or, on the opposite, knew exactly where to find what they needed. "I do not use queries, I use specific manuscripts in specific collections" was one remark. One participant acknowledges that the fact of existing digitized collections at a library is not always previously known: "Main query is going to the library to see actually if they have digitized their manuscripts. Most will have a specific link to the manuscript collection." Two others mention the RISM-OPAC as their starting point for music manuscript research, one of them describing the situation when this is the case: "This is, of course, for materials that one does not know where they are to be found, but it takes knowledge of composer, work, and direct line of inquiry. This is quite difficult to navigate, particularly since RISM does not generally make assumptions about issues of authorship." The same person also mentions acquiring help from library staff and the possibility to ask for the digitization of physical manuscripts: "The final line of query is to ask the librarians there to send a digitized link or download for manuscripts not already done."

A specific problem was described by one participant, who highlighted the missing option in as good as every existing access system for music manuscripts to distinguish between male and female composers, which is making gender-based research difficult.

Summing up the results of the two surveys, we can state that there are three different ways how music researchers are looking for music manuscripts in digitized collections:

[2] Translation: "(...) I have been scrolling through the collection because I find it interesting to see what it contains, even possible future concert projects in mind. Then, I dwelled on trio sonatas, which I retrieved and took a closer look on."

1. Often they know in detail what they are looking for and where the manuscript is found. Then, they prefer to use *library shelf numbers* or other distinct identifiers to get to exactly the right source.

2. Sometimes, they want to get an overview on the collection. Then they stop their search at finding the collection, continuing by browsing the collection's contents.

3. In other cases, wider search queries are used, for example in the search for concordances, for music to play in a concert, for music with the same text, for all the sources representing one composition, or for all the music by one certain composer. Then, the most common search query is the *composer's name*, followed by the *title of a piece*, the *genre*, and the musical *medium*. More seldom, depending on the context of the research, it can be of interest to search for *watermarks*, *keys*, *year of origin*, or *text language*.

4.1.2 Interview and observation results

Luckily, the people volunteering for an interview were from different fields within music research. In addition, some of them were more and some less experienced within both music research and the use of Internet resources. They were three men and two women, three (one woman and two men) above the age of 60, two (one woman and one man) at around 40. Two of the men were very experienced with computers and the Internet, one man and one woman knew how to use search interfaces, but did not have more detailed knowledge, and one woman hardly possessed any digital literacy at all. In terms of music research, there were two Ph. D. students, one musicology professor, one musician, and one person with a hobby in music research. With such a broad distribution in different aspects, I could assume rather unbiased results, despite the low number of participants.

As described above, five interviews have been conducted, one of them in writing, three with observations and protocol analysis. Because they are concerning different collections and search interfaces each, the results will be presented below for one collection at a time.

About the *Schrank II* collection, I was allowed to interview and observe a 76-year-old, male Ph. D. student in musicology who has been doing research in music for a couple of years and is well acquainted with using the Internet. I call him Ephraim, which is not his real name.

Ephraim showed me how he has found an old music print in the SLUB's digital collections via RISM. The problem with this print, a compilation of many pieces in several volumes, is that it is lacking a table of contents, in the printed source as well as in the metadata description. It is not possible to find single pieces that are contained by their text beginning; you can only see entire volumes without any notion of their specific contents. If you do not know in advance in which volume to look for a certain piece, you will not be able to find it. This cannot be remedied by even the best search interface, because the information is missing in the metadata itself.

Once you find what you are looking for, Ephraim says, the quality of the digital material is very high, and there is sufficient information about the material in the displayed metadata, disregarding the missing table of contents in the mentioned example.

During observation, I could follow Ephraim's search process in the matter of one piece within the print in several volumes described before. Thanks to his previous efforts of generating his own table of contents with volume and page references, Ephraim was able to find the digitized images. He first entered the composer's last name and three words from the compilation title into the search field. Then, he found the right volume with some effort, because the volume number was not included in the main heading in the search result presentation. Within the volume, he used the page numbers to navigate to the right image.

On the matter of the *Utile Dulci* collection, I had three interview participants. The first one was a 74-year-old, female musician who does not do much music research, but on one occasion needed to retrieve music from the collection, which she could play with her baroque ensemble. She does not have much knowledge in computers or the Internet, which is why no observation could take place. I name her Catherine.

Catherine told me about that time she had been searching the *Utile Dulci* collection. Then, she was at the MTB in Stockholm together with a colleague, a more frequent Internet user. A librarian guided them to the right collection at a library computer, and then they browsed the collection for pieces of their interest. Catherine does not believe that she would be able to find the digital collection on her own, but is fascinated by the possibility of accessing the music online.

The second interview participant about *Utile Dulci* was a 64-year-old, male musicology professor who has been researching music for 42 years and even made a great number of modern sheet music editions from old manuscripts, enabling musicians to read and play the music. He is a competent user of digital resources, and has been participating in digitization processes. I name him Daniel.

Unfortunately, even Daniel could not be observed, because he was not allowed to go to his office due to the COVID-19 outbreak and did not have a sufficient device at home. He answered my questions in writing. These are his experiences when searching the collection:

> I began researching original sources in Stockholm (...) back in the 1980s before digitization. Currently, the catalogue of manuscripts reveals a repertory that is pan-European in scope, and my explorations of the music itself (analytically) has meant I have explored the bulk of the materials, though not yet downloaded all for special attention. The Utile dulci collection is extremely easy to viw [*sic*] in its digitized form, though on site would have the advantage of looking at details of the works. Formerly, the Utile dulci website with the downloadable pdfs was easy to navigate and quite complete. Now, the main issue is that it has been folded into the main catalogue of the

> Statens Musik och Teaterbibliotek, and to obtain a complete list to peruse has required several more layers. Here is where the former links were more useful than currently. The material can also be found on RISM, but one has to navigate many layers to find what one needs, and even then the collection is not highlighted as a complete entity (Daniel).

Daniel's main concern, thus, is the abandonment of the old MySQL and PHP based system and the incorporation of the collection into the general MTB OPAC.

With my final interview participant for the *Utile Dulci* collection, I was able to perform the observation and protocol analysis. He is a 39-year-old, male IT specialist, who has been doing music research as a hobby during the past two or three years. I name him Bill.

To Bill, the most important aspect is that he can download the music. He does not like the scan quality, which is black-and-white only, looking like Xerox copies. However, if Bill needs to take a closer look on any of the material, he can go to the library and take better photographs himself with his mobile phone camera. He is appreciating that the library is allowing that nowadays. On the other hand, he thinks that the information given in the catalogue is not sufficient. He is frequently using the digitized old card catalogue instead of the main OPAC, because there, information is more detailed, and he can see the shelf number, which he needs to order the originals for examination and photographing.

During observation, Bill described how he mostly is browsing the whole collection to pick out pieces of interest. Yet, he sometimes also is interested in finding music by specific composers or ensembles. The search for the composer's last name did not pose any difficulties, but when Bill entered the search term "utile dulci + kvartett" (kvartett is the Swedish word for quartet, referring to string quartet as a musical medium) into the search field, he received zero hits. When the Swedish word "kvartett" was exchanged for the Italian "Quartetto", the search was successful in Bill's eyes; a number of hits were listed, among which a few caught Bill's interest. He was not expecting to find every single quartet in the collection, and he did not know previously how many quartets there should be to find, so he was content.

Concerning the *Düben collection*, I had one interview with a 43-year-old, female Ph. D. student in musicology, whose main occupation is music research and has been for the past 12-13 years. She knows how to use digital resources, but does not possess any deeper knowledge about the systems behind the interfaces. I name her Anne.

Anne was, in large, very content with the DCDC. She says that she had not even been to Uppsala to view the originals, which she was convinced that she would have to do when starting her work with her Ph. D. thesis. She still thinks that it would be good to see them, because they might provide details to her research that are not possible to see in the digital version, but on the other hand, she finds the metadata so rich and detailed that the originals so far hadn't been necessary for answering her research questions.

On the search interface, she remarked that it was a little difficult to learn. She kept mainly to the "Basic search" function, because she could find most things she needed there, but for some queries, she had to use the "Advanced search" page. Anne told me that her preferred queries were the composer's name, text language, and title. She believed that it was not possible to search for copyists, which is not true; presumably, she was confused by the label "Main hand" in the search interface (see figure 14), which is referring to the main copyist. She was right, though, about other search options that she was missing: musical genre, watermark, and text category. There is the possibility to search for text beginnings and text sources, but both are very specific. Anne states that she needs for her research some division into broader text categories, for example "Psalm settings" or "Latin poetry", to spare her from looking through the whole collection.

During the observation, Anne chose to search for a composer. She picked the name in the drop-down list and found all relevant compositions. The information presented at the different stages towards the digitized images were useful to her, providing her with everything she needed to know for her research. She also showed me how she was trying to find compositions from different text categories by means of combining the search fields "Text source" and "Language", picking "poetry" from one drop-down list and "Latin" from the other. The results were not satisfying, returning too few hits; already in the drop-down list, Anne could see that there were many entries containing the word "poetry" and something else. She thought that she would have to conduct several search instances, one each for each term combination. Anne was not able on her own to determine that choosing the option "Text source: contains" instead of the drop-down list would have eliminated the problem. This shows the sometimes overwhelming complexity of the search interface for the average Internet user.

4.1.3 Analysis of the survey and interview results

The results of both surveys, interviews, and protocol analysis indicate that there are three different ways in which music researchers approach digitized music manuscript collections, determining their behavior: searching for specific material they found out about by means of other sources, for example RISM or research literature, a clear case of *known item searching* (KIS); *browsing* the collection as a whole, to get a view on the contents, which is more of a data-driven approach (see Marchionini, 1995, chapter 6); or searching for the contents within certain categories, which could be identified as *subject search*. It can be discussed whether all three are expressions of KIS; in all three cases, the music researchers know quite a lot about the collection. In his study, Lee argues that most of the queries used for finding music in Google are closer to KIS than to *subject searches*, because the user knew that some music matching the search criteria existed (Lee, 2010, p. 1035). However, I do not think that this can be said about the behavior of music researchers. When browsing the whole collection or searching by, for example, a composer's name, the researchers often do not know what exactly they will find: which exact pieces or, in a philological approach, which exact manuscript sources. Their aim, then, clearly is to find out about the contents of the collection and searching for a certain type of music, not already knowing the results. Thus, I would summarize the three common approaches as *known item searching, browsing,* and *subject searching.*

Even though specialists have different needs than non-specialists when it comes to finding music sources, there are some parallels to the findings of Lee: the most searched for topics by far are title and originator of a piece of music (Lee, 2010, p. 1034). Here, music researchers are no exceptions. The question is if it is appropriate to see those categories as possible representatives for a subject search. Within LIS, it is still an unanswered question what a subject search within instrumental music should be: "What all of this shows is that despite enormous efforts to pin music down into a form that can be broken up and analysed, notated and explained there is still no universal way of determining what music is about, and how it works" (Inskip & MacFarlane, 2007, p. 693). While I cannot possibly define the aboutness of music, I can see some patterns in the survey and interview answers that suggest that there is a point to Lee's very broad use of the term *subject search* in connection with music manuscripts, which is backed up by Newcomer et al.:

> 'Known-item' queries are more common in music searching than in general searching; this is true of both 'classical' and 'popular' music. However, users do not always 'know' a lot about the entity they are seeking. Title is a notoriously unreliable access point, especially for Western art music. 'Subject' is a problematic concept; music subject headings often reflect non-subject attributes such as form, genre, and instrumentation. Perhaps because of these difficulties, personal names are frequently used as an access point in music searching. However, many composers are very prolific, and their works exist in many versions, making personal name alone an insufficiently precise access point" (Newcomer et al., 2013, p. 521).

Usually, when using title and author as a query within repositories of printed music, this has to be classified as KIS, because the important thing is the content, the music itself, which the user knows about. When it comes to music manuscripts, though, the musical content often is not the main interest for the music researcher, but the specific *manifestation* in manuscript. Then, the composition as such would be the *subject* or *topic* of the search, while the manifestations would be the previously unknown search results. This is happening especially within music editing or philological manuscript studies. In addition, the title of a piece of music often is not very specific, but similar to a genre classification; in the three collections I examined, there are hundreds of pieces called "Sinfonia" or "Sonata". Even within vocal music from the 17th and 18th century, the number of *Magnificat*s or *Te Deum*s is uncountable. In those cases, the title does not resemble more than a topic, and for correct identification of the piece, opus or work catalogue numbers are inevitable. Depending on the user's intentions, within music manuscript collections author and title, thus, can sometimes be topics for a subject search. More typical for the subject search, though, are other categories: genre, musical medium, key, or year of origin.

Whether KIS is the quantitatively dominating search process for music researchers within digitized music manuscript collections cannot be shown in this study due to the purely qualitative methods. Concerning the search queries used within library OPACs, several existing studies suggest that this might be the case:

> Differences in methodology make it difficult to draw any firm statistical conclusions, but the two studies with the lowest percentage of subject searches were the two music studies, Chicago (10%) and Illinois (11%). In other words, users in the two music studies were seeking out known musical materials approximately 90% of the time (King, 2007, p. 7).

On the other hand, only one of my interview participants (Ephraim) was conducting what can be identified as a KIS process, the others were all showing or describing subject searches. This could be a coincidence, but could also indicate a shifting of preferences caused by the arising digital possibilities - prior to 2007, when King gathered previous study results, browsing a collection for the contents was not that simple. Those two of my interview participants who were applying subject search transcending the category of authorship belonged to the younger generation who started their career in research after 2007, which might mean they had not had time to learn music research within those old OPAC systems and card catalogues, but were presented with digitized music manuscript collections from the very beginning.

> (...) information seekers consider the mental and physical actions taken during information seeking and adapt their personal information infrastructures accordingly. Thus, the experience itself becomes part of the searcher's knowledge for dealing with future information problems (Marchionini, 1995, p. 48).

It might be the case that music researchers now are learning new ways of searching that simply were not applicable before and therefore, still, most of them are mainly using the topics of author and title. New research trends might cause the need for new search possibilities, as the survey comment about gender aspects indicates (see chapter 4.1.1). My results cannot illuminate this further, but I would like to pose the question for future studies.

That the research purpose has an impact on the choice of search approach has been shown before:

> The Chicago study found that when a patron requested a music score for the purpose of performing it, they used a subject search 23% of the time. The percentage of subject searching for all purposes (course assignment, personal study, actual performance, and reading along with a performance) was only 10% (King, 2007, p. 8).

And:

> The Music Faculty study provided examples of music specialists choosing subject searching to fulfill certain musical needs. Searching by genre was a common access point for conductors, instrumentalists and vocalists, who are looking for music to perform, and for composers and theorists, who wish to study certain types of music. It was not commonly used by musicologists, who are studying particular composers or pieces of music. (King, 2007, p. 8).

My interview with Anne shows that musicologists, depending on the topic of their research, also demand *subject search*; not all musicologists are studying particular composers or pieces of music. Anne pointed out several cases when her research caused her to conduct a subject search.

One aspect mentioned often in both surveys and interviews was *browsing* the collection to get an overview of the contents. It shows how important the design and content of the result presentation is; if it is informative enough, music researchers could often do without the viewing of the digital images.

> In such cases, the actual 'seeking' (i.e., obtaining) of the object might never occur and the search will end when the correct metadata is acquired. In such cases, what the users are seeking is not necessarily an item, but information about that item (or manifestation, expression, work), yet the nature of the search and the search process closely resembles other known-item searches (Lee, 2010, p. 1036-1037).

The "known item" in the KIS being, in this case, the whole collection. According to my results, to be sufficient for the *browsing* behavior, the "correct metadata" should include at least the composer's name, the title of the piece, the key, the genre, and the musical medium; when concerning vocal music, even the beginning of the text (not always identical with the title) and the text language.

4.1.4 Evaluation of the survey and interview methods

While the age and gender distribution of the interview participants was widely spread, so that different aspects of the target user group could be investigated, this happened to be the case because of pure luck. Purposive sampling is not the optimal way of generating representative results (see Bryman, 2012). If I had had more time and resources for this study, I would have wanted to put more effort into finding interview participants representing different user groups.

When reflecting on the execution and results of the interviews, I would like to make some critical remarks. Firstly, I would have wanted to interview more people, in order to get several views on each collection. Secondly, I would have loved to observe people using the catalogue at the library in question, so that I could have examined the ways in which music researchers ask librarians for help – this would have been especially beneficial in the case of the unexperienced user I named Catherine. Finally, I would have liked to ask the respondents more detailed about the design of the different websites, search pages, and result presentation, which would have enabled me to perform a proper design analysis instead of the descriptions I added in the introduction of this study. This would have been similar to the approach of Thomas (2011). Then, the impact of the design on the user experience and the success of the information seeking process could have been investigated. Unfortunately, that idea evolved too late in the progress of this study to be implemented.

Yet, for analyzing the information seeking process and the queries used by music researchers, the mixed method approach of combining surveys, interviews, and protocol analysis has proven successful, as I could determine previously unknown aspects of the information seeking behavior of music researchers.

4.2 Stage 2: Technical evaluation

Here, I will first describe how the queries for the experiments were created (4.2.1). After presenting the results of the experiments (4.2.2), I analyze them in relation to the question how well the systems function for music researchers (4.2.3). Concluding the chapter are my thoughts about the experimental setup and how it could have been improved (4.2.4).

4.2.1 Creating relevant test queries

When generating the test queries for the technical evaluation, the specific behavior of music researchers within music manuscript collections has to be considered. In addition, there are two different types of topics, as described by Lalmas and Tombros (2007, p. 41): *content-only* (CO) and *content-and-structure* (CAS) topics. While two of the search interfaces I examined are designed for CO searches (*Schrank II* and *Utile Dulci*), where one free-text field is used for exploring all metadata categories, one only allows CAS queries (DCDC), where each metadata category has its own search field.

For allowing conclusions about the usability of each search interface for music researchers, the queries had to be formed just as an average music researcher would have done. This means that I sometimes had to do things incorrectly on purpose:

> Despite their intimate understanding of music scores, musicians may lack the sophisticated understanding of computing required to interact with a query interface that imposes strict syntactic compliance requirements (Bahraini & Tilevich, 2019, p. 797).

To generate comparable data, I decided to use the same query categories for all three collections, mapping them to the contents of the collection to generate the specific queries. It would have been rather useless to search for the same composer in all three collections, because not a single composer is present with works in all three of them. I chose the following categories: *composer*, being the most mentioned query in surveys and interviews; *title word*, which is also resembling a *genre*, because I search for instrumental music; and *musical medium*, also referred to as *instrumentation* (see for example Pugin & Zitellini, 2013), because this query is used by music researchers and described in the literature as a problematic topic (for example by Lee & Robinson, 2017). I also adapted the combinations *composer and title*, as well as *composer and musical medium*, to test the interfaces' capabilities in terms of combined searches within different metadata categories. For that purpose, I used the form of title spelling and musical medium indication that had been working best in the previous tests. The order I applied in all three search interfaces was as follows:

Query 1: *Composer's last name*

Query 2: *Composer's last name*, misspelled

Query 3: *Title word*

Query 4: *Title word*, different spelling

Query 5: *Musical medium*

Query 6: *Musical medium*, different way of expressing it

Query 7: *Composer's last name* + *title word*

Query 8: *Composer's last name* + *musical medium*

4.2.2 Experiment results

Those queries, I adjusted to the contents of each collection. Then, I entered each query into the search mask of the discovery system and counted TP, FP, and FN in the entire hit list. The counts were used to calculate precision, recall, and F_1.

4.2.2.1 Test on SLUB Schrank II (Dresden)

For the *Schrank II* collection, searched via the SLUB catalogue interface for digital collections, I based my choices on an Excel-file provided by the project contributors on the project's homepage, which I also used for relevance assessment (https://hofmusik.slub-dresden.de/themen/schrank-zwei/). I chose the composer Tomaso Albinoni, by whom 28 compositions are found in the collection, the title word or genre "Sinfonie" (one of the preferred spellings of "symphony" in German and the one used in the Excel-file), to which I manually assigned 178 relevant documents, and the musical medium of a trio consisting of two violins and basso continuo, the standard instrumentation of the trio sonata, a popular genre at the time, with 271 relevant documents in the collection. I expressed this in the following queries, according to the above named categories:

Query 1: *Albinoni*

Query 2: *Allbinoni*

Query 3: *Sinfonie*

Query 4: *Sinfoni**

Query 5: *Trio**

Query 6: *vl 1 + vl 2 + bc*

Query 7: *Albinoni + Sinfoni**

Query 8: *Albinoni + vl 1 + vl 2 + bc*

With those queries, the following results were generated:

in %	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Precision	100	-	50	98.3	52.9	56.3	100	81.8
Recall	100	0	0.56	96.7	6.6	50.9	100	100
F_1	100	0	1.1	97.5	11.8	53.5	100	90

Table 1: Results of the evaluation of the SLUB search interface for digital collections

The results show that the interface is performing very well with the composer's name, if it is spelled the right way (Q 1). It appears as if documents were retrieved by *exact match*. For the user, help is available in the form of a drop-down menu appearing after typing the first three letters, where the right spelling can be chosen. If, as in this case, the name is misspelled within the first three letters, no documents are retrieved (Q 2).

In the case of title words, the matter is more complex. The results still are very good when the title word is spelled in exactly the right way or truncated in the right place (Q 4). On the other hand, they are horrible if a different spelling is used - for "Sinfonie", only two documents were retrieved, one true positive and one false positive (Q 3). Today, there are two accepted ways of spelling "symphony" in German, "Sinfonie", or "Symphonie". During the 18th century, there were several more, most of all "Sinfonia". For the user, it is not possible to know in advance which spelling is used in the titles and metadata descriptions. Unfortunately, the drop-down list is not much help here, because it shows original manuscript titles, not common title words, which is applicable for KIS, but not sufficient for subject search.

As expected, the most problematic query is concerning instrumentation. Even the best combination of query terms, determined by a trial-and-error approach, is not giving a satisfying result. The word "Trio", which actually is written on most of the title pages of the photographed sources, seems not to appear in the metadata especially often. When not truncated, it generated 15 hits only, while there are 271 relevant documents in the collection. With the truncation "Trio*" (Q 5), the hits were more than doubled, but now there were 16 false positives among the 34 retrieved documents, all of which ranked among the first 20 hits, which makes it even more serious. The missing consideration of musical aspects in the ranking algorithm becomes obvious. If natural language is left aside and the user instead is working with abbreviations (Q 6), it becomes apparent why it is such a big problem that instruments cannot be excluded from the search. Two violins and basso continuo are present in many different ensemble forms in 18th century, what distinguished the trio is the *absence* of other instruments. The only reason for the interface not to generate more than 245 hits is the practice to label pieces for larger ensembles with "orchestra" in the metadata rather than to spell out all the individual parts. On the other hand, there still were 133 false negatives, which are presumably notated in scores, not in single parts, which is why the part information is not appearing in a searchable form in the metadata. Among the first 20 ranked hits, there are 16 false positives, and it takes the user to scroll down to the 11th position in the list to find the first true positive.

When combining the most effective search terms, the results for the combined queries are very good for this specific composer. Even the problematic instrumentation search only generates two false positives and zero false negatives in combination with the name of Albinoni. This is because all of his trio sonatas in the collection are preserved in single parts, not only in scores.

4.2.2.2 Test on the Utile Dulci collection (Stockholm)

For the *Utile Dulc*i collection, searched via the MTB OPAC interface, I chose the composer Karl Joseph Toeschi, by whom six compositions are found in the collection, the title word or genre “sinfonia” or “sinfonie”, to which I manually assigned 283 relevant documents, and the musical medium of a string quartet, consisting of two violins, viola and cello or basso continuo, with 122 relevant documents in the collection. The string quartet was chosen, because it occurred as an actual search term during the observations. Since this interface is searching the whole OPAC catalogue, the term “utile dulci” has to be added to every query. I expressed this in the following queries, according to the above named categories:

Query 1: *utile dulci + toeschi*, as well as *utile dulci + töschi*[3]

Query 2: *utile dulci + toschi*

Query 3: *utile dulci + sinfonia*

Query 4: *utile dulci + sinfonie*

Query 5: *utile dulci + quartetto*

Query 6: *utile dulci + à 4 + vl 1, vl 2, vla*

Query 7: *utile dulci + toeschi + sinfonia*

Query 8: *utile dulci + toeschi + quartetto*

With those queries, the following results were generated:

[3] The plus sign (+) is not necessary in the search field, all search terms are automatically combined with AND. I added it here for clarity.

in %	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Precision	100	-	87.5 77.8 94	97.8 82.2 100	100	61.6	100	100
Recall	100	0	100	15.6 15.0 15.9	11.6	80.3	100	100
F_1	100	0	93.3 87.5 96.9	26.9 25.4 27.4	20.7	69.7	100	100

Table 2: Results of the evaluation of the MTB OPAC

Even here, searching for the composer's name is working best, though it is crucial to find the right spelling, and the search interface does not offer any help in getting it right. While one relatively simple alternative like writing the "oe" as an "ö", as both Swedes and Germans would naturally do, has been taken into account and delivers the same number of correct hits (Q 1), another one like leaving out the dots above the "o", as users from the English-speaking population might do, is completely ruining the search, resulting in zero retrieved documents (Q 2).

When it comes to searching after "sinfonia" or "sinfonie" (Q3 and Q4), the matter of deciding which documents are relevant and which are not is not an easy one. It depends on the background and motives of the searcher. At the time when the music manuscripts were written, "sinfonia" or "sinfonie" could mean many different things. The problem is not as obvious in the *Schrank II* collection, because here, the title writers have been more consistent. In the *Utile Dulci* collection, though, there are pieces called "Sinfonia" that are fitting the modern definition of a symphony, but even opera overtures or chamber music pieces. Librarians have added to the confusion by, in the catalogue, labelling pieces without an original title "Sinfonia" in square brackets; to me, it is not obvious at all what this decision was based on. Many of the pieces with four or less parts might just as well be string quartets or other chamber music sonatas. Thus, I have decided to give three different values for each parameter. The first is counting all pieces called "Sinfonia" or "Sinfonie" that are intended to be played by an orchestra, with at least four string parts, including even opera sinfonias. The second value is excluding the opera sinfonias, which are considered a different genre. The third value is including everything that is called a "Sinfonia" of "Sinfonie" in the original sources, no matter what kind of pieces they are, as well as pieces with more than four parts that have been labelled "Sinfonia" by a librarian.

The numbers show that, even here, spelling is essential. "Sinfonia" (Q3) is the label that the library has been using, and thus working considerably well under the circumstances. Bearing in mind that the label has been put on quite a lot of pieces that might not be sinfonias at all, but maybe string quartets or similar, it is understandable that precision is a little lower, but the recall is 100%. While precision is a lot better, the recall for "Sinfonie" (Q4) is devastating - only such pieces are found that have the exact spelling in the original title. I tried truncating maybe to improve the results even further, but that is not possible in this search interface. For the user, which induces the need to find the exact same spelling that has been used by the library for labelling, otherwise the chances of finding all the relevant documents are low.

Searching for musical medium is difficult in this interface, too, although improved in comparison with *Schrank II*. Even if Q 6 is the best search query I could find with a trial-and-error approach, for retrieving pieces with those four instruments and only those, the results remain unsatisfying. While the numbers seem to come closer to an acceptable level, it needs to be mentioned that none of the pieces actually called “Quartetto” or “Quattuor” has been found with Q 6, even though the quartets are the most relevant pieces in the collection for this search. This is surely due to the addition “á 4” in the search query, but if I leave that out, the search engine is giving me 535 hits. Relating that to the size of the whole collection (794 documents) and the number of relevant documents (122) shows that the addition is needed, or we would completely lose precision. The problem is that the majority of pieces have four string parts - but most of them also have other instruments, or even vocal parts. Since Boolean operators are not working in the search interface, there is no way to exclude other instruments or voices. At least, the format of notation (in parts or in score), does not have any effect on the results.

4.2.2.3 Test on the Düben collection (Uppsala)

For the *Düben* collection, searched via the DCDC “Basic search” interface and restricted to instrumental music only, I chose the composer Anders Düben, by whom 19 pieces are found in the collection, the title word or genre “Courante”, to which I manually assigned 76 relevant documents, and the musical medium of five different, but not further specified instruments, with 122 relevant documents in the collection. The reason why I did not search for specific instruments is that, within instrumental music of the 17th century, the exact instrumentation often is not given in the original sources. There might be a division into different registers, but it remains open if the piece is to be played by string or wind instruments. In other cases, alternatives are indicated, so that, for example, either a viola or a trombone could play a part. This is why, for a large part of the material, it is impossible to tell the specific musical medium.

Because I focused on instrumental music only in this experiment, I had to choose “instrumental” in the associated search field for every query. I expressed the above named categories in the following queries:

Query 1: Vocal/instrumental: *instrumental* + Composer contains *Düben*

Query 2: Vocal/instrumental: *instrumental* + Composer: *Düben, Anders*

Query 3: Vocal/instrumental: *instrumental* + Title contains *Courante*

Query 4: Vocal/instrumental: *instrumental* + Title contains *curante*

Query 5: Vocal/instrumental: *instrumental* + No of instruments: *5*

Query 6: No of voices: *0*; No of instruments: *5*

Query 7: Vocal/instrumental: *instrumental* + Composer: *Düben, Anders* + Title contains *Courante*

Query 8: Vocal/instrumental: *instrumental* + Composer: *Düben, Anders* + No of instruments: *5*

With those queries, the following results were generated:

in %	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Precision	73.1	100	100	-	100	98.4	100	100
Recall	100	100	100	0	100	100	100	100
F_1	84.5	100	100	0	100	99	100	100

Table 1: Results of the evaluation of the DCDC Basic search interface

This search interface is applying *exact match*, which gives a rather binary feeling to the process. Choose the right search terms and functions, and you can rely on getting absolutely everything that is relevant. Choose or spell wrongly, and you will not get anything at all. Recall is always either 100% or 0%. This goes for single search terms as well as for any combination. Fortunately for the user, the contents of different search categories are listed in drop-down menus to choose from, which eliminates the risk for erroneous spelling.

The reason why the precision for Q 1 is not 100 % is that there are several composers with the last name "Düben" present in the collection. The seven false positive hits show pieces by Gustav or Peter Düben. This problem is easily eliminated by picking the name from the drop-down list (Q 2), where all the first names are included. There is a problem hidden in this binary approach, though. All the pieces that are now attributed to Anders Düben have once been assigned to the composer Adam Drese instead, because only the initials are given in the source. This is indicated in the hit list by the symbols "^?" in the column "Attr status". If I select one of the hits, I find the corresponding information: "Composer given in source as 'A: D: C[appelmeister]'. Wollny 2001 suggests that this refers to Adam Drese. Schildt 2014 argues instead that this stands for the Swedish Hofkapellmeister Anders Düben (sr)" (https://www2.musik.uu.se/duben/presentationWork.php?Select_Dnr=2671&Select_Wnr=2196). If I happen to have the older information, searching the collection for instrumental music by the composer Adam Drese, I will not find any, because the attribution has changed. The concerning information is available only after successfully completing the search, though. Since there is only one composer allocated to each piece, this problem will occur each time the authorship is uncertain. In the more modern interfaces for the *Schrank II* and *Utile Dulci* collections, this is not an issue, as long as both authors are named in the descriptive metadata.

The second case when precision is not 100 % is Q 6, in which I tested a way of finding pieces for five instruments without limiting the search to instrumental music only. I tested if, by setting the number of voices to zero, I could achieve the same result. The numbers show that it is working almost perfectly, with the exception of one piece of vocal music, in which the vocal parts are missing - one false positive hit.

Concerning the problematic search for instrumentation, the DCDC interface provides a solution in the “Advanced search”. Assuming that I want to find pieces for one violin and basso continuo only, there are two ways of searching: I could use the field “Scoring” and pick “vl bc”, which will result in 18 relevant hits; the problem is that, in the drop-down list, I can see the position “vl, bc”, too. Choosing that provides another six relevant hits that have not been included in the first 18, which leaves me with 24 relevant hits. A simple inconsistency in punctuation in the metadata description is causing a decrease in recall for both options, yet the precision is in both cases 100 %.

Another possibility is to use the field “Scoring: contains” in combination with a limitation of the number of instruments. If I enter “Scoring: contains vl AND contains bc” and limit the number of instruments to one (because the basso continuo usually is present in all compositions of that time and can consist of more than one instrument, it is not counted in the number of instruments), I get 22 hits. One is a false positive, because it is for violone (vlne) and continuo, and three of the previously retrieved relevant documents are false negatives, because they had the wrong number of instruments assigned in the metadata. That leaves the precision at 95,5 % and the recall at 87,5 %. While I still cannot find everything in the collection that fits the instrumentation criterion, those numbers are immensely much better than what I could achieve even with my best efforts within the examined search interfaces for both the *Schrank II* and the *Utile Dulci* collection.

4.2.3 Analysis of the experiment results

> Searching a bibliographic music score collection using a traditional library system is a challenging task. Multiple versions of the same work can exist, or a score can contain only a part of a work, an aria from a larger work for example. With large databases, having a tailored system becomes necessary. The particularities of music scores, however, make conceiving such systems complicated. One particularity of music scores is that they are intended for a specific instrumentation. Although instrumentation is only one of their particularities, it is known to be a very important one for end-users. Musicians especially often search for scores with an instrument or voice distribution matching their particular ensemble. But searching for instrument or voice distribution is generally problematic. Typically, a singer searching scores for bass voice with “basso” will obtain a result list including also all the scores of the Baroque area because of the “basso continuo”, very common in this repertoire. In practice, it often discourages the users from utilizing the resources that are available (Pugin & Zitellini, 2013, p. 195).

Not surprisingly, the queries that caused most problems in all three interfaces were all concerning the musical medium, and the issue described by Pugin and Zitellini is exactly what happened in my experiments. Only the complex interface of the Düben collection allowed me to improve precision and recall for an instrumentation query to a satisfying level; a comparison of the F_1

measures for Q5 and Q6 in all three collections shows this. This is, without any doubt, because this interface, among those I examined, is the only one specifically designed for music manuscripts and, thus, considering the matter of musical medium during the classification process.

> Examining music classification reveals that medium is a multipart and complex part of musical works; so, as medium is also a fundamental part of classifying music, unpicking the complexities of classifying musical medium will greatly aid our understanding of music classification (Lee & Robinson, 2017, p. 258).

In the MTB OPAC, where it is possible to search the *Utile Dulci* collection, the musical medium is a central part of the recorded metadata, because the whole library is specialized in music. This is why the results for the optimized instrumentation query (Q 6) are better than those for the SLUB digital collections interface, by which I searched the *Schrank II* collection. However, carefully classifying the musical medium is not enough, as long as the search interface can confuse the query information with other things:

> Even in systems where there is a dedicated search for instruments, extraneous results will often be returned because the abbreviations used for instrumentation can appear elsewhere in the database (Pugin & Zitellini, 2013, p. 196).

If, and only if the system allows the exclusion of unwanted instruments from the search, the complexity of this matter can be conquered, as shown by the example of the RISM database (Pugin & Zitellini, 2013, p. 197).

All three search interfaces returned very good results when searching for the correctly spelled composer's name, representing the "author" category that all bibliographic library records have in common. They differ, though, in the amount of help they offer for finding the right spelling. In the *Schrank II* and the *Düben* collection, drop-down lists facilitate the correct version; in the DCDC, this list is browsable and searchable by the very first letter, while it needs the three first letters for the list to appear in the SLUB catalogue. The MTB OPAC does not offer any help, trial-and-error is the only possible approach here.

In the matter of title words or genre, which in instrumental music often are overlapping, all three interfaces performed well if treated the right way. The problem that genres have evolved and received different names in different times is consistent throughout music history. Music researchers are aware of that; it is part of their training.

> Experts in a field of study have comprehensive vocabularies in the domain, know what types of sources are best applicable to the problems, and are aware of alternative access points for finding information in the domain (Marchionini, 1995, p. 34).

To me as a music researcher, improving the relevance of the retrieved documents by altering the spelling or trying a truncated term came naturally. Expecting a search interface and retrieval system to provide solutions to matters of musicological dispute, like in the case what is and what is not a "sinfonia", would be absurd. Sometimes it might help, though, to provide a list of terms or thesaurus, so that the users have a chance to look up the right query to their information needs.

4.2.4 Evaluation of the experimental setup

Overall, I am quite content with the experimental setup. It was straightforward and uncomplicated, the outcome clear and significant. There have been a few issues, though, which I would do differently if I would conduct this kind of experiment again.

The greatest issue is that my relevance assessment was done by one person only - myself. Especially in the *Schrank II* and the *Utile Dulci*, I might have missed single relevant documents concerning the instrumentation queries (Q 5 and Q 6) while looking through the material. I am sure, though, that these documents are not many, because I double-checked each time the search interface deemed a document relevant. This means that I still can rely on my results. In addition, due to the clear numbers in those problematic cases, three or four wrongly classified documents would not make a great difference. However, it would have been optimal to have a second (or even third) relevance assessment made by another person. This was not possible within the present study.

A different way of determining the number of relevant hits for each query would have been to let different users perform the task of testing given queries and assessing the results for their relevance, as Fluhr et al. (2006) have done. This approach, though, was not feasible for me, because I did not have access to a number of volunteering users for each collection. While it would have added objectivity to relevance assessment and validated certain results, it would have increased the effort for the technical evaluation beyond acceptable proportions.

Another problem was the definition of relevant documents in case of the unclear title query “Sinfonia” in the *Utile Dulci* collection. Defining in advance, what should be meant by the term would have saved me some trouble. On the other hand, I think that my solution with three different interpretations of the term illustrates the complexity of the matter.

5 Discussion

Brown revealed in 2002 that primary sources are the most important resource for music scholars in the early stages of the research process (Brown, 2002, p. 82, Table 4), and Lavranos showed that this is true even for performing musicians:

> Musical creativity is directly linked to music information seeking and to the operation of music libraries, and at the same time it can be influenced by the availability of music information services and the information profile of the musicians involved (Lavranos, 2018, p. 555).

There cannot be any doubt that the accessibility of musical sources is crucial to the work of music researchers. They are using search interfaces for digitized music manuscript collections in three different ways, depending on their information needs: by *known-item searching* when researching specific manuscript sources that they know about from other sources; by *browsing* when they want to examine the contents of the collection as a whole; and by *subject search* when they need to find music manuscripts around a certain topic. This is an approach they share with information seekers within other domains, and the procedures are widely known within LIS. Yet, concerning music researchers' information seeking behavior within digitized music manuscript collections, the terminology has to be used in a different way than usual, due to the fact that the known items in KIS are specific *manifestations* of compositions, and that the subjects in *subject search* are not alike topics in the meaning of other definitions within LIS, because music is not *about* anything outside the music itself. Topics for a *subject search* within digitized music manuscript collections can be *genre*, musical *medium*, *key*, *year of origin*, or even things usually associated with KIS, like *composer* or *title* (see chapter 4.1.3).

My experiments have been limited to queries that are common, not untypical at all, part of the general vocabulary of music researchers. Unfortunately, the complexity of even such "simple" queries concerning music material has often been overlooked; Bahraini and Tilevich, for example, jump directly to even more specific matters a music researcher might be looking for, putting the problematic issue of instrumentation down with the lapidary remark that there is metadata:

> Typical score metadata includes the piece's title, composer, time period, style, and sometimes instrumentation. As a result, one can search for all the scores written by Mozart for a string quartet. However, it would be impossible to search for a subset of such scores that, for example, limit the constituent instruments to given pitch ranges (Bahraini & Tilevich, 2019, p. 796).

They are right, of course, in the sense that looking for scores with limited pitch ranges in single parts is, at present, impossible. They are wrong, though, in assuming that you can easily find music materials by their instrumentation, just because there is metadata. This might be the case within repositories like the Petrucci Music Library (IMSLP, https://imslp.org/wiki/Main_Page), who have created a large number of metadata sub-categories for each and every possible combination of instruments and voices, and even that tool is most effective if you use their category walker instead of search fields. However, it is not in most library catalogues for digitized music manuscripts.

> Users' discovery and identification of musical works frequently draw on titles, often in conjunction with creator. Particular musical works are often referred to by many different titles in various languages, for example: Symphony no. 5, Fifth Symphony, Sinfonie C-Dur, Symphonie op. 67, etc. (Newcomer et al., 2013, p. 497).

As my experiments have shown, that circumstance can cause problems when using common catalogue search interfaces. Newcomer et al. suggest alphabetic lists as a solution to this problem:

> Alphabetical lists facilitated browsing in this complex system because users were not required to determine and input keywords to begin a search. A significant weakness of most current keyword searching is that it does not take advantage of alternate forms found in LC/NAF authority records. These alternate forms are indispensable in music searching, given the vagueness of even 'known-item' queries. It is extremely difficult for untrained users to predict the vocabulary that will be used in uniform titles and subject headings, and current systems rarely provide much guidance (Newcomer et al., 2013, p. 521).

This might be the reason why the music researchers answering my surveys and interviews were quite satisfied with the design of the DCDC search interface, despite the fact that it is old-fashioned and hopelessly complicated - it provides drop-down lists for almost every single search category. Once used to choosing from those lists, a user like "Anne" in my interviews (see chapter 4.1.2) might even rely completely on finding everything in those lists, preferring them to any other search alternative. Because Anne is researching the sources for her Ph. D. thesis, she needs to be entirely sure that she has found absolutely everything that is relevant; going through the drop-down lists gives her that certainty.

> The specificity of a goal can range from single fact to an idea to an interpretation or opinion. In the case of facts, information seekers are assured of a high level of certainty that they have accomplished the task and reached the goal (Marchionini, 1995, p. 37).

This has presumably been a factor why Anne has not felt the necessity yet to travel to Uppsala and view the originals, a clear advantage from the aspect of manuscript preservation.

According to Inskip and MacFarlane, the "effective organisation of information determines whether or not users are able to search for and retrieve items that fulfil their needs. If an information retrieval (IR) system is going to be of value to the user then it must give meaning to the information which matches the meaning given to it by the user" (Inskip & MacFarlane, 2007, p. 387). Against this background, I would like to discuss whether ranking according to relevance is feasible when it comes to music manuscript collections, and if so, how it should work. In the results of my experiments, relevance ranking did not work well in the two systems that applied it, and the users showed their approval of the one system without ranking in surveys and interviews. The first type of search performed by music researchers, the *known-item search* for one specific source, has a very clear goal; nothing else is relevant but the known item. The results are either relevant or not. In this binary event, ranking does not make sense, if not with the purpose to show similar manuscripts; then the algorithm would have to take a number of musical facets into account. The second type, *browsing*, has the goal to view all the contents of the collection, which means that all contained documents are equally relevant, none more than the other. In this case, the user might want to *sort* the results according to certain preferences. Ranking would be feasible, if the algorithm could determine the degree of certainty, to which a document belongs to the collection in question or not. In case of the third procedure, the *subject search*, ranking might be of greater interest. In this case, when searching for a genre, the user might prefer if the relevance ranking would consider how certain it is that the piece belongs to the genre. This means that librarians would have to provide the right information to the system, which would require a genre analysis of every piece in the collection. In the complex case of instrumentation, ranking could help the user to find the right pieces if applied in a different way than today. The system would have to rank all the pieces first that contained the query instruments *only,* no other instruments; and it would have to consider structure, to avoid the matter of abbreviations appearing elsewhere in the metadata. A meaningful relevance ranking for music researchers, thus, is hard to achieve; it might be better to leave it out entirely, as the DCDC interface does.

While ranking by an algorithm developed for books, as applied on the two examined collections, is not improving the usability of search interfaces for digitized music manuscript collections, a possibility to express CAS queries might. The interface where users search for queries within structural metadata fields, the DCDC interface, is outperforming both free-text operated systems. The problem here is that users have to learn how to handle the search interface first, which not every music researcher can manage; an important drawback from the user's point of view.

It has to be said that all three search interfaces perform well when treated the right way, with the exception of instrumentation, which only is searchable properly by CAS queries in a system also offering ways of excluding instruments. In addition, all three collections can be explored via the RISM-OPAC (http://www.rism.info/de/service/opac-suche.html), too, in which those options are available. Most music researchers who answered my surveys and interviews were content with the search options and the results, not experiencing any problems. This can be explained by the role the user's expectations play during information seeking: expectations determine, largely, how a user will experience the search process (Marchionini, 1995, p. 38). Being able to find digitized music manuscripts online is a quite new phenomenon. Many survey and interview participants expressed their thankfulness, despite the issues they might have experienced, that the digital images are available at all. Finding music in card catalogues and other analogue search interfaces is even more challenging than in each of the electronic interfaces I have examined. Thus, music researchers' expectations to find immediately what they are looking for might not be high.

All three search interfaces are performing well when used for *known-item searching*. From other aspects of usability, though, there are issues within each of the three interfaces, which have been mentioned in surveys and interviews.

When looking through the results of a search in the *Schrank II* collection, users cannot easily identify specific pieces, as the metadata shown in the heading and hit information is not considering musical facets. This makes it hard to perform *browsing*, because many different pieces are labelled with the same information. The thumbnail images sometimes can offer help, when the information on the image of the title page is more extensive and clearly visible, but that is not the case for all sources. Another problem is caused by the circumstance that the link to the specific digital collection is not permanent, but adapting to the user's behavior; for a researcher, it is often necessary to make references, sometimes to the whole contents of a collection. This is hard to achieve for the digital collections of the SLUB. In addition, as mentioned before, a search for specific musical facets is not working well in the catalogue, making *subject searching* almost impossible for music researchers. On the other hand, the high-quality digital images are presented in a very neat and feasible way. For finding them, the user should take the advice given by the project team and search the collection by means of the RISM-OPAC.

When it comes to the *Utile Dulci* collection, users might have trouble finding it from the start, due to website design as well as language and linkage issues. Despite the catalogue belonging to a music library, it is not working well when searching for musical facets; the results of a *subject search*, while possible, are depending on the subject and the query: As long as the subject is contained in the long heading for each item and not easily confused with other abbreviations, the system is performing well. The images, when finally getting through to retrieving a document, are not presented in an acceptable quality to today's standards, and there are not any thumbnail images that could help identifying the scanned material among other sources, like books or modern music editions. In addition, important bibliographic information like the type of the original material or the library shelf number is completely missing in the catalogue posts. On the other hand, the long headings with added descriptive metadata facilitate *browsing* and make it possible to identify pieces directly in the hit list.

In the *Düben* collection, even music researchers who know the collection well and are used to different online search interfaces are not always able to use the complex CAS search fields in an optimal way; if they are, though, they can rely on finding absolutely everything, which actually also applies on a *subject search*. Problems can occur when attributions to composers change, because the system does not allow pieces to be associated with more than one composer. *Browsing* is a lot harder to do than in the other two interfaces, because there is not any way of showing a list of all the documents in the collection. The closest you can get is by displaying all the hits for vocal or instrumental music separately. Then, the information provided in the hit lists is sufficient for successful browsing. The image presentation could be improved, from a user's point of view; they have to click their way back and forth many times, to collect all the images belonging to one document, and they cannot zoom in or out on the images in the web browser.

Based on the factors that have an impact on the information seeking process of music researchers, it is not easy to say which of the three discovery systems is providing the best results to their queries. All three have advantages and disadvantages. While the DCDC interface is allowing all three of the identified search options (though it needs some tricking in the case of *browsing*), and it is performing well, it is so complicated that music researchers have difficulties using it correctly. The SLUB interface for digital collections has the most modern, most good-looking design and the best image presentation, but is lacking the necessary possibilities to search for other facets than the composer in a reliable way. The MTB catalogue is best for browsing the collection, because all the necessary metadata about the piece is included in the heading, but has many other issues and was never meant to be the main search interface for the *Utile Dulci* collection. When redesigning their interfaces according to the needs of music researchers, the libraries should consider both the availability of musical metadata in the result list, providing alphabetic lists for potential search terms, and the possibility of putting CAS queries as an additional, maybe not the only option.

One aspect that has not been examined in my experiments, but named by single participants in surveys and interviews, are search functions that are not available today, but desirable for the future. The composer’s gender has been one example, the possibility to search for melodies another. Unfortunately, the resources libraries have for digitizing music collections and developing optimized search interfaces are limited. Additionally, Laplante and Fujinaga found out that problems do not end at a lack of funding; libraries experience even a lack of skilled staff when digitizing music, because finding people who understand both musicological and IT procedures is difficult, and are sometimes in the middle of political differences, when responsibilities are not clear. Often, digitization projects are started without planning the presentation of and access to the materials, or without a thought on data preservation (Laplante & Fujinaga, 2016, p. 46-47). Some of these issues are reasons why the former search interface for the *Utile Dulci* collection, which several music researchers are missing, is not in use any longer. A closer cooperation with music researchers, which, according to Laplante and Fujinaga, is not often attempted, might help:

> Researchers had not been consulted, at least not formally, during the planning process, for instance to make decisions regarding the metadata or the user interface. That does not mean the planning had been done without the end-user in mind (the efforts they reported investing in metadata shows they cared about end-users), but it was mostly based on their informal knowledge of the needs of music researchers. For instance, one participant indicated that the search interface had been ‘designed specifically to help music researchers’, although there had been no consultation or usability testing (Laplante & Fujinaga, 2016, p. 47).

I hope that the results of my study can inspire others to delve deeper into this matter and improve the situation for both music libraries and music researchers.

6 Conclusion

> Music document collections are an important part of the world cultural heritage. Digitization of these collections is essential for ensuring their preservation and future access in searchable digital music libraries (Calvo-Zagaoza, et al 2016, p. 37).

While digitization of music manuscript collections at the present is an ongoing and prioritized project in many libraries, it has been shown that their accessibility for music researchers is not always considered sufficiently in those processes - for practical, financial, or political reasons at the library, but also because of the specific properties of the musical material and the divergent information seeking behavior of music researchers.

I have found that music researchers are looking for digitized music manuscript either by *known item search*, by *browsing*, or by *subject search*. In KIS and browsing, their behavior is comparable to that of other information seekers. Yet, when performing subject search, music researchers have different goals than other information seekers. The emphasis of the subject is moved from broad categories and the question what music is *about*, which is neither answerable nor of interest for anybody looking for music manuscripts, towards single *manifestations* of music pieces.

Music researchers use queries mainly for KIS and subject search; browsing is performed to get an overview on the collection's contents. The composer's name and title of the piece are typical for KIS, but when looking for manifestations in manuscript, they often share properties of a subject search, because the titles are vague, and composers have written many pieces with similar titles, especially within instrumental music. Instead, music researchers prefer library signatures, opus numbers, or work catalogue numbers for KIS. Typical queries for subject search are musical *genre*, musical *medium* (also called *instrumentation*), or *key*.

Because most libraries' digital catalogue systems are not designed especially for music and, thus, are not considering the specific properties of music manuscripts, finding all the relevant documents in a collection has proven to be difficult. While the examined access systems are sufficient for a successful KIS, they are lacking in either browsing possibilities, subject search performance, or both.

Designing access systems in a way that fits this information seeking behavior would be one possible step towards improving the accessibility of digitized music manuscripts. I hope to have given some information on issues that have to be addressed within such attempts in this study. Future research should provide further insight in the matter.

The approach of integrating a music search interface into the OPAC system shown by Thomas (2011) is one possible solution. Yet, even other options can be considered; there are different ways to enhance images and make them even more useful to the target audience:

> Today, with digital text, one can reasonably expect to be able to perform some dynamic functions on the text, such as searching, highlighting, adaptive

> display, reading aloud, and in certain circumstances, light editing. These functions are made possible by the presence of the textual content embedded in a digital text underlay, where each letter and punctuation is as if 'typed up' and linked to its corresponding location on the image (Szeto, 2018, p. 305).

With a technique like that, it could for example become possible to connect single images within digitized music manuscripts with the equivalent passage in a sound recording, making it possible to read along with the music. However, since this would require gigantic resources and the target audience, containing music researchers only, is relatively small, it does not seem practicable. According to my findings, it might not even be appreciated, because it is not something music researchers need, even though it sometimes might come in handy for educational purposes. They would prefer a plain, intelligible search interface with regard to all musical and material facets of music manuscripts and clear browsing options to such fancy enhancements. This does not mean that they would not want further developments; my survey participants mentioned watermarks and the composer's gender as queries that are not possible in all present search interfaces. New, hitherto unthought-of search options might even call forth new research trends within musicology. For further research in this field, I would wish for a study examining not only the present information seeking behavior and information needs of music researchers, but also their wishes and dreams within music manuscript discovery: If you could search by any query you could think of, which would it be?

In addition, the effect of learning on the queries used most times would be an interesting research problem to delve deeper into, because the experiences users make with existing search systems have a massive impact on the information seeking process (see chapter 4.1.3). Maybe, music researchers would seek information in an entirely different way, if they had not grown up with the knowledge that composer's name and title are the queries that work best in most music-related search interfaces. Finding the perfect search interface for digitized music manuscript collections would require at least a thought on that matter.

The final aim within music information retrieval is to make not only the digital images, but also their contents, the actual music, searchable through interfaces:

> A thousand years of print and manuscript music sits on the shelves of libraries and museums around the globe. While on-line digitization programs are opening these collections to a global audience, digital images are only the beginning of true accessibility since the musical content of these images cannot be searched by computer (Fujinaga et al., 2014, p. 1).

When this is possible, and only then, the possessors of digitized music manuscript collections need think about other potential user groups but music researchers. Until then, the information seeking behavior of music researchers needs to be considered more closely, because they are the ones giving access to the music to other people – without their work, none of the wonderful music enclosed in those illegible manuscripts could ever be heard.

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Mentioned internet resources

DCDC - The Düben Collection Database catalogue at Uppsala University Library: https://www2.musik.uu.se/duben/Duben.php (visited 2020-05-03).

IMSLP - Petrucci Music Library: https://imslp.org/wiki/Main_Page (visited 2020-05-15).

ISMIR - International Society for Music Information Retrieval: https://www.ismir.net/ (visited 2020-05-03)

Kitodo library software: http://www.kitodo.org/ (visited 2020-05-10).

Koha library software: https://koha-community.org/ (visited 2020-05-10).

RISM - Répertoire International des Sources Musicale: http://www.rism.info/de/service/opac-suche.html (visited 2020-05-15).

Schrank II at Sächsische Landesbibliothek - Staats- und Universitätsbibliothek Dresden (SLUB): https://hofmusik.slub-dresden.de/themen/schrank-zwei/ and https://digital.slub-dresden.de/kollektionssuche/ (visited 2020-05-04).

Shazam music recognition app: https://www.shazam.com/ (visited 2020-06-12).

Sunet Survey & Report: https://www.sunet.se/tjanster/survey/ (visited 2020-05-17).

Tunepal app for finding folk music tunes: https://tunepal.org/ (visited 2020-06-12).

Utile Dulci at Musik- och teaterbiblioteket Stockholm: https://discover.musikverket.se/cgi-bin/koha/opac-search.pl?q=utile+dulci#_ga=2.223028382.48251460.1583231391-1824306627.1582019325 (visited 2020-05-03).

Appendix I: anonymous online survey

Note: If not stated otherwise, all questions were open-ended.

Dear music researcher!
This survey is about your use of digitised music manuscript collections. My aim is to find out which search queries are used by music researchers, how easy it is to find what you need, and if some current information retrieval systems are posing any trouble for the research process.

Why is that important?
You might know that not a lot of research has been done about music researchers. Few digitised music manuscript collections have been evaluated regarding their functionality within music research. This is what I want to do. The long term goal is to make life easier for you, developing new ways of finding music manuscript sources in the digital world.

Who am I?
My name is Juliane Peetz-Ullman. I am music historian with a focus on older music manuscripts. During the past years, and even at the moment, I have been working with the digitisation of music manuscripts in different projects. Now I am writing my master's thesis about information retrieval systems for digitised music manuscript collections at Borås University within the master's program "Digital Libraries and Information Services". This survey is part of that research.

How does it work?
You kindly answer a few questions in your own words and submit your answers to me. This is happening anonymously. Just before submitting your answers, you will be asked if you would like to help me even further and take part in a more specific interview; then you can add your e-mail adress. Anyway, your answers are valuable to me, even if you are not prepared to take part in another interview.

[End of introduction]

1. Did you use one of the following collections during the past year?
- Schrank II at SLUB Dresden
- The Düben Collection Database Catalogue at Uppsala University Library
- Utile Dulci at Musik- och Teaterbiblioteket Stockholm

(Answer possibilities ”Yes” or ”No”, when answer ”No”, the survey was ended)

2. Which collection do you want to tell me more about? *(Drop-down to choose from)*

3. Why did you search that collection?

4. How often approximately did you use the collection during the past year?

5. What did you search for?

6. What search fields and queries did you use?

7. Did you find what you were looking for? *("Yes" or "No")*

8. What problems did you encounter?

9. Thank you for answering my questions! Would you like to help me even further? May I contact you for a more specific interview?

Please read before proceeding:
You are being invited to participate in a research study conducted at the University of Borås. The purpose of the study is to analyse the information behaviour of music researchers within digitised music manuscript collections. Responsible for the study is Juliane Peetz-Ullman, s185134@student.hb.se

We would like you to provide certain information about yourself. The personal data we would like to collect and process is your e-mail adress.

The personal data will be used to contact you for an interview.

The University of Borås is the controller of the processing, and the legal basis for the processing is article 6.1 (a) GDPR (consent).

The personal data will only be used and accessible by the researchers who conduct the study. The information is however official documents that may be disclosed if some-one requests access to it according to the principle of public access to information.

The personal data will be stored within the EU/EES and archived in the university's archive after the study is completed.

The research results will be presented in anonymised form, so that no data can be traced to you.

Your participation in this study is completely voluntary. If you consent to the process-ing of your personal data as described above, you may withdraw your consent at any time whereby we will stop using your personal data. Because of legal provisions we may however be prevented from immediately erasing your personal data.

If you agree to the conditions above, please enter your e-mail adress:

Thank you very much for your participation!

Juliane Peetz-Ullman

Appendix II: Interview guide

Interview about your search process in digitized music manuscript collections

1. Your personal background

1.1 What is your name?

1.2 What is your current occupation?

1.3 How old are you?

1.4 For how many years have you been doing music research?

1.5 Why are you searching for music manuscripts online? What is the purpose of your research?

1.6 How experienced are you when it comes to using online or digital tools in your research?

2. Your use of a digital music manuscript collection

2.1 Which collection (Utile Dulci, Schrank II, Düben collection) do you want to talk about?

2.2 Describe your experiences with that collection.

2.3 Describe your typical search process for that collection - how you approach it, how you get to the search interface, what search field and/or query you use, what results you get, how you evaluate and use the results, what view options you choose, how content you are with the results, what problems you face, and other issues you might want to highlight. You may describe different search processes, if you think that they usually differ from each other.

3. Please, share your screen with me and perform a search in the collection you mentioned. Tell me what you think while you are searching.