



THE OXFORD HANDBOOK OF

SINGING

Edited by

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All three of the cases above describe situations in which practicalities impede progress. In one case, travel is required in order to access resources. In another, resources collected by one group are tied to a particular research project. Take for example the collection of over 3,000 improvisations that Sági and Vitányi (1988) gathered systematically from 220 persons in an exploration of the natural ability to create songs in Hungary. Consider also the recordings of the developmental psychologists Papoušek and Papoušek (1981) of their child's early vocalizations, or the annual recordings at ages 5, 6, and 7 years in a longitudinal study of over 180 primary school children in London who sang two songs and their independent

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This chapter provides background on the concept of a digital library and the functions of a digital library in the support of research. It then discusses the general benefits of a digital library for research on singing, and also describes the general challenges encountered in such an initiative. A particular example of the development of a digital library for singing research is then presented with specific reference to the AIRS Project (www.airsplace.ca), which aims to advance interdisciplinary research in singing.

EXAMPLES OF DIGITAL LIBRARIES

At its most basic, a digital library is an organized collection of electronic resources related to a particular topic or area of knowledge. Beyond this, however, the term “digital library” may mean different things to different people. A highly influential paper entitled “What are digital libraries: Competing visions” contrasts the perspectives of researchers who see digital libraries as “content collected on behalf of user communities” with the view of practicing librarians who “view digital libraries as institutions or services” (Borgman 1999, p. 227).¹ Some digital libraries, or repositories as they are often called, are dynamic, allowing for the inclusion of new data (such as commentary, annotations, or analyses) over time, and others

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The British Library Sound Archive

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This resource of the British Library contains over 89,000 selected recordings of "music, spoken word and human and natural environments." A number of collections of songs of ethnomusicological interest can be found here: for example, songs of the Dinka of South Sudan. Song and singing play a special role in the lives of the Dinka people, and the songs were recorded for the purpose of exploring the relation between the Dinka song and language (Ladd 2013). This specific collection is not dynamic, but other collections are. For example, a collection of children's games and songs (see <http://sounds.bl.uk/Accents-and-dialects/Opie-collection-of-children-s-games-and-songs>) resulting from the dedicated efforts of Iona and Peter Opie (1985) primarily in the 1970s provides an "Add a note" link on the image of the sound file, which, pending approval, can be stored with the file. While some

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of these digitized recordings are almost 50 years old, their fate is much less precarious than songs stored on analogue tape or other media. The British Library aims to address the critical fragility of its old analogue audio resources. There is a costly race against time to preserve degrading cylinders, recorded disks, and tapes through a massive digitization project.

The Library of Congress in Washington, DC

<https://www.loc.gov/>

The US Library of Congress lists a total of over 400,000 results for the word “song” in its catalogue and over 125,000 items that are available online. Some materials are available in collections such as the “Coal River Folklife Collection” and “California Gold: Northern California Folk Music from the Thirties Collected by Sidney Robertson Cowell.” The vast majority of the song-related content is in the form of digitized sheet music (also accessible in the Sheet Music Consortium described earlier), but there are also approximately 5,000 audio recordings and 1,000 video recordings available online. However, due to copyright restrictions, most of the material is not available for download for further data analysis.

The Smithsonian Institution and the Folkways project

<http://www.si.edu/>

The Smithsonian Institute, also based in Washington, has collected vast archives of historical and scientific materials, datasets, art, and other cultural artifacts such as audio and video recordings, with more than 1.3 million accessible online (<http://collections.si.edu/search/>). A search on “singing” produces over 1,200 examples, many of which are audiovisual recordings that are immediately playable. The Smithsonian Folkways project (<http://www.folkways.si.edu/browse-collection/smithsonian>) contains folk music collections from the United States and around the world, such as the Archives and Research Centre for Ethnomusicology (A.R.C.E.) (www.folkways.si.edu/archives-and-research-centre-for-ethnomusicology-arce/smithsonian), which holds recordings of Indian music. Many of these recordings are albums available for sale (through Smithsonian Folkways, the non-profit record label of the Smithsonian Institution), with short excerpts of every song accessible for previewing. Smithsonian Folkways also hosts the UNESCO Collection of Traditional Music, which “contains music recordings from more than 70 nations” that were mostly collected as field recordings.

DigiCult and Europeana

<http://www.europeana.eu/portal/>

As part of the Community Research and Development Information Service (CORDIS), the Digital Heritage and Cultural Content (DigiCult) program (<http://www.echo.lu/digicult/>) has funded many digitization projects designed to share and archive important cultural material from all member countries of the European Union. Now housed under the Creativity strand of the European Commission’s ICT program (<http://cordis.europa.eu/>

fp7/ict/creativity/creativity_en.html), it aims to fund projects including leading-edge ICT research and innovation and to provide policy support. A search of the European Digital Library, Europeana (<http://www.europeana.eu/portal/>), for the word “song” produces more than 80,000 results, some including audio recordings, while others provide links to libraries and online repositories that host the digital audio content. Searching for the word “song” in other European languages also results in thousands of audio recordings of sung material. However, many of these materials are not available for download and data analysis due to copyright restrictions.

Variations—Digital Music Library of Indiana University

www.dlib.indiana.edu/projects/variations3

In the late 1990s, the University of Indiana started a project that aimed to provide online access to the library’s collection of sound recordings and to “integrate a database of music information objects (text, images, scores, sound, and a catalogue) with a graphically oriented hypermedia user interface” (Dunn and Mayer 1999, p. 12). The Variations Project (<http://variations.indiana.edu/index.html>) enabled scholars and music students to access a variety of information related to a particular musical “object” in one online location. This successful project has continued to grow, with the open-source Variations3 in 2009 (<http://www.dlib.indiana.edu/projects/variations3/>) allowing other institutions to take advantage of the University of Indiana’s digital library for music. In addition, the Variations3 project created a new metadata model “centered on the notion of the musical work” to “improve the music search experience for users over traditional catalog systems.” (Indiana University Digital Library Program 2009). In 2011 the Variations on Video project began as a multi-institutional endeavor to update the existing technology and add videos, as well as enhance the search capabilities and experiment with enabling end-users to enrich the basic metadata about musical works.

It has been said, when it comes to computing, “if you can do music, you can do anything” (Ichiro Fujinaga, personal communication 2008). In 2010, the Variations Project led the way to an expanded system that went far beyond its focus of supporting the streaming of music for university courses to supporting both university teaching and research needs, which were more and more centered on audio and video. Called the Avalon Media System, this free, “open source system for managing and providing access to large collections of digital audio and video” (<http://www.avalonmediasystem.org/>) aims to enable libraries to create online audiovisual archives which researchers, students and members of the public can access. A consortium of 12 educational, media, and open-technology institutions have developed the system, under the leadership of the libraries of Indiana University and Northwestern University in the USA.

CNRS Musée de l’Homme audio archives database

<http://archives.crem-cnrs.fr/>

As described by Khoury and Simonnot (2014), “(t)he online Web-based platform for the French CNRS-Musée de l’Homme audio archives offers access to about 28,000 published

and unpublished recordings of music” from around the world. The catalogue is organized according to four hierarchical levels, from highest to lowest: the Archive Series, Corpus, Collection, and Item levels. The sound file is the lowest-level unit and is ingested at the “item” level. Associated items are placed within a collection, the main level of entry into the database. Because someone or an institution has taken responsibility for the gathering or depositing of data, all of the collections by this person or institution are organized into a separate corpus identified by a theme or geographical area, and all corpora associated with that individual or institution are part of the highest-level category, the series. Thus the highest level is designated with respect to the originator who holds or held responsibility for the corpus. Additional contextual information about the individual or institution is attached to these highest levels of series and corpora.

Cornell Lab of Ornithology, Macaulay Library

<http://macaulaylibrary.org>

The Macaulay Library claims to be “the world’s largest and oldest scientific archive of biodiversity audio and video recordings” (Cornell University Lab of Ornithology 2016). Its original focus on birdsong was later expanded to the sounds of all living species. Originating in the late 1920s, the first recordings were audiovisual and were made with new film technology. Eventually various audiotape recording techniques provided better archiving potential, leading to an entirely audio collection of the rest of the twentieth century. In the twenty-first century, recognizing that audio represents only one aspect of behavior, video regained interest at the same time that digitized audiovisual recording became feasible. The library for sound now welcomes video recordings. It is noted that this largest sound repository has only 16 audio recordings of humans, compared to over 3,500 for other primates, and almost 135,000 of birds of many species including storks (49), penguins (154) and passerines (almost 95,000).

CHILDES—Children’s Language Data Exchange System

<http://childes.talkbank.org/>

Child language and speech development has been greatly advanced by the Children’s Language Data Exchange System (CHILDES), which was co-founded by Brian MacWhinney and Catherine Snow (MacWhinney and Snow 1985; MacWhinney 2000, 2014), who have both contributed to empirically based child language theory for over four decades. More than 100 researchers have transcribed children’s spoken discourse in accordance with codes specially created for CHILDES. A common coding system for sounds, grammatical features, words, and utterances, as well as higher-level descriptors of the data (age of speaker, gender, other interlocutors, location/context) was designed to allow for the flexible search and analysis of samples. In recent years, through Talkbank, a more general, higher-order content management system for communications research of all types, content in the database includes audio and video recordings. The CHILDES database has

led to over 5,000 published research papers, primarily in the field of developmental psycholinguistics. The success of this digital library in serving the community of researchers of early child discourse suggests the possibility that a similar digital library might have equal success in serving the community of researchers interested in how children acquire the ability to sing and in communication through singing more generally. A “CHIMES” digital library could in theory provide a foundation for a massive outpouring of research on the acquisition of singing.

Singing corpus

http://sldr.org/voir_depot.php?id=774&lang=en&sip=1

A corpus consisting of two songs (“Happy Birthday” and a specific romantic melody) sung by 50 trained vocalists, from 19 to 66 years of age, was collected by Pauline Larrouy-Maestri (2012) from the School of Psychology at Liège University in Belgium. The first song was initially sung naturally, and then with an operatic performance style. The second song was sung three times: first naturally, second, with an operatic technique, and finally humming (with a closed mouth). The corpus is hosted by the Speech and Language Data Repository (SLDR/ORTOLANG) and this “Happy Birthday” corpus (along with a wide range of language archives) is available for download by researchers who register to become part of this group. Submitting the 200 songs (i.e. all but hummed versions) to acoustical analysis, Larrouy-Maestri et al. (2014) showed that vocal technique rather than melodic style impacted the acoustical parameters measured (e.g. energy distribution, vibrato characteristics) as well as musical features such as the average tempo, and loudness (sound pressure level), and were also able to develop a profile of the operatic singing technique. An earlier corpus created by Larrouy-Maestri (2011) includes the recordings of “Happy Birthday” performed by 166 French occasional (untrained) singers, ranging in age from 14 to 76 years. These recordings were submitted to acoustical analysis of note accuracy and were also judged for accuracy by 18 experienced vocalists or instrumentalists, which revealed congruence between the objective and subjective measures. As these databases would be available to others with legitimate research interests in singing, it would be possible for other researchers to analyze the materials in other ways (e.g. the choice of starting note; correlation of various measures with age; the role of voice quality or rhythmic accuracy on the subjective judgments), including ideas suggested by Larrouy-Maestri et al. in their publication (2014).

Developing and maintaining the valuable digital repositories described above requires the commitment of technical expertise and time; steady financial support from major granting agencies, foundations, universities, and industry; the application or adaptation of new technologies and infrastructure; and dedicated space. None of the existing digital libraries for sound could fulfill all the functions required by a dynamic digital library that would support the singing research conducted by AIRS collaborators’ international, multimodal, interdisciplinary research. However, the various functions that these digital libraries serve suggest that this endeavor is within the capability of current technology.

DEVELOPMENT OF THE AIRS DIGITAL LIBRARY

The Advancing Interdisciplinary Research in Singing (AIRS) project began a major collaborative research initiative on singing (Cohen 2008, 2011), with over 70 investigators and many more students from around the world. The AIRS project aimed to conduct interdisciplinary research on singing from the perspectives of development, education and well-being. A digital library was required to facilitate distant AIRS members' work on the same data, such as the analysis of examples from voice studios around the world, stage performances, playgrounds, public places, solos, groups, classrooms, intergenerational or multicultural choirs, therapeutic settings, or new tests of singing skills (Cohen 2008; Vincent et al. 2011). Plans also included tools for annotation and analysis along with relevant documents and images. This section describes the preliminary prototypes, stages of development, and the current functional implementation of the AIRS Digital Library. It is noted that although singing is primarily an acoustic and auditory phenomenon, video records of the singer(s) are very valuable. Their benefit, however, must be weighed against challenges arising from ethical considerations and digital storage requirements. Issues of ownership and data sharing are also raised, as well as practical matters of choice of platform, storage, formats, backup, human resources, and long-term preservation.

One should not underestimate the time to develop a user-friendly, comprehensive digital library, particularly a dynamic one in which users can not only access data but can also add new data collections and comment or add to existing datasets. Khoury and Simmonot (2014) comment on seven years of work by engineers of the CREM (the Laboratory for Musical Acoustics) and web developers (from the Parisson Company) which led to a content management system and architecture to support the audio archives database for the Musée de l'homme. Once established, two full-time engineers with an ethnomusicological background manage the system with the additional help of part-time employees and students.

Fenlon et al. (2014) also describe the process of designing resources for researchers, including those in the digital humanities. They point out that at the heart of much research is the creation of collections of information. Support for research entails enabling researchers to build, access, and share these collections. The authors report on their focus group study which asked researchers to speak about their needs as builders of collections. The findings highlight the difficulty of designing digital resources to meet the unique and changing requirements of the individual researcher. Needless to say, the establishment of a digital library for AIRS was ambitious and has understandably undergone several iterations in its efforts to serve the interdisciplinary research team.

Functionality of the AIRS Digital Library

The AIRS Digital Library was developed to have the following functionality:

1. Long-term storage of vocal recordings at reasonably high resolution, including data collected in laboratory studies, solo (voice studio) and choral pedagogy, choir rehearsals, singing in natural settings (e.g. school playgrounds) and therapeutic settings (e.g. homes for seniors), and singing and speech data for the same individual.

2. Allow researchers to add information (e.g. annotation) or link to their data analyses (e.g. acoustic) so that they can build on one another's work and so that knowledge can accumulate rather than be duplicated. One example of singing contains more information than any researcher can fully analyze. By uploading new knowledge and tools along with examples, a multidisciplinary team can better develop our understanding of the nature and benefits of singing.
3. Provide examples for educators, music therapists and others:
 - (a) Songs and singing examples with information about the cultural context that gives meaning to the songs or through which the songs bring cultural understanding;
 - (b) Pedagogical examples of models (e.g. singing lessons within a voice studio) that can be used for serious voice study or voice pedagogy study (i.e. how to teach singing);
 - (c) Materials for use in intergenerational singing (e.g. in homes for seniors or community choirs) or for developing international or multicultural choirs;
 - (d) Singing exercises for various health disorders (e.g. lung diseases, Parkinson's disease, speech and language pathology).
4. Provide a place for rare, potentially otherwise perishable, cultural archives (e.g. native songs that exist only as oral tradition) that can be used for studies of song and cultural evolution (although there may be more appropriate ethnomusicological repositories).
5. Provide tools for analyzing or transforming vocal audio or notational data, both for particular individuals and groups: acoustical, anthropological, linguistic, (musical) structural, psychological, and sociological analyses. Specific procedures or tools developed by one researcher or research group (e.g. Ness et al. 2010) can be made available in one place for all researchers.
6. Provide search features using an appropriate, well-designed metadata scheme and leading-edge open-source technology. Using an open-source platform to hold the digital material allows for greater flexibility in the included information and annotation features.

In the AIRS project, each singing-related research question fits into a research framework that focuses on development, education, and well-being, along with sub-categories for each theme (see Table 19.1). A fourth primary research outcome of the project is the AIRS Digital Library itself. A key component of metadata for the AIRS Digital Library is to assign every resource to at least one theme or sub-theme using the hierarchical structure of this AIRS Research Framework.

AIRS Digital Library Prototypes

A first prototype of the AIRS Digital Library, devised with the help of the UPEI Robertson Library using the Drupal open-source software content-management environment, provided a further breakdown within each of the nine sub-themes: Experiments, Studies, Demonstrations, and Miscellaneous. Navigating to a particular category within a sub-theme led to another drop-down menu, which listed all of the experiments, studies, etc., for which data existed. Navigation to an experiment with the AIRS Test Battery of Singing Skills (Cohen et al. 2009), for example, produced a further menu that revealed the code name for a participant, one of five sessions, and the 11 different components for each test session. Each

Table 19.1 Structure of AIRS Research into three primary themes each with three sub-themes

| Development | Education | Well-being |
|--------------------------------------|----------------------------|---|
| Perception and Production of Singing | Learning to Sing Naturally | Singing and Cross-cultural Understanding |
| Multimodal Aspects of Singing | Formal Teaching of Singing | Singing and Intergenerational Understanding |
| AIRS Test Battery of Singing Skills | Using Singing to Teach | Singing and Direct Benefits to Mental and Physical Health |

component revealed an audiovisual clip of a participant in the study performing a particular singing skill, such as creating a song, singing a familiar song, learning a new song, or carrying out a language task. An ingestion system enabled the uploading of each segment and the provision of searchable metadata. While the ingestion process was slow, the primary issue was that this database was not built for scale. Its great value was in the establishment of a working prototype, whereby audiovisual information from a research study could be uploaded through a hierarchy of structural levels for sharing across a network of individuals.

In 2012, Nyssim Lefford conducted a formal survey of the needs of AIRS researchers regarding data types, quantity, and file formats. With this information, a new Digital Library prototype (version 1.0) was developed and included a wider variety of data. The model was developed using Drupal and was highly accessible, available as part of the AIRS website to anyone with a user ID and password. The prototype held mainly textual information, such as descriptors of datasets and links to the content owner (i.e. an individual AIRS researcher). While AIRS DL 1.0 contained a wide variety of singing research examples, the search features were limited.

The third AIRS Digital Library (version 2.0) was developed later in 2012 and improved permission features by enabling a sub-group of researchers to share otherwise confidential data. This prototype also added advanced search features, based on custom metadata options that reflected content types important to the AIRS user community. Each content type was associated with a custom set of metadata fields, some of which were common to all content types while others were unique to a particular content type. As an example, the Bibliography content type had metadata fields including: Title, AIRS Theme, Researchers/authors, Publication date, Keywords, Format, and Permissions, whereas the Interview content type also included fields such as Subject/Country and Authority lists.

AIRS Digital Library version 3.0

In 2014–2015, the AIRS Digital Library version 3.0 was built using an open-source Drupal website integrated with Fedora (or Flexible Extensible Digital Object Repository Architecture), together known as Islandora. Islandora was developed as a digital asset management framework by Mark Leggott, Donald Moses, and their team at the UPEI Robertson Library (www.islandora.ca).

This version of the AIRS Digital Library has benefited greatly from earlier versions in terms of both structure and functionality. However, an important advantage of version 3.0 is that the AIRS Digital Library is now integrated with the main AIRS website, using the same login ID and password to determine user access (viewing, downloading, and editing capabilities) for a file or the saved information about a file. Some of the AIRS Digital Library files can be viewed and downloaded by the general public (without logging in) whereas other files are available only to people who have the appropriate AIRS login credentials, only to people in a particular AIRS sub-theme, or only to specifically identified individuals (e.g. collaborators on a research project that is still in progress). Achieving this level of control over user access permissions was an essential requirement for AIRS researchers, in part due to the sensitivity of participants who are singing (who themselves have the ethical right to define who has the right to see their data), in part due to the fact that the data are not just audio but also video, and in part because the researchers themselves wanted a secure and private workspace for their particular team. However, this does not mean that the researchers would never share information with other AIRS members or beyond to the public arena for research and educational purposes. Figure 19.1 shows four sample screenshots from video



FIGURE 19.1 Sample screenshot from video clips related to a cross-cultural study of singing which involved children in Brazil, Kenya, China and Canada. Top left shows Brazilian children singing and top right, an individual child modeling the pronunciation of the first line of the song [with kind permission of Alda de Jesus Oliveira, from the Quadcultural Songbook study under direction of Lily Chen-Hafteck]. Bottom left shows children from Kenya singing and bottom right, an individual child modeling the pronunciation of the first line of the song. [With kind permission of Elizabeth Andang'o, from the Quadcultural Songbook study.]

clips related to a particular cross-cultural study that involved children in Brazil, Kenya, China, and Canada.

There are multiple ways to access the resources held in the AIRS Digital Library. Users may browse items that have been grouped by theme or sub-theme, or they can search for individual files using the basic and advanced search functions. Depending on the search terms and the metadata included for particular files, the search functions will return a different number of results; if too many files are found, it is possible to refine the search criteria (e.g. by date of publication) by choosing that option on the search results screen.

Examples of singing data for the AIRS Digital Library include:

- audio recordings of individuals and small groups singing
- audio and audiovideo recordings of 4–9-year-old children from the AIRS Test Battery of Singing Skills (ATBSS)
- citations linking to published resources related to the AIRS themes and sub-themes
- image files of poster presentations about singing that have been given by AIRS members
- PDF files of singing-related research papers that have been published by AIRS members
- video recordings of voice lessons in the teaching studio
- video recordings of adults (young and older) obtained from the ATBSS.
- video recordings of AIRS annual meetings (presentations and performances)
- video recordings of successive rehearsals of a choir
- audiovisual materials supporting a multi-national project.

For those who wish to contribute to the AIRS Digital Library, there are several ways to upload different types of files, including a batch upload option. Registered users may upload as many items to the AIRS DL as they wish, provided that they include the required metadata for each one. An online webform for uploading individual files makes it clear to the user which information about the resource must be provided. The required information includes the file type, the title, the type of resource, the AIRS theme or sub-themes, and copyright and user access information. For batch uploads, only one file type (e.g. .pdf) can be uploaded at a time. The metadata for each file is first entered into rows of a special Excel spreadsheet and then a macro is used to convert a Word file into multiple plain text files with the metadata for each resource. These individual text files are then combined into a .ZIP file along with each of the .pdf files corresponding to the metadata, and then uploaded to the repository. For more information, see the AIRS Digital Library at <http://airsplace.ca/about/digital-library>.

As previously mentioned, one of the advantages of the AIRS Digital Library is that it enables researchers in any location to access and contribute to the project, including the analysis of others' collected data. For example, in a project measuring how singing leads to the development of gross and fine motor skills, for which video recordings of children's singing and clapping games were collected, the same data could potentially be used by later investigators along with a larger corpus of children's singing to chart the natural development of singing accuracy for rhythm or pitch amongst children of different age ranges or in different cultures.

Figure 19.2 shows how the data for a particular research study might be found within the current structure of the AIRS Digital Library. Clicking on the folder for Theme 1–Development reveals a deeper level, consisting of three different sub-themes, which then leads to a level listing the surnames of different researchers working in that sub-theme.

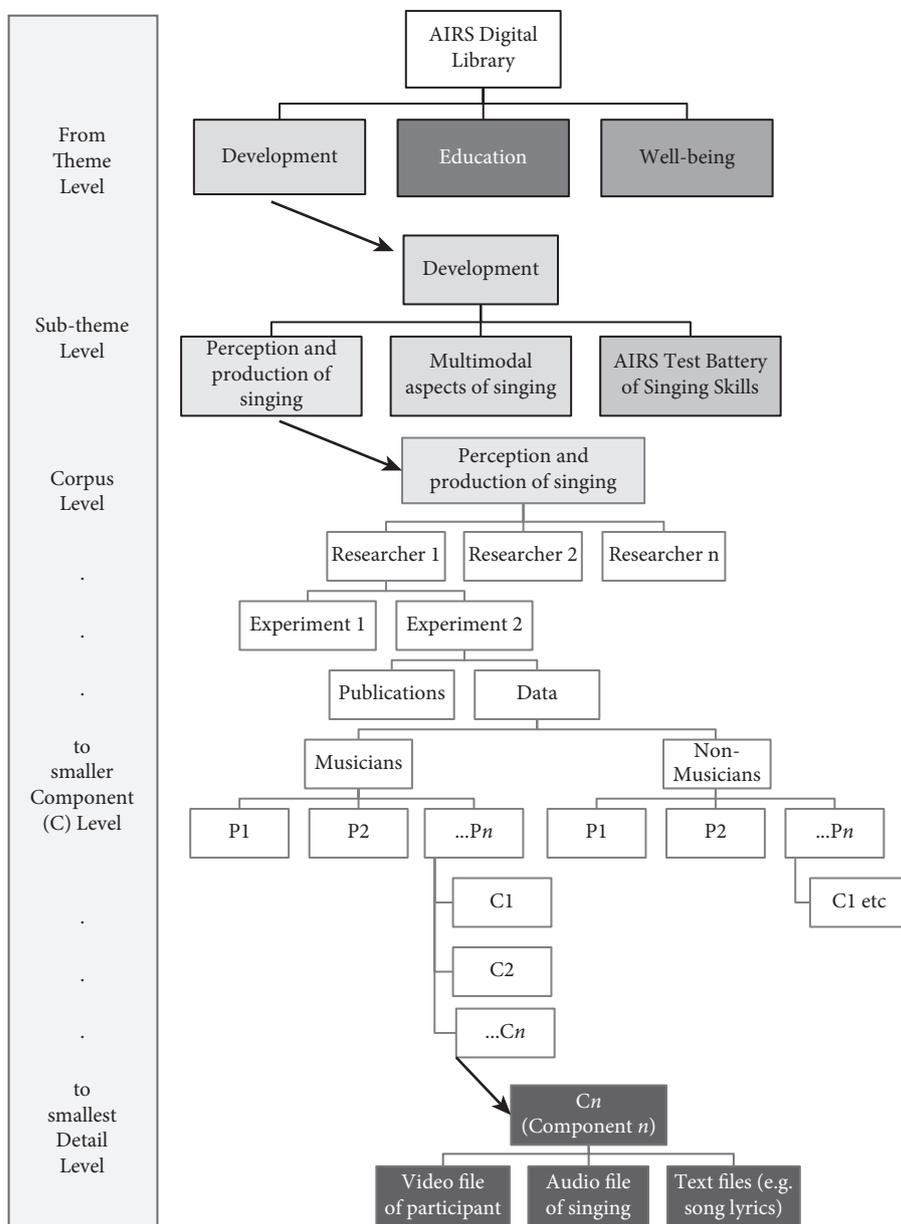


FIGURE 19.2 An example of the hierarchical structure of the AIRS Digital Library, showing the highest level of the three themes, the next level of the breakdown of the sub-themes within that research theme, several researchers contributing to that sub-theme at the next level, an experiment carried out by a researcher, a further breakdown into publications and data, the latter broken further into the data of musicians and non-musicians, and a folder for each of the participants (e.g. P1, P2, . . . , Pn), various sung components for each participant, and finally video, audio, and text files for each component.

Underneath this level may be folders that list different projects, for example, a particular research study, experiment, or demonstration. In this project, an “experiment” refers to the acquisition of data through a formal set of procedures that allow various conditions to be compared in the testing of hypotheses, whereas a study might be more exploratory, following a process more likely to be carried out in the arts and humanities than in the sciences, and the data analysis might be more amenable to qualitative as opposed to quantitative techniques. A study might entail the collection of a particular kind of singing data (e.g. from particular choirs of interest at successive rehearsals) that would provide a resource for those researchers or others to use later. The particular example represented in Figure 19.2 shows an Experiment, but similar concepts could apply to the other research categories, each of which may have many types of data and files associated with a particular project within that sub-theme.

After choosing “Experiment 2,” in this example the user can view a further sub-level for Publications or documents associated with the Experiment or data derived from the experiment, found in the Data folder. The diagram expands the Data category, which in this case is further divided into two categories, musicians and non-musicians, and within each category a folder is included for each individual participant. Within the participant folders are files for each task completed, called components ($C_1, C_2 \dots C_n$). Within each component, the data types acquired in this example experiment include video, audio, and text files. This is the lowest level shown; however, additional levels could be added to further analyze the data files. For example, the segmentation of each note in the audio file for each participant could be added, furthering the pitch analysis conducted by ear or by a computer algorithm. Thus, other researchers can build on the data and analysis provided in this study, or check the accuracy of a new method compared to previous analysis techniques.

CONCLUSION

Data collected in research is costly and time consuming. Moreover, its funding typically comes from government resources, which in turn have come from taxpayers. Other institutions may have also provided resources. Looked at in this way, all research outcomes might be regarded as jointly owned by the researchers who dedicated their time and intelligence to the work, and the organizations and government institutions that supported the work. Recognizing research as a public resource, funding agencies such as the Wellcome Trust in Britain, the National Institutes of Health in the United States, the Social Sciences and Humanities Research Council of Canada (SSHRC), the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Canadian Institute for Health Research (CIHR) have instituted a requirement to provide open access to all publications arising from their funding. This requirement, however, only goes so far. A further step is to publish the data along with the research publication. Beyond this, provision of the statistical tests carried out on the data would add a further level of information. But ultimately, access to raw data, such as audiovisual recordings of singing, may be of greatest benefit to the research community.

There are, however, costs in providing access to data through a digital library. As mentioned earlier in this chapter, simply depositing information in a digital resource is of no use unless the resource is searchable. The infrastructure must also be organized so as to effectively serve end-users, and it must be maintained over time. In addition, safeguards must be put in place such that the use of data is properly managed and acknowledged, in the same way that using information from a published article entails acknowledging the work through a complete reference. The AIRS Digital Library has been developed with ideals in mind of maximizing data sharing, reuse, transparency of workflow, linkage of data to publications, and broad dissemination of findings. While the process of development is complex, we believe that ultimately there will be extraordinary benefits for progress in our field of research on singing in its many aspects.

In closing, we point to a few questions that the AIRS Digital Library (and singing-related DLs in general) can hopefully help us answer. Some are feasible with the data and analysis tools we already have, whereas others are projects for the future.

- To what extent does the natural development of children's singing correspond to the rate of their development of speech, and how does vocal training support these skills?
- Can we identify different levels of singing ability in order to target age- and skill-appropriate group training for use in school, extracurricular, or community settings?
- What are effective techniques for training singers in the voice studio?
- What are effective techniques for choral leadership?
- How can singing be best exploited to teach other skills, for example, language?
- Can we use the relatively intact ability of individuals with Alzheimer's disease and dementia to sing old favorite songs to improve relationships between these individuals and those who help care for them?
- To what extent does enjoyment in singing depend on your cultural understanding (whether of your own or another culture), as represented in the song being sung?
- Can singing the songs of another culture increase an individual's positive attitude toward members of that culture?

Author Note: A portion of this work was presented at the International Congress on Acoustics in 2013 as represented in a conference proceedings paper (Cohen et al. 2013). This was prior to the work of Karen Ludke as postdoctoral fellow who, over an eight-month period, managed the recent development of AIRS DL 3.0 between December 2013 to August 2014.

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