# Researcher-library collaborations: Data repositories as a service for researchers

## Introduction

Databrary (2015a) is a web-based domain repository for storing and sharing videos collected as raw data for research on child development and learning. Databrary is designed to meet researchers’ needs, not as an isolated project initiated by the university library or central IT department. The focus is on a specific scholarly domain, the developmental and learning sciences, and on a particular data type—video.

Databrary has already enjoyed some level of success. Initial funding for Databrary was provided by the National Science Foundation (BCS-1238599) and the National Institute of Child Health and Human Development (U01-HD-076595). New York University (NYU) hosts the repository and its staff, with additional support from The Pennsylvania State University. Databrary began accepting contributions in early 2014 and opened for general use in October 2014. In less than a year of operation, the number of institutions with authorized users grew to 69, with 121 individual, authorized investigators from North America, Europe, South America, and Australia. As of May 2015, 35 individual contributors representing 25 different universities have contributed video data or excerpts, totaling approximately 2700 hours of video.

Most researchers who study child learning and development collect video as raw data, but various barriers have prevented them from openly sharing their video data. One critical barrier is ethical. Although personally identifying information can be removed from text-based data while preserving the integrity and reuseability of the data, the same is not true of video data. Raw research videos typically contain faces, voices, names spoken aloud, and the interiors of children’s homes and classrooms. These sorts of personally identifying information cannot be removed without violating the integrity of the data and reducing the value of the videos for reuse. Furthermore, the collection of video and other identifiable or sensitive information requires approval by a research ethics board and informed consent from the participants. The consent process formalizes a promise by the research team to protect participants’ identities from disclosure. Researchers risk breaking this promise if digital images are viewed or released to others without authorization.

Despite the challenges of sharing, video has significant potential for re-use. Video uniquely captures the complexity and richness of behavior, and it is largely self-documenting. Thus, videos recorded in one research setting for one purpose can be used by other investigators for different purposes. As such, sharing video has large potential payoffs for research reuse if contributors trust that their data will be treated with proper care and participants grant permission to share.

To realize the promise of video data sharing, Databrary has focused on reducing barriers and on forging community consensus. Project innovations include the development of policies to enable sharing of identifiable data, the creation of technical infrastructure that implements secure sharing, active curation and data management tools, easy citation of video data and related materials, and the adoption of practices that encourage researchers to share videos when they are most comfortable.

Experts in the NYU Library and project staff with training in library and information science have played a critical role in creating the infrastructure for sharing. Through intense interactions with researchers in the developmental/learning science communities, Databrary’s library and information science experts have learned about the diverse curation requirements of datasets collected through very different lab processes, and how to represent those datasets in a standard fashion for future access and re-use. Accordingly, the Databrary project offers insights about ways that libraries and librarians may engage with scholars in specific topic domains to serve emerging demands for sharing research data.

In this paper, we discuss how Databrary established itself as a data repository that works closely and frequently with researchers. We describe how Databrary found solutions to many of the barriers that limit video sharing through close interaction with our target community. Finally, we outline future enhancements to Databrary that will further this work.

## Literature Review

Creating and operating research data repositories pose many challenges. Two structural features are critical to the success of a data repository: how the repository is integrated within the host institution and how it interfaces with content producers. Databrary has strong ties to the NYU library but operates autonomously to serve the developmental and learning science research communities, similarly to other domain repositories (Peer & Green 2012; Ardini, Pan, Qin, & Cooley, 2014).

Collaborations between libraries and research entities or content producers are common. For example, Purdue Libraries and Information Technology at Purdue collaborate on the Purdue University Research Repository (PURR) (Witt, 2012). The Inter-university Consortium for Political and Social Research (ICPSR) emerged from the Institute for Social Research at the University of Michigan to encompass a consortium of institutional partners (Lyle, 2014). Yale’s Office of Digital Assets and Infrastructure (ODAI) collaborates with the Institution for Social and Policy Studies (ISPS) on an open data repository in the social sciences (Peer & Green, 2012).

New policies and practices concerning communication and engagement with the scientific community are critical to bolster scholarly practices through the curation of research data (Ogburn, 2010). Purdue Libraries, for example, developed a process for interviewing researchers about their data curation needs when contributing to data repositories because, in Carlson’s (2012) words, “services that do not align with real-world needs of researchers will not be used” (p. 12). Librarians have strengths in metadata creation and standardization across domains. Their involvement can help to reduce barriers to sharing that often plague data dissemination, particularly where research cultures widely differ (MacMillian, 2014). A librarian whose curation services are informed by working with the researchers who will be content producers can ensure better material description and documentation. This results in a better repository and more high quality research outcomes (Federer, 2013). Librarians acting in a liaison capacity can also guide and assist researchers with data management tools and best practices that make it easier for the data owners to describe and prepare their data for preservation (McLure, Level, Cranston, Oehlerts, & Culbertson, 2014). Databrary’s experiences working with investigators to curate research data bear out these observations.

Developing successful data repositories will require new practices to manage workflows involving technology and metadata creation. Researchers are increasingly held responsible for documenting and sharing the raw data from their research along with its products and derivatives (Heidorn, 2011; Greenberg, White, Carrier, & Scherle, 2009). Research data include diverse materials related to scholarly *process* as well as to products. The inclusion of process-oriented materials means that research data differ from other products of research such as journal articles and books, and it raises questions about how libraries should respond (Wickett, Sacchi, Dubin, & Renear, 2012; Hourclé, 2008). Representing research data outside of its original context risks making the data more difficult to interpret (Borgman, 2012). How should libraries represent datasets in a manner that allows them to be cataloged, preserved, and cited?

Propagating research data is fast becoming a core component of scientific communication, but a bridge between researchers and repository staff must be built to facilitate that propagation (Castelli, Manghi, & Thanos, 2013). A survey of repository staff workers in Australia and New Zealand illustrates some of the challenges ahead. For example, building digital data repositories will require library workers to develop new skills related to the repository software and skills to communicate with IT departments (Simons & Richardson, 2012). Library staff will also need to develop working knowledge about semantic web-based metadata schema such as the Resource Description Framework (RDF), multimedia file formats, and access concerns such as copyright legislation and open access standards (Simons & Richardson, 2012). Libraries are a natural place for these new responsibilities and practices to emerge, but they are not trivial to implement. Beyond these new roles and practices there will also need to be institutional changes such as the reorganization of roles, positions, and the development of library infrastructure to support research data curation (Giarlo, 2013). Databrary’s experience echoes many of these points. Staff who lack library or information science backgrounds have had to learn about curation, preservation, and metadata, and staff with that background have had to acquire a range of new technical skills pertaining to software development.

## Description of Services

Databrary’s working principles are focusing on community outreach and the provision of services for scholarly communication, working productively through institutional partnerships, offering services for data curation developed with the guidance of information professionals, and developing and maintaining a strong technical infrastructure. We discuss each of these in turn.

### Community Outreach and Scholarly Communication

From the outset, Databrary sought to connect with the research community in a meaningful way, in part by hiring staff who understand both the professional needs of researchers and the requirements for preserving information and facilitating access to it. Early on, the project team came to understand that researchers were more likely to share video data with colleagues who were part of the same scholarly community—people who held the same understanding about the sensitivities involved in sharing identifiable data related to children and families. At the same time, the team understood that it would have to change prevailing sentiments about the feasibility of sharing videos openly and bring knowledge about data curation and preservation practices to researchers unfamiliar with these topics. This led to a decision to hire two staff, one with specific responsibilities for community outreach and a second with experience in library and information science. These team members and our technical staff interact directly with researchers, providing hands-on support at every stage of the researcher’s interactions with Databrary. Staff assist with initial user registration, consult with research ethics boards, and manage data curation (see Curation below). The Databrary team actively seeks out new potential contributors and datasets, and the team has established partnerships with some of the primary scholarly associations in the developmental and learning sciences: the Society for Research in Child Development, the International Congress on Infant Studies, the Cognitive Development Society, and the American Educational Research Association.

Databrary has also attempted to forge a consensus on professional values concerning the questions of what materials to share, when in the research life cycle materials should be shared, who should share, and how one should acknowledge the use of shared videos and other materials. Databrary's Data Sharing Manifesto (Databrary, 2015b) articulates that *all* researchers should share as much material as they are comfortable sharing and have permission to share; researchers should share as early on in the research life cycle as possible; and researchers should properly acknowledge all materials contributed by others that inform their research products. To support proper citation behavior, Databrary provides valid uniform resource identifiers (URIs) in a standard format for datasets as a whole and for subcomponents within them. The system also connects via persistent identifiers such as Digital Object Identifiers (DOIs) to publications associated with a dataset. Library and information science experts have been instrumental in shaping the design and implementation of these features.

Finally, through communication with researchers, we learned about the important connections between data privacy requirements, trust in the security of the repository, and a potential contributor’s support for open data sharing. Databrary has had to create policies and technical systems to protect data privacy and establish trust. Sharing identifiable research data requires that the Databrary system restrict access to materials on the basis of the permissions granted by individual participants and on the level of sharing granted by the researcher. Databrary offers several permission levels, allowing researchers to share data only with their own lab, in bilateral relationships with specific individual Databrary researchers, with the entire community of authorized Databrary researchers, or with the general public. Because of this, Databrary staff work closely with data contributors to determine how a dataset’s original distribution restrictions, usually governed by a research ethics board (e.g., IRB), map to Databrary’s access levels. As such, privacy is a significant component of the curation process.

### Institutional Positioning

Databrary has established relations with a diverse “internal” community, as well. The project relies on several collaborations and partnerships within NYU. These enable Databrary to navigate swiftly between the University Library and the community of researchers on campus and elsewhere. The system employs a hybrid technical architecture, developed initially by the NYU Libraries and the central IT organization. The Databrary web application uses central IT servers and storage. The Libraries and central IT, in turn, guarantee the preservation of Databrary collections indefinitely, even if project funding is interrupted. This partnership requires that Databrary follow digital preservation best practices. This model is new for the Libraries and central IT, but it represents a desired direction for enhanced central support for research data repositories across the University.

Another significant partnership is with the Office of Sponsored Programs. Normally, this office does not work closely with projects after funding has been received. However, in the case of the Databrary project, the Office of Sponsored Programs has been an active partner, helping to develop new policies for granting access. The office acts as a model university Authorized Organizational Representative, a role that is critical in the legal and policy framework Databrary developed for sharing between institutions. Similarly, the General Counsel’s office, ordinarily a strictly administrative office that challenges or defends legal issues, is an active partner in developing the legal and policy framework for inter-institutional sharing.

A document called the Databrary Access Agreement enables inter-institutional sharing (Databrary, 2015c). This agreement is signed by an authorizing official, commonly referred to as an Authorized Organizational Representative in the U.S. context, or someone that has the authority to affirm the enforcement of research practices on behalf of institutions elsewhere. This is typically the director of the institution’s Office of Sponsored Programs. Individual researchers may then be authorized by an officer at their institution to access and share data using Databrary. Researchers agree to treat data from Databrary with the same standards of care and ethical concern that would apply to data they collect themselves, to respect the desired release preferences of people depicted on videos contributed to Databrary, and to supervise the use of Databrary videos and other materials by students and staff under their guidance. The agreement permits both access to the data and, with ethics board approval, contributions. To our knowledge, this combination of privileges makes the agreement novel, and like other aspects of the Databrary project, it emerged as a way to reduce barriers to sharing that the team discovered in engaging with the target scholarly community.

By bringing together and creating collaborations among various administrative entities in new ways, Databrary has also influenced university administrative processes. These relationships were envisioned from the start, with the collaborating units participating in conversations even before proposal writing began.

### Curation

A primary purpose of Databrary’s community outreach efforts, internal partnerships, and policy framework is to secure contributions of raw research videos. Databrary supports *after-the-fact* and *active curation*, or what Giarlo (2013) refers to as *post hoc* and *sheer curation*, respectively. After-the-fact curation consists of ingesting datasets after all data collection has been completed, typically after all study products (research papers, analyses, etc.) have been created. After-the-fact curation nearly always involves significant assistance and effort from a library and information science professional as well as time and energy on the part of the data owner to convey the essential aspects of their dataset for ingestion. Active curation involves tools built into Databrary that enable researchers to organize and manage their raw data and metadata online in the midst of its collection. Databrary has built a web-accessible user interface that allows researchers to enter study metadata and upload their videos after each data collection. Making active curation a regular part of a researcher’s workflow then makes sharing a quick and final step.

A central challenge in developing a data repository is defining a metadata schema that will accept a wide variety of datasets while adding a level of standardization to allow deposits to be easily searched (Hourclé, 2008; Orchard, 2014). Through working with researchers, Databrary learned early on that requiring only a minimal amount of metadata to make a dataset understandable by the intended community was preferable to making exhaustive data descriptions mandatory. The latter burdens researchers, reducing their incentive to participate. Moreover, the developmental and learning science communities support a diverse range of research topics, and with few exceptions, no common metadata ontologies have emerged. As a result, Databrary chose to create a system that defines minimum requirements for metadata, but supports the addition of information beyond that minimum even after a dataset has been deposited. This approach standardizes the internal representation of datasets while facilitating discovery and sharing from the outset. We think it also lays a foundation for the emergence of stricter metadata standards as researchers achieve consensus within the user community.

**After-the-fact curation.** Communication with researchers remains a key component in the curation of data already collected. These types of datasets include recordings collected recently and those collected many years or decades ago (often requiring digitization from tape or film). Early in the curation process, Databrary staff discuss the datasets with the researchers who plan to contribute. Frequent communication with researchers helps Databrary staff to understand how target contributors envision the representation of their data inside the repository. These discussions also inform the ongoing development of the metadata schema, ensuring that it continues to meet the diverse needs of a wide range of individual labs.

Since Databrary’s model for seeking permission to share data is new, most data eligible for after-the-fact curation were gathered under a different set of provisions. Communication between Databrary staff and the researcher helps to forge a mutual understanding about how to interpret pre-existing restrictions in a way compatible with Databrary’s policies and ethical principles. Because access restrictions are essential metadata and apply to the study volume, session (i.e., analytic units within studies), and individual video files, gathering the permissions constitutes considerable curation effort. Problems encountered and solved in the process of curating new datasets informs the process of curating new contributions. Finally, embedded library staff collaborate with research lab staff who have content domain knowledge to ensure the quality and organization of all ingested data.

After a dataset has been approved for ingesting and the contributor has been authorized for access, staff begin to gather, organize, and prepare the data. Staff will review data for personal information Databrary does not wish to upload, such as recordings of residential addresses or Social Security numbers. In the case of older video collections, where relevant metadata may have been lost or never documented, staff also review videos for any relevant metadata related to participant tasks or conditions. In these circumstances, staff with expertise in library science and in behavioral science work side by side.

Finally, once all the metadata have been organized into a set of comma-separated value (CSV) files, and video files have been uploaded to a staging server for ingest, a set of scripts merge the metadata into a JavaScript Object Notation (JSON) file which is then submitted via the web application. This initiates the uploading of the video assets, the creation of research sessions and records, transcoding of video files to a standard format, and clipping of video assets to remove identifying information where specified in the JSON file. After upload, the original and resulting video assets are stored on the long-term preservation location within NYU’s ITS data centers as described below.

**Active curation.** The curation of data well after its collection requires significant resources. Thus, researchers naturally balk at the prospect of preparing data for sharing after a study has ended. Researchers who invest a lot of time in interpreting and processing their data are less likely to share (Borgman, 2012) and after-the-fact data curation does not scale well (Giarlo, 2013). From the beginning, Databrary was intended to be an active repository in which users browse, comment on, excerpt, cite, modify, deposit, and reuse data. To realize this vision, Databrary needed to provide tools to assist researchers with managing and preserving research data from early in the research life cycle. To be useful, the tools would have to reflect and augment common practices for data collection and management in this field of research.

The decision to make active curation a priority emerged from Databrary’s focus on reducing the barriers to data sharing faced by its target research field. To make active curation compelling for researchers to use, we needed to craft interfaces that were familiar to them. The team incorporated insights drawn from observations of data management practices in a sample of laboratories. From these, we created a set of data management features that empower researchers to upload data with accompanying metadata as each study unfolds. The insight that the observational session is a basic analytic unit of behavioral science (Bakeman & Quera, 2012) inspired the decision to create a spreadsheet interface that focuses on sessions. This spreadsheet interface (see Figure 1) allows for entering, editing, and viewing session-level metadata (e.g., participants, experimental conditions or treatments, grouping variables, tasks, session access levels, etc.). Most researchers use desktop spreadsheets for precisely this purpose in their own labs, making the interface and functionality transparent to users. We have also implemented a timeline for uploading, viewing, and tagging video assets related to sessions. The timeline view is designed to look and operate like video-coding software such as Datavyu, Mangold Interact, and Noldus Observer, which many researchers in developmental science use to code videos for behaviors of interest (see Figure 2). The timeline allows users to upload video files, position them to reflect the temporal order of each component of a study session (i.e., metadata records and files), and annotate video sections with user-generated tags. These tags become additional metadata indices for search and discovery.

INSERT FIGURE 1 ABOUT HERE [Figure 1: Spreadsheet metadata interface for a dataset hosted by Databrary (Fabricius, 2014). For transparency purposes, Databrary exposes as much metadata about a study as possible without sharing sensitive or identifiable information.]

INSERT FIGURE 2 ABOUT HERE [Figure 2: Timeline for one of the sessions in a dataset hosted by Databrary (Fabricius, 2014). This session has been shared with the Databrary community, but not with the public. Still images from the video are hidden and a warning message is shown. Authorized users are able to view, download, and tag the video.]

Achieving a deep familiarity with the practices of researchers in the target domain also enabled Databrary to create a representational model for data that most researchers understand and a data management workflow similar to existing practices, but strengthened by the web-based interface. Moreover, we acknowledge that our target research domain is what Borgman (2015) would classify as “small” or “little science.” That is, our target audience reflects a domain characterized by localized and heterogenous data management practices instead of a community-wide set of standard practices. As such, we anticipate that the use of a standard metadata tool will contribute to the harmonization of metadata tags and greater standardization of data management practices, including, the possibility of standardized ontologies. If it works as intended, active curation will reduce significant barriers to sharing. As a result, active curation will accelerate the pace of contributions and inclusion of new data contributors.

To encourage new research data management practices, it is not enough to build a piece of technology and hope researchers will use it. Helping contributors to navigate the site, upload their data, and reuse other researchers’ data is also a core function of our ongoing community outreach. Furthermore, we use these outreach opportunities to gather feedback and gain a better understanding of what we need to add and improve to make Databrary a useful part of our target communities' data management workflows. Evaulation of whether active curation works should partly be based on how many of our datasets are added by the researchers themselves compared to datasets ingested after the fact by Databrary staff. Gathering feedback from users through more targeted usability testing would also help to gain a better understanding of what works and what needs improvement. In addition, we will assess how much time active curation saves both researchers and liaison librarians compared with after-the-fact curation.

### Technical Infrastructure

Because many of the system requirements for Databrary were novel and specific to the particular target domain, the team opted to build a new application rather than adapt an existing tool. The result is an open-source (Github, 2015) web application built in Scala on the Play Framework to support a responsive user interface, a complete application program interface (API), and high-performance streaming. The backend is a PostgreSQL relational database. The user interface is built primarily on the AngularJS JavaScript framework, and all data access is performed through an open JSON API.

NYU Libraries have played a critical role in advising the development team about storage and computing technologies available within the NYU IT system and in helping to negotiate access to and cost-models for IT services. As part of the curation process, Databrary stores at least two versions of each item of Databrary video content: a copy for access, and the received original file if it was digital, or a 10-bit YUV digital preservation copy if the original version was not digital. Currently, the access version format is H.264 with AAC audio in an MPEG-4 container, although we expect the appropriate video formats to change over time, as has been the case with many recent digital video formats. The system uses NYU’s High Performance Computing (HPC) cluster to transcode videos upon ingest using ffmpeg.

For preservation, the original file (if digital) or the preservation copy will be stored in a long-term preservation repository managed jointly by the NYU Libraries and the central Information Technology Services (ITS) unit. This repository ensures that each content item has a METS structural metadata file that associates the digital asset with its metadata. It stores files in two mirrored and geographically distributed locations, and a third copy on offsite tape; it performs regular fixity checks; and it provides a format migration capacity, in the event that a stored format becomes at risk of obsolescence.

## Next Steps

The Databrary team continues to build upon the lessons learned during the project’s design and initial rollout. Priorities for the next several years include improving active curation capabilities, developing feature enhancements, more extensive integration with other services, and planning for long-term sustainability.

### Improve Active Curation

As the Databrary user community grows, we will continue to update and codify our curation and collection development processes. The more datasets we see, the more we can refine our metadata schema to represent diverse datasets. In codifying our curation process, we will incorporate best practices like the Data Curation Profiles Toolkit and similar initiatives (McLure et al., 2014). Our user interface for active curation is still new, so we plan to continue gathering feedback from users to improve these tools. We aim to strike a balance between representing data as researchers want to represent it and maintaining a structure that makes information useful to and discoverable by others.

### Enhance Databrary’s Feature Set

With Databrary established as a working service, we will add enhancements that will help researchers to search and access Databrary’s materials. Full-text search is becoming relatively trivial with off-the-shelf search engines like Apache Solr or Elasticsearch, but the same cannot be said about video data. Higher level descriptions of video data can assist viewers in finding relevant content, but creating metadata that describes video file content, especially on a frame-by-frame basis, poses real challenges. By extending the video tagging and annotation tools on the session timeline, we will allow researchers to add metadata that will be useful for others to identify interesting segments of video. Similarly, we will enhance tools for researchers to create their own excerpts—small, illustrative clips gleaned from larger video files—that contain some salient event or example of a phenomenon. With the permission of the participant, investigators may share excerpts with other scholars or use them in the classroom and at conferences. Excerpts also become a means within the repository for finding and selecting datasets that have a conceptual relationship. Because many investigators who collect video do so in conjunction with other temporally dense data streams—physiological measures (e.g., heart rate, brain activity), body motion, or eye gaze position—we will explore ways to link Databrary’s video assets to external repositories storing these measures, or where feasible, provide internal support for them. Finally, we plan to incorporate ways to read and write files compatible with the most prevalent video coding/annotation tools used in the developmental and learning science communities. This will allow researchers who use Mangold or Noldus, for example, to annotate videos to share with colleagues who use other coding tools.

### Integrate with Other Services

Databrary plans to strengthen its connection with existing library services (i.e., the library catalog and other aggregate searches over existing data repositories). Going forward, we are well positioned to provide interoperability with library-based metadata schemas (such as export of data packages cross-walked to Dublin Core) and to implement standards such as the Open Archives Initiative - Protocol for Metadata Harvesting (OAI-PMH). This will allow for the automated incorporation of data that researchers add to Databrary into federated library searches with other domain-specific data repositories.

Additionally, by providing a refined API and assigning DOIs to volumes, we will provide libraries and other information systems the opportunity to tap into Databrary datasets in a more customized fashion. Minting DOIs for datasets in Databrary will also allow data to be cited in future journal articles. This helps contributors by making measurable the scholarly impact of deposited data.

### Plan for Long-term Sustainability

For the time being, Databrary does not charge users for storage, curation, or reuse services. The NSF and NICHD project grants bear the cost. Sustaining domain specific research data repositories on project-specific grants is common, but the model has flaws. Databrary is part of a consortium of domain specific repositories led by ICPSR that has called for new, more sustainable funding models (Ember et al., 2013). In the meantime, the project team continues to develop plans for long-term sustainability of Databrary, with focus on the ArXiv (ArXiv, 2015) and ICSPR institutional subscription models, storage volume/curation load based fees-for-service, and professional society partnerships.

## Conclusion

Library practitioners are engaged in active discussions about the appropriate role of libraries in the collection and management of research data. Databrary offers a working model that demonstrates how a research data repository can benefit from interacting closely with the research community. Databrary shows that a diverse team of experts can devise novel policy, technical, and curatorial solutions to problems encountered in fostering wider data sharing. The project also demonstrates that being strategically and structurally attached to library systems through management, staff, and technology is an important ingredient in building a successful repository.

We do not assume that all data repositories will be able to replicate the exact process undertaken by Databrary. Larger scale data repositories that serve different fields of research will most likely not have the available staff to shadow every domain their datasets come from. The development of data repositories will require new practices (Heidorn, 2011; McLure et al., 2014; Simons & Richardson, 2012; MacMillan, 2014). It will require the work of information professionals equipped with new skill sets that allow them to translate the needs of the library to research teams. It will require leaders who are capable of navigating between repository, policy, and library workflows, and committed to embedding themselves in the work of researchers who may not have the time, motivation, or capability of properly preserving their data for the long term.

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