

Animal Behaviour in the 21st Century: A White Paper on DRI for Animal Behaviour Research in Canada

Authors: Dr. Laura Adams (Psychology, Langara College), Dr. Kristin Andrews* (Philosophy, York University), Dr. Adam Bebko (Biomotion Lab, York University), Dr. Suzanne MacDonald (Psychology, York University), Dr. Noam Miller (Psychology, Wilfrid Laurier University), Dr. Valérie A.M. Schoof (Biology, Glendon College, York University)

Background: Animal behaviour research generates massive quantities of data, using both conventional and recently developed technologies such as photography, live video recordings of behaviour, camera traps, drone video, GPS data from trackers, movement data from accelerometers, data from crowdsourced science applications, and ethograms and data sheets used to collect animal behaviour data with pencil and paper. Often, much of these data are never analyzed or shared due to the painstaking tasks associated with preparing such large datasets for analysis and the difficulties with offering raw data to colleagues. In addition, as technologies for collecting data improve, the challenges of dealing with immense amounts of data only increases.

Animal behaviour data have the potential to offer significant benefits given the increasingly apparent importance of animal behaviour to human goals, including those related to health, development, environment, ethics, and food production. From the city rats that live in our gardens, the endangered snake species threatened by human development in their habitat, the captive mink infected with COVID-19, anthropozoonotic disease transmission risk between humans and wildlife resulting from increasing levels of interaction, and the polar bears who are facing extinction due to shrinking sea ice, understanding the behaviour of animals is essential to solving many of humanity's current problems. Some of the relevant research is conducted at field sites, some in laboratories, but in both cases the currently used and sorely needed digital research tools are largely the same.

Current DRI Environment: Current DRI tools and services that are used in animal behaviour research include data sharing and organizational tools such as Excel, Dropbox, and email, as well as a growing number of databases and "citizen" or crowdsourced science apps (e.g., iNaturalist,

* Corresponding author (andrewsk@yorku.ca)

Global Mammal Parasite Database (<https://gmpd.nunn-lab.org/>), and AviBase (<https://avibase.bsc-eoc.org>)). Data collection tools include a number of different coding software packages that come in varying degrees of functionality and expense (e.g., CyberTracker, Noldus Observer), including bespoke software used for data collection (e.g., as created for VAMS primate research); such tools may include programs that display stimuli on touchscreens, video tracking software, as well as hardware such as voice recorders, handheld computers and personal digital assistants, video cameras, and eye trackers. Data analysis and reporting tools include statistics software, specialized graphing software for vision estimates, and a lot of software written in-house, including models (e.g., for predicting navigation routes or analyzing social networks), video tracking software, data analysis scripts (mostly written in Python, R, and Matlab). Additional tools include off-the-shelf video editing software (e.g., Adobe, Camtasia) authoring tools (e.g., Word, Excel), and reference managers (e.g., Zotero, Mendeley).

Unmet DRI Needs: Researchers often lack access to some of the tools they need, depending on the resources offered at their institutions and the particular projects being undertaken. In particular, access to software written in-house often relies on the expertise of the researcher. Typically, there are no local resources for writing code and researchers must either learn to create these tools on their own, find graduate students or colleagues with whom to collaborate, or outsource such tasks to programming consultants at great expense. Even finding colleagues with whom to collaborate or professional consultants to hire can be a difficult task, when researchers don't have the time to understand what their DRI needs are or where to find colleagues whose areas of expertise could meet those needs. There is a certain amount of redundancy in researchers' efforts to find these resources on their own. Because many researchers in animal behaviour come from psychology, biology, or anthropology backgrounds, they often lack training in software creation, thereby often creating hurdles to management and analysis of collected data.

Particular needs for conducting research in animal behaviour that are often not met include sufficient storage for video and sound data that permits easy sharing, digital tools to analyze data, and access to experts in animal behaviour and software creation. For those researchers who have the skills, what is needed is additional time for tool development created for specific applications. In addition, currently there is a lack of standardized research protocols, including data collection and ethics protocols. The field would benefit from a centralised digital forum for animal behaviour researchers.

Furthermore, the quantity of data collected by animal studies is often so great that there remain large quantities of unanalyzed data. Public data repositories would provide the research community with easily accessible data for increased collaboration and resource sharing between different research groups (e.g., Primate Life Histories Database (<https://plhdb.org/>)).

The biggest challenges for animal behaviour researchers regarding DRI is **lack of expertise, training, time, and funding** when it comes to developing software used for collecting, managing, and analyzing data, as well as the **lack of centralized forums** for sharing techniques, data, and experiences.

The Future of DRI for Animal Behaviour: An ideal future state of DRI for animal behaviour researchers in Canada would address the current problem, namely that animal behaviour research gathers much more data than is usually analyzed, and data collection is rarely coordinated between research groups and is often not shared. Tools that can mine existing datasets and that can systematize how future data are collected, managed, and shared to facilitate large collaborations are sorely needed. Creating a digital repository for these data that relies on a single standard and which is made accessible to animal behaviour researchers across Canada and the world would be an invaluable resource. Standardized and easily accessible methodology and data would greatly assist in collaboration and comparative studies across research projects and species. The expertise and researcher support in using these tools is also critical to make the most of the available data and technologies. Using such a database would lead to a greater optimization of funding sources by helping researchers ask novel research questions, limiting some of the current redundancy in research, piloting measures before running an experiment or engaging on a field trip, acquiring a baseline of behaviour frequency when designing a study, and it would support blended designs which use both observational and archival data. Sharing data would also reduce the need for the use of animals in research, which is a goal of most institutions, including the Canadian Council on Animal Care (CCAC).

As technology continues to improve, current problems will become more pronounced as more animals are tracked in the wild and in labs, generating ever-increasing amounts of data. The need for shared tools and access to people who could help implement and modify those tools will only grow. The appetite for such tools is also immense; to give one example, the NIH funded the development of ImageJ, and in 1997 it was offered free to everyone and was, until the recent development of automated tracking, one of the most widely used trackers around. Other fields

have seen enormous innovation once standardized datasets have been made readily available. For example, in recent years the creation of standard datasets has spurred rapid advancement in artificial intelligence research and facilitated image recognition capacities used in everything from medical diagnoses to security applications. There is huge potential to develop this technology for research in conservation and animal behaviour, where it has a few current applications; however, this technology is inaccessible to most researchers as it is not part of standard training in the field.

Three Elements of an Animal Behaviour DRI Environment: We envision a DRI environment that includes access to excellent and readily accessible free tools in order to standardize research in the field. Among these resources, we envision using **dynamic databases** that can unify animal research in a way that would support comparative and intersectional research. Databases can systematically organize a range of data types, such as ethological (currently collected in Excel-type spreadsheets), ranging (e.g., GPS coordinate lists), audio/visual, ecological (e.g., vegetation/resource distribution and availability/weather patterns), and endocrinological data. Such databases could be used to integrate data from various domains. For example, a database could be used to link ethological data with temporally-associated ranging data in order to estimate where an animal was when a particular behavioural record was taken, or it could be used to examine behavioural interactions between species, including between humans and other animals. A recent example of such a system is the ATLAS project by the Minerva Center in Israel, which allows for detailed tracking of large numbers of animals in the wild and for extensive sharing of the resulting data between researchers, and has already led to several impactful publications.

Databases that employ a range of standardized data collection procedures would facilitate collaborations and collation of data from a variety of groups, increasing the depth of our knowledge. We also envision using databases to create a repository of research that is proposed, ongoing, and importantly, completed but not published. This would help researchers choose topics that are novel, and avoid strategies that did not pan out. As researchers, we envision using databases of DRI experts who are also trained in certain sub-fields of animal behaviour in order to seek local or specific expertise. This would help to create a community of animal cognition researchers, something that currently does not exist in Canada, in order to create large scale research teams who can together answer some of the pressing questions in the field.

Secondly, we also envision a DRI environment in which **consultation and training services** are available. Some research programs require use of existing tools, and while there is a lot of free

software currently available, it doesn't work "out of the box" for most applications. An experienced coder who specializes in this kind of work can typically adapt existing software to a specific experiment in a few days. Other research programs require creating new tools, and this is only possible with a level of expertise and amount of time that many researchers lack. For graduate students coming of age in a new DRI ecosystem, training in the use of these tools will be an important element of graduate education.

Finally, we envision a DRI environment that includes **a centralized forum** that would host dynamic databases and repositories as well as offer consultation and training services for digital technologies. The forum would consist of a small team of experts trained in both digital research techniques and animal behaviour who can create tools and modify existing ones, train colleagues and the next generation of researchers on using digital tools, maintain databases, and advertise these resources. This forum would include space for unlimited and dedicated data storage, permitting researchers to share data and find collaborators for large-scale projects.

Challenges: The primary challenges will be advertising these resources to gain widespread uptake and training researchers in their use. The metrics currently used to evaluate researcher productivity (e.g., funding, citation indices) may require conversations about the ownership of data and the sharing of null results. Institutional support and granting agency requirements can help to support the uptake of these tools and data sharing. Because of the wide range of needs across different research groups, such that many of the tools developed will require significant adaptation to specific applications, specialized support will be essential. While it may seem efficient to share a DRI expert with other disciplines, expertise in animal behaviour will be vital to developing useful DRI tools in this context.

How NDRIO Can Help: As animal behaviour researchers, we propose that NDRIO support the creation of a DRI Forum for Animal Behaviour. This can be achieved by hiring a small team whose primary role will be to create the resources for analyzing and managing the immense amount of data that is generated by animal behaviour researchers. The Forum will unify research in animal behaviour across Canada and will lead to a transformative approach to animal behaviour research that will help us answer the pressing questions of today, and tomorrow.