EUTOPIA TRAIN
Transforming Research and Innovation

Understanding Metadata

A Beginners' Guide for Researchers & Data Stewards (v2.0)

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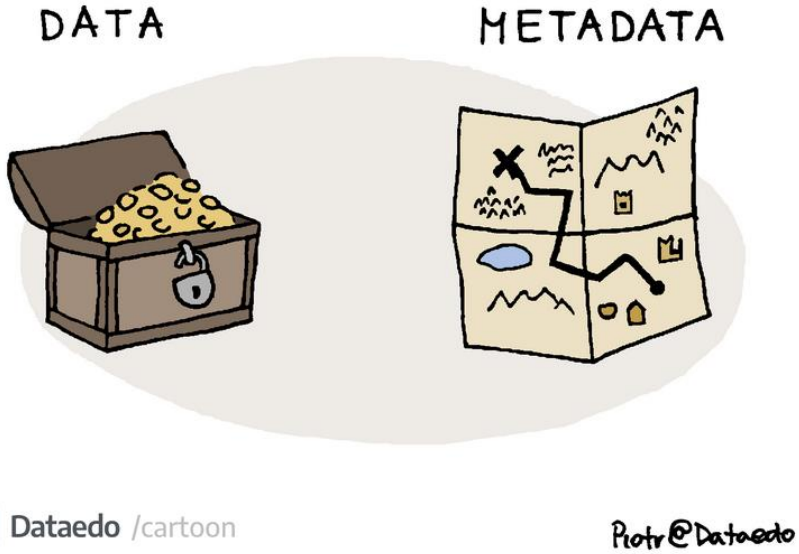
WARWICK

Outline

- Documentation
- Metadata
- FAIR Data & Metadata
- Metadata Standards
- Controlled Vocabularies
- Key Takeaways



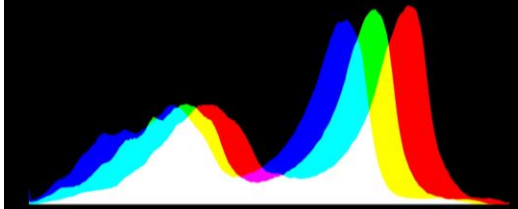
Source: Data vs Metadata #2 – Dataedo Data Cartoon
License: Creative Commons Attribution-NoDerivs 3.0 License

Data

PHOTO INFORMATION

File name: IMG_20220415_113110
Time: Apr 15, 2022 11:31:11
Resolution: 3456x4608
File size: 4.91 MB
Maker: OnePlus
Model: ONEPLUS A6003
Flash: No flash
Focal Length: 4.25 mm
White balance: Auto
Aperture: f/1.7
Exposure time: 1/2371
ISO: 100

IMAGE HISTOGRAM



OTHER

Path: /storage/emulated/0/DCIM/Camera/
IMG_20220415_113110.jpg

Metadata

DATA DOCUMENTATION

What is it and Why is it necessary?

Data Documentation

- Contextual and descriptive features of the data
- Created for
  - People who are not familiar with your research and data
  - Future YOU – who does not remember anymore what is what, where, why…
- Everything someone needs to know about data to be able to understand/use them:
  - Who collected/generated the data and how?
  - What were the research questions to be answered?
  - What kind of data was collected; when and where?
  - Was there an ethical committee approval?
  - How and by whom was the study funded?
  - Why were certain decisions made over the others (during data collection, participant selection, data manipulation, etc.)?
  - Etc.

Examples of Data Documentation

- Laboratory notebooks & experimental protocols
- Questionnaires, codebooks, data dictionaries
- Software syntax and output files
- Information about equipment settings & instrument calibration
- Database schema (see coming sections of this guide)
- Methodology reports
- Provenance information about sources of derived or digitised data

Documentation at various levels

Data documentation needs to happen at several levels:

- Study-/project-level
- File-/database-level
- Item-/object-level

Documentation: Project-level

1. Why was the data created?
2. What does the dataset contain?
3. How was the data collected?
4. Who collected the data and when?
5. How was the data processed?
6. What possible manipulations were done to the data?
7. What were the quality assurance procedures?
8. Where can the data be accessed?

Source: CESSDA Training Team. (2020). CESSDA Data Management Expert Guide. CESSDA ERIC. https://doi.org/10.5281/zenodo.3820473

Documentation: File-level (or Database-level)

Individual files within the collection – e g. text files, interview transcripts, data files, images, …

- How do all the files (or tables in a database) that make up the dataset relate to each other?
- What format are they in?
- Does any file supersede (or is superseded by) another file?

A README.txt file is a classic way of accounting for all the files and folders in a project.

TIP: README.txt

- Classic way of accounting for all the files and folders in a project (project-level)
- Can also be used at the file- or database-level...
- Usually a ".txt" file
- May or may not be in a pre-structured format
- Documents the content and structure of a (group of) dataset(s) or a project
  - README file for the whole project: primary README file
    - general information on the project or the group of datasets: e.g., title, creator, grant, etc.
    - information on the organization of the files and folders: e.g., file naming system, folder structure, short description of file content
  - README file(s) for subfolders/subsections of a project: secondary README files
    - methodological information on the data collection, processing, versioning and quality assurance: e.g., collection date (or range), methods used, software used and/or necessary to open dataset, geographical location, problems, caveats, etc.
    - information on sharing and accessibility of the data(set): e.g., licenses, links to publications
    - data-specific information (repeat this for each dataset or file): e.g., information described in a codebook

How to make a README.txt file

- Keep your README file as short as possible
- Insert blank lines to separate different blocks of information from each other
- Use standardized vocabularies and common conventions used in your discipline
- Name the file in a way that it is obvious that it includes documentation: “ReadMe.txt”, “ReadMe_DatasetX.txt”, “Note.txt”, “Documentation_FileY.txt”
  - It is also recommended to add “00_” in front of the file name (e.g., “00_ReadMe.txt”), so that it appears at the top of your file overview and is easily findable by (re)users

- Examples:
  - Cornell Uniersity: AUTHOR_DATASET_ReadmeTemplate.txt | Powered by Box
  - DataverseNO: DataverseNO_README_file_template_general_v_2_1.txt - Google Drive

Documentation: Item-level (or Object-level)

- How exactly did an object of analysis come about?
- Were there any modifications/manipulations to the item?

- E.g., data codebook contents, structure, and layout of the data – including,
  - name of the variable,
  - the full label explaining the meaning of that variable in terms of how it was operationalised,
  - the unit of measurement,
  - whether it was calculated based on other variables (and how), etc.

- Can be embedded in the individual files (e.g., R data and/or syntax files) or provided separately in another file (e.g., README.txt file)

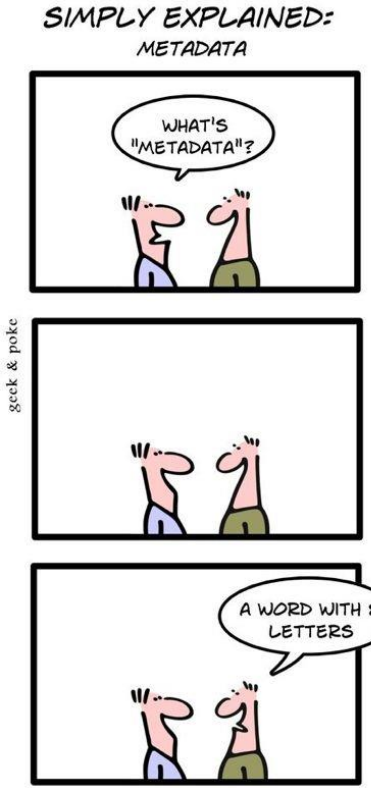
METADATA

What are they and how are they different than documentation?

Metadata

- “Data about data”
  - Describes and gives information about the data
- A specific form of **documentation** in a
  - Structured and standardised format
  - Human- AND *machine-readable** format

* (Meta)data in a *machine-readable* format are structured and standardised, and hence, can be processed correctly by computers. This is the major difference between free-style data documentation and structured metadata.



Source: Geek&Poke (geek-and-poke.com)

Types of Metadata

- *Descriptive* metadata – the descriptive information about the data, used for discovery and identification: e.g., title, abstract, author, keywords, etc.
- *Structural* metadata – the information on the physical and logical structure of the data, indicating how data elements are put together in a single dataset: e.g., variable names, location of various information in the dataset, how pages/sections are ordered, versions, relationships, etc.
- *Administrative* metadata – the information to help manage data: e.g., data/file type, permissions, when/how data were created, etc.
  - *Rights management* metadata dealing with intellectual property rights
  - *Preservation* metadata containing information needed to archive and preserve data

Source: NISO – National Information Standards Organisation (2004). Understanding Metadata. ISBN 978-1-880124-62-8. Wayback Machine (archive.org)

1. Descriptive Metadata

Anything that “describes” your data in general, such as:

- Title
- Author
- Subject
- Funder
- Abstract
- Data creator
- Codebook
- Principle investigator
- Year/date
- Discipline
- Methods → Methods used to collect data, process data, visualise data, etc.

2. Structural Metadata

Anything that describes the structure of your data, such as:

- How different datasets relate to each other
- Whether anything precedes something else
- Relationships between different files
- Versions of data and/or publications
- Hierarchy among items (parent/child files)
- Taxonomy
- Database scheme
- List of variables
- Glossary
- Dictionary

TIP: Dictionary, Glossary, and Taxonomy

- *Dictionary*: a reference source in print or electronic form containing words usually alphabetically arranged along with information about their forms, pronunciations, functions, etymologies, meanings, and syntactic and idiomatic uses

- *Glossary*: a collection of specialized terms with their meanings and brief explanations

- *Taxonomy*: classification (e.g., orderly classification of plants, animals, diseases, etc. according to their presumed natural relationships)

Source: Dictionary by Merriam-Webster: America's most-trusted online dictionary

3. Administrative Metadata

Anything that describes how the data is managed, such as:

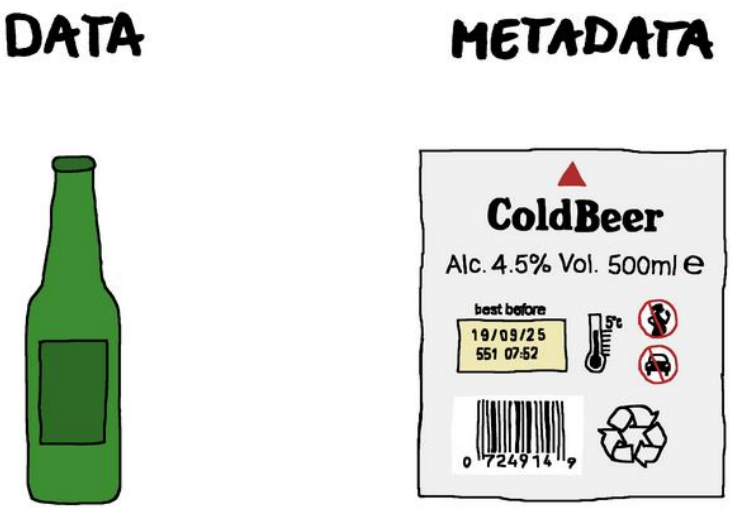
- Data/file types
- Data/file versions
- When/how the data were generated
- Rights management (reuse, intellectual property, etc.)
- Permissions
- Any other information needed to preserve and archive the data properly

Wrap-up: Metadata for each level

- Metadata is a sort of documentation and hence, they can contextualise and describe data at various levels, e.g.:
  - Item
  - File
  - Project

- For all these levels, different types of metadata can be produced
  - Descriptive
  - Structural
  - Administrative

Link between Data and Metadata

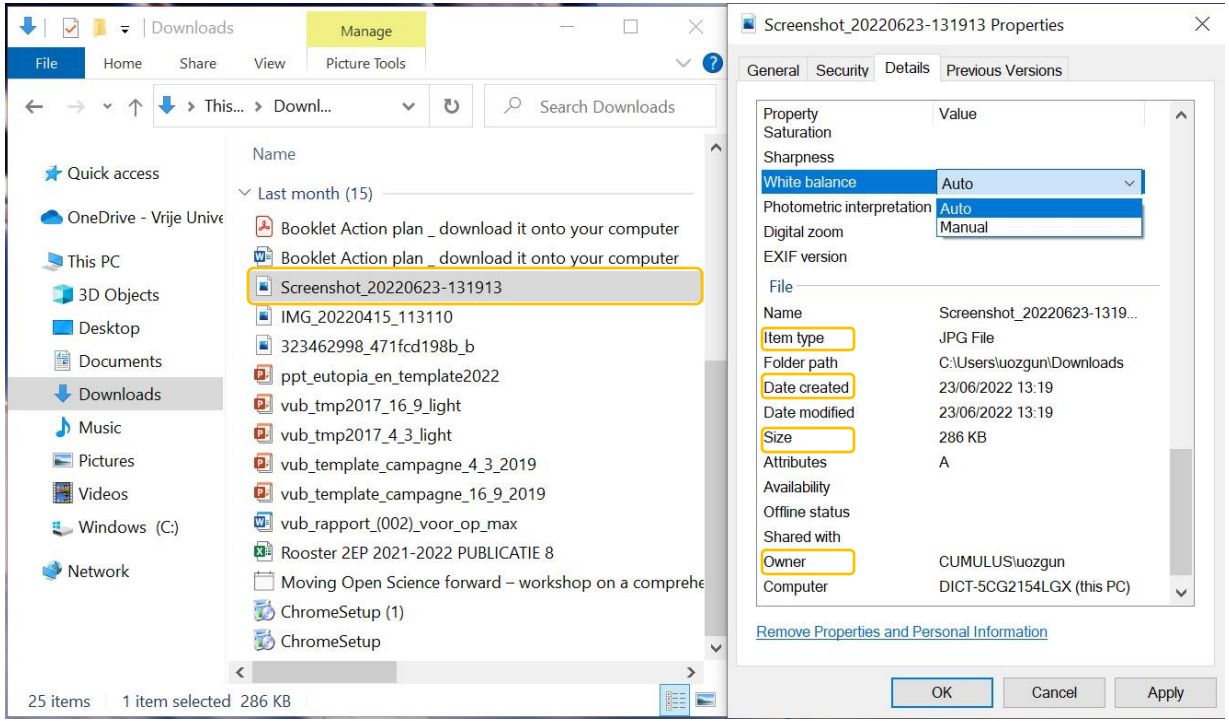


Metadata may or may not be embedded in the (digital) object or data

→ Example shows a case where the metadata is embedded in the data

Source: Data vs Metadata #8 – Dataedo Data Cartoon

Embedded Metadata: Example 1: Image



Questions:

1. What level of metadata is this?
2. What kind of metadata is this?

(Answers below & upside down)

Answers:

1. Item-level
2. Descriptive

Embedded Metadata: Example 2: Syntax

The syntax that you write to analyse your data or do another type of data modification or data generation, is also considered metadata (because you write the syntax in a structured way).

Every time you add the description of what you exactly did with/to your data (free-style explanations), you also add new data documentation.

Metadata not embedded in the data: Example

- Sometimes (some) metadata cannot be embedded in the digital file itself
- In these cases, the metadata needs to be generated separately

- Example: *README.txt* file
  - The information in this file is not embedded in any of the files but sits next to them
  - Hence, it is still possible to make sense of individual files separately or brought together

FAIR DATA & METADATA

FAIR Data

- Findable: Easy to find by both humans and computer systems and based on mandatory description of the metadata that allow the discovery of interesting datasets
- Accessible: Stored for long term such that they can be easily accessed and/or downloaded with well-defined license and access conditions (Open Access when possible), whether at the level of metadata, or at the level of the actual data content
- Interoperable: Ready to be combined with other datasets by humans as well as computer systems
- Reusable: Ready to be used for future research and to be processed further using computational methods

Source: Wilkinson, M., Dumontier, M., Aalbersberg, IJ., Appleton, G., Axton, M., et al. (2016). The FAIR Guiding Principles for scientific data management and stewardship. Scientific Data 3: 160018. https://doi.org/10.1038/sdata.2016.18

FAIRness on a Scale

- Think of FAIR principles on a scale:

- Sky is the limit to maximum **FAIR**ness of data and metadata
- Hence, aim for continuous **FAIR**ification

- Examples:
  - Quick and easy: adding your ORCID ID to the metadata
  - Further time investment: adding a unique and persistent identifier (PID)
  - More time investment: using a metadata standard

Findability of Metadata

- Metadata must include a unique persistent identifier (PID/UPI)
  - E.g., Digital Object Identifier (DOI)

- Metadata enrichment increases **F**indability
  - Enrichment via user-defined tags and keywords, glossary terms, links to other data or outputs, etc.
  - The more information you include in your metadata, the richer your metadata becomes
  - Linking the data to the creator/researcher(s) (e.g., ORCID ID)

- **F**indability is the prerequisite to **A**ccessibility
  - Note: Even if you choose to restrict access to the data itself, it is good practice to make the metadata **F**indable

TIP: A note on Metadata **Enrichment**

- Metadata enrichment is *going above and beyond* what is minimally expected (i.e., filling in the fields of the selected metadata standard as complete as possible) in order to increase discoverability and FAIRness of your data
- You can enrich your metadata by adding and linking further information, such as:
  - Publications related to the data
  - Videos, images, PDF files, quality assessments, etc.
  - Tags, keywords, etc.
  - More identifying information (e.g., ORCID IDs of all contributors) that make crosslinking across websites possible
- There is not one way to enrich metadata
- Sky is the limit to enriching your metadata

Accessibility of Metadata

- Whenever possible, provide Open Access (OA) to your data and metadata
  - Note that you can make your metadata OA and not your data…
  - It is recommended that your metadata is licenced CC0
- "As open as possible, as closed as necessary" has been the motto of Research Data Management in EU-funded research projects

  Source: Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013 (Text with EEA relevance). PE/12/2021/INIT. OJ L 170, 12.5.2021, p. 1–68. Retrieved on 01/08/2022 from here
- If OA is not possible for your data, explain why and define clearly who may have access under which conditions – examples:
  - OA possible after embargo period?
  - Who should be contacted to access the data?
  - Any other reason why data cannot be OA?

TIP: FAIR (Meta)data ≠ Open Access (Meta)data

- Making your (meta)data FAIR is a priority even if you do not (want to) share your data

- Sharing your (meta)data may not be a good idea in the case of possible
  - Dual-use (military and civilian)
  - Commercial valorisation
  - Confidentiality
  - Intellectual property
  - Personal data
  - Data protected by copyright
  - Etc.

Interoperability of Metadata

- “The importance of metadata lies in the potential for machine-to-machine interoperability”
  Source: Documentation, metadata, citation (ed.ac.uk)

- Increase *technical* interoperability:
  - Comply with the metadata standard you chose
  - If possible, give reference to open formats (e.g., .csv instead of .xls)

- Increase *semantic* interoperability:
  - Use controlled vocabularies instead of generic keywords open to different interpretations

- Increase *legal* interoperability:
  - Try to choose widely used licenses
  - Do not be overprotective with your data without a good reason

Source: Online course "Research Data Management at VUB - introductory course" (restricted access)

Reusability via Metadata

- Data should be reusable as this is
  - the only way scientific studies can be replicated and verified
  - the only way for the data to be useful beyond your study
- Reusability gives back to scientific community in many ways
- Provide clear data (re)use agreements and licenses so that access and reuse conditions are obvious
  - Who, how, when, why, under which conditions and/or restrictions, etc.

TIP: More on FAIR Principles?

- Learn more:
  - GO FAIR initiative
  - FAIRsFAIR project

- Test your FAIR knowledge at FAIR-Aware (knaw.nl)

Is it always a good idea to share your metadata?

- Even though it is recommended to share your metadata openly, note that metadata is also subject to GDPR!
  - Metadata can also be used to identify an individual and/or uncover confidential information

- Make sure to not share the metadata that may
  - Have the potential of dual use or valorisation, or
  - Contain information that might uncover confidential or personal data

METADATA STANDARDS

Why, What, and How

Metadata Schemas

- Metadata **schemas**: overall structure for the metadata
  - describe how the metadata is set up, and
  - address standards for common components of metadata (e.g., dates, names, places)

  Source: Standards/Schema - Metadata for Data Management: A Tutorial - LibGuides at University of North Carolina at Chapel Hill (unc.edu)

- There are also *discipline-specific* schemas used to address specific elements relevant to a discipline
  - BECAUSE biologists, musicians, historians, physicists, and sociologists speak different scientific languages
  - HENCE, they need different details to understand data and metadata in their respective disciplines

Metadata Standards

- Metadata **standards**: metadata schemas developed and maintained by organisations
  - ✓ So, basically, metadata *schemas* and *standards* are pretty much the same thing – the latter are maintained by an organisation so that they are standard, nice and tidy
- They simplify the process of data **F**indability and **A**ccessibility & makes data **FAIR**er
- Metadata standards are automatically applied when data are deposited in a trusted data repository
  - ✓ The information required by the repository is usually recorded and organised based on a metadata standard

Metadata Standards Explained (1)

"To illustrate this, **imagine that you have been asked to write a description of each house in a street**. You are given a blank notebook and a pen, nothing more. What do you do?

Most people will, perhaps unconsciously, tend to **adopt a set of rules or guidelines for their work**. These can be thought of as the answers chosen to a set of questions such as: 'what do I need to write for each house?', or 'what style is appropriate?'

Imagine now that only one house can be described each day. Over time **you might forget what you have done on previous days**. In order to minimise issues such as this, the answer is to **make a list of the types of information recorded and notes on style, perhaps even a form to complete**. The list or form can be referred to as each house is described. **Such a list would be a data standard**."

Source: MIDAS Heritage – The UK Historic Environment Data Standard, v1.1 (2012) retrieved on 29/07/2022 from MIDAS Heritage v1.1 (2012) (historicengland.org.uk), p. 8.

Metadata Standards Explained (2)

"Now imagine that someone wants to use your description to find out about one of the houses. Common problems that might occur are:

- you have not recorded the **particular information** asked for in your description (e.g., you described the colour of the walls, but what colour was the door?)
- you have recorded the information but not in a **format familiar to the enquirer** so they cannot find it (e.g., you wrote 'vermillion'; they were looking for 'red').

Now imagine that you want to combine your description of one street with those made by others. A common problem that might occur is:

- your list of what to record is different to the list used by your fellow worker – you have recorded **different information in a different style**."

Source: MIDAS Heritage – The UK Historic Environment Data Standard, v1.1 (2012) retrieved on 29/07/2022 from MIDAS Heritage v1.1 (2012) (historicengland.org.uk), p. 8.

Metadata Standards Explained (3)

"**The answer to this is to develop an agreed list: a standard that meets an existing need and tells future users the information that has been recorded and why.** This will ensure that all the important information is recorded. The list can tell a user what information is available, and the methods that can be used to find it; and different people can record the same sort of information and share their knowledge."

Source: MIDAS Heritage – The UK Historic Environment Data Standard, v1.1 (2012) retrieved on 29/07/2022 from MIDAS Heritage v1.1 (2012) (historicengland.org.uk), p. 8.

Example: Dublin Core (Simple & Advanced versions)

1. Title
2. Creator
3. Subject
4. Description
5. Publisher
6. Contributor
7. Date
8. Type
9. Format
10. Identifier
11. Source
12. Language
13. Relation
14. Coverage
15. Rights

"Advanced" Dublin Core further includes:

16. Audience
17. Provenance
18. Rights Holder
19. Instructional Method
20. Accrual Method
21. Accrual Periodicity
22. Accrual Policy

Source: DublinCoreGenerator.com: http://nsteffel.github.io/dublin_core_generator/index.html

Simple Dublin Core Metadata for the image below

<dc:title>Man walking with two horses</dc:title>

<dc:creator>Özgün Ünver</dc:creator>

<dc:subject>man, horses</dc:subject>

<dc:description>This photograph was taken on the day of the Course Camarguaise in Arles, on 15 April 2022. Course Camarguaise is a sort of bull fighting organised each year around Easter time in the Camargue area in South of France.</dc:description>

<dc:publisher>EUTOPIA Project Consortium</dc:publisher>

<dc:contributor>Vrije Universiteit Brussel</dc:contributor>

<dc:date>2022-04-15</dc:date>

<dc:type>Image</dc:type>

<dc:format>image/jpg</dc:format>

<dc:identifier>IMG_20220415_113110</dc:identifier>

<dc:source>n/a</dc:source>

<dc:language>n/a</dc:language>

<dc:relation>n/a</dc:relation>

<dc:coverage>Arles, France</dc:coverage>

<dc:rights>CC BY 4.0</dc:rights>

TIP: When in doubt about how to fill in a box (e.g., the format of the "date"), check the guidelines of the metadata standard. (e.g., DCMI: Using Dublin Core)

Discipline-Specific Metadata Standards

In every scientific discipline, there are different types of information that needs to be included in the metadata.

Hence, the importance of discipline-specific metadata standards.

Remember the explanation by MIDAS Heritage (previous section):

The information you'll need to log when you're describing the houses in a street will depend on whether you're describing them from the angle of, for instance:

- Geography
- History
- Architecture
- Engineering
- Aesthetics
- Demographics
- Economics
- Public health
- Chemistry

Depending on your discipline, you and your colleagues will prefer one type of metadata standard over another…

Example of discipline-specific metadata standard (1): ECRIN Metadata Schemas for Clinical Research Data Objects

European Clinical Research Infrastructure Network (ECRIN) has proposed "a metadata schema covering the discoverability, access and provenance of data objects generated by clinical research, including individual participant data sets, to help support the 'FAIRification' of those data objects".

They used two schemas:

(1) for clinical studies, based on the data structures within ClinicalTrials.gov, and

(2) the other for related data objects, based on DataCite.

Find more information about this metadata standard at https://doi.org/10.5281/zenodo.5554961

Example of discipline-specific metadata standard (2): Ecological Metadata Language (EML)

- Mostly used in earth and environmental sciences (but also in other disciplines)
- Community-maintained
- Includes metadata fields to fully detail data papers that are published in journals
- Includes modules for
  - Identifying and citing data packages
  - Describing the spatial, temporal, taxonomic, and thematic methods and protocols
  - Describing the structure and content of data within sometimes complex packages of data
  - Precisely annotating data with semantic vocabularies

Find more information about ELN at [Ecological Metadata Language (EML) (ecoinformatics.org)]

TIP: Find Discipline-specific Metadata Standards

Here are some links that compile a list of metadata standards:

- Research Data Alliance (RDA): Standards (rd-alliance.github.io)
- Digital Curation Centre (DCC): Disciplinary Metadata | DCC

Disclaimer: These lists may be incomplete, so do your own research.

CONTROLLED VOCABULARIES

What we talk about when we you talk about “control”

Controlled Vocabularies

- Standardised words and phrases created for indexing and information retrieval purposes
- Controlled Vocabularies include taxonomies, thesauri, ontologies, etc. – for example:
  - ISO 3166-1 codes for representation of countries
  - Darwin Core for the use of scientific names for species
- In thesauri, one term is selected as “preferred term” and alternative or near-synonymous terms are re-directed to this preferred term
- Different vocabularies used and linked together are called “mappings”

Source: Using Controlled Vocabulary – YouTube by University of Washington Libraries

Example of Controlled Vocabularies: **Cronquist System**

- Cronquist system is a taxonomy of flowering plants developed by Arthur Cronquist
- In this system, there are two broad classes of flowering plants: (1) Magnoliopsida (dicotyledons) and (2) Liliopsida (monocotyledons)
- Under these classes, there are subclasses, orders, families, and subfamilies

Keywords vs. Controlled Vocabularies

Keywords:

- Generated by database users, intuitive, individual, more subjective, may or may not return results
  - Basically, you can tag your content however you want
  - E.g., dog

Controlled vocabularies:

- Generated by indexers, (sometimes) organised hierarchically, specific, more objective, designed to return (a least some) results
  - Basically, you choose from what is available to tag your content
  - E.g., canis familiaris

Example: "Rose" in the image, in plant taxonomy

- Class: Magnoliopsida (dicotyledons)
  - Subclass: Rosidae
    - Order: Rosales
      - Family: Rosaceae
        - Subfamily: Rosoideae
          - Tribe: Roseae
            - Genus: Rosa
              - Species: Rosa × alba
                - "Blanche de Belgique"

Advantages of Controlled Vocabularies

- Control of synonyms – as the “preferred term” is already defined
- Control of linguistic anomalies – as the potential noise is removed via the minimalization of redundant vocabulary or grammatical variations
- Promotion of consistency and efficiency even if the person providing the metadata changes
- Clearly defined terminology that improves consistency, comparability, and efficiency
- Promotion of **I**nteroperability – as using controlled vocabularies enables cross-collection searching
- Support for machine-actionability:
  - Controlled vocabularies facilitate metadata being not only machine-readable, but also machine-interpretable

Source: Jaaskelainen, T., Moschner, M., & Wackerow, J. (2010). Controlled Vocabularies for DDI 3: Enhancing Machine-Actionability. IASSIST Quarterly, 33(1-2), 34. https://doi.org/10.29173/iq649

Challenges related to Controlled Vocabularies

Controlled Vocabularies may be

- *LESS* flexible, intuitive, up-to-date
- *MORE* controlled, structured, organised

Hence, beside controlled vocabularies, it is advised to use also *keywords* and *tags* during searches

Source: Using Controlled Vocabulary – YouTube by University of Washington Libraries

KEY TAKEAWAYS

Best Practices for Documentation & Metadata

FAIR data and metadata

- Deposit your data in a trusted data repository
  - If/when you deposit your data in a trusted repository, the repository will probably generate metadata as well
    - *Note: You can still register your metadata even if you don't deposit your data in a repository*
  - Check with your institution regarding possible restrictions (e.g., highly confidential data, valorisation, dual use, etc.) before you make your data and metadata openly accessible
- Enrich your metadata
  - Make your data more **F**indable and **A**ccessible
- Use controlled vocabularies and keywords (if applicable, also tags…)

Document, document, document… everything!

- Start as early as possible to document your data
  - ➢Earlier = Better!
- Document 5W1H: What, Where, Why, When, Who, and How
  - ➢E.g., not only save your syntax during data analysis, but also (in a separate document) explain which syntax was used at which stage
- Do not take your intimate knowledge of your data for granted, especially during data collection and analysis phases
  - ➢You are going to forget!

Create structured metadata as soon as possible

- Use both: (structured) metadata AND (unstructured) documentation
- If you document your data and research process right from the start, you can create machine-readable “metadata” at a later stage
- Choose a metadata standard that is widely used in your discipline
- Do not wait until the end of your research to start thinking about your metadata!

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