

# bead

a provenance tool

Krisztián Fekete Miklós Koren

2025-09-10

# The Editor Gives You One Week

You need to:

1. Address reviewer concerns about source data
2. Redo analysis with new data
3. Recreate Figure 1
4. Submit within one week

# But the Submission Was Months Ago

- Research submitted months ago
- Team has been improving data cleaning since then
  - Some team members left
- Different statistical methods now
- **First question:** How *exactly* was Figure 1 produced?

# Luckily, You Worked Reproducibly

Figure 1 = code(data)

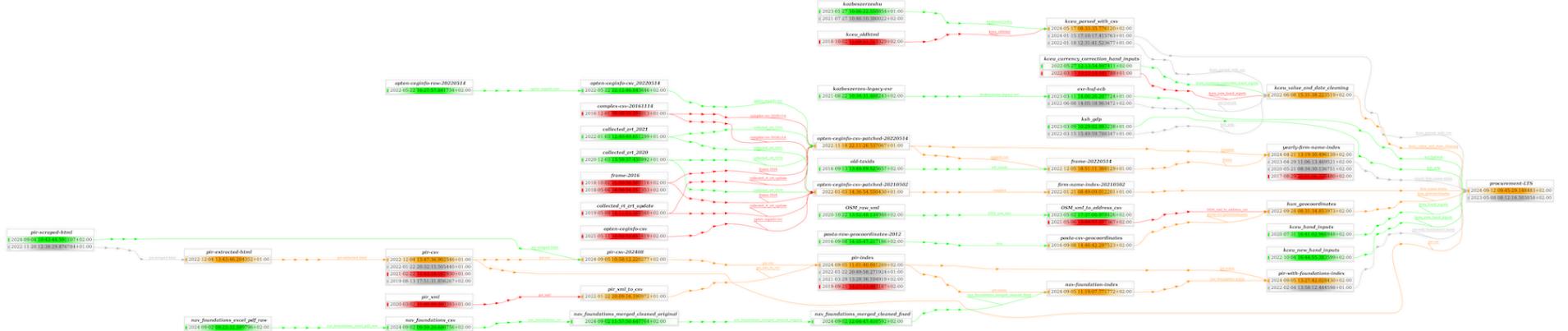
- Results depend on both algorithms and data
- Code under version control (Git) ✓
- Tagged commit at submission ✓
- **But what about the data?**

# Data is Also a the Result of a Computation

`data1 = code2(data2)`

- Data transformed by wrangling/cleaning steps
  - countries dropped
  - transformations applied
  - feature engineering details
- **Chain of data provenance**

# A Real-World Data Pipeline



# The Data Provenance Problem

# **Why It Is Complex:**

- 1. Frequent changes:** Code and data both evolve
- 2. Complex pipelines:** Many steps, multiple datasets
- 3. Tool heterogeneity:** Python, R, SQL, DuckDB all in one project
- 4. Team dynamics:** People join, leave, change roles

# Existing Solutions

# Version Control (Git)

- Great for code
- Not suitable for large binary data

# Data Version Control (DVC)

[dvc.org](https://dvc.org)

- Similar spirit to bead, but delivery/versioning focused
- **More complex than needed for provenance tracking**

# Orchestration Tools

- Apache Airflow (Python) - [airflow.apache.org](http://airflow.apache.org)
- dbt (SQL) - [getdbt.com](http://getdbt.com)
- KNIME (no-code) - [knime.com](http://knime.com)
- **Too complex for heterogeneous teams**

# Enter bead

A command-line tool that captures your data's story, step by step.

- Much simpler than alternatives
- Language agnostic
- Supports heterogeneous teams

# What bead Does NOT Do

# Not a code runner

- You run your own code
- Python, R, Stata, SQL - doesn't matter

# Not a file sharing system

- File system stores your files
- Sharing it with others is your responsibility (but can be easily automated)

# Only requirement:

- Works with flat files on file system
- Files not too big (20GB works fine)

# Core bead Concepts

# The bead

- Self-contained unit of computation
- Contains code, *reference* to input data, results
- Packaged as ZIP file
- Remembers exact provenance

# Simple Commands

```
1 bead new my-analysis  
2 bead input add source-data  
3 bead save
```

# Demo Time



# Design

- Integrity
- Ease of use
- Reproducibility

# Inspiration

- Human concept of story
  - Stories are composable
  - Helps us make sense of the world
- Project
- Publishing: ISBN / ISSN



# Demo

Conference session classification by title

- Inputs:
  - list of sessions
  - session theme classification rules
- Output:
  - list of sessions extended with theme

```
/demo $
```

```
/demo $ : ⚙ Setup
```

```
/demo $ : ⚙ Setup  
/demo $
```

```
/demo $ : ⚙ Setup  
/demo $ : prepared files
```

```
/demo $ : ⚙ Setup  
/demo $ : prepared files  
/demo $
```

```
/demo $ : ⚙ Setup
/demo $ : prepared files
/demo $ tree /demo
```

```
/demo $ : ⚙ Setup
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $
```

```
/demo $ : ⚙ Setup
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
```

```
/demo $ : ⚙ Setup
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $
```

```
/demo $ : ⚙ Setup
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $ mkdir /demo/projects
```

```
/demo $ : ⚙ Setup
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $
```

/demo/projects

```
/demo $ : ⚙ Setup
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $ cd /demo/projects
```

/demo/projects

```
/demo $ : ⚙ Setup
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $ cd /demo/projects
/demo/projects $
```

/demo/projects

```
/demo $ : ⚙ Setup
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $ cd /demo/projects
/demo/projects $ : box = storage for beads
```

/demo/projects

```
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $ cd /demo/projects
/demo/projects $ : box = storage for beads
/demo/projects $
```

/demo/projects

```
/demo $ : prepared files
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $ cd /demo/projects
/demo/projects $ : box = storage for beads
/demo/projects $ mkdir /demo/bead-box
```

/demo/projects

```
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $ cd /demo/projects
/demo/projects $ : box = storage for beads
/demo/projects $ mkdir /demo/bead-box
/demo/projects $
```

/demo/projects

/demo/bead-box

bead

```
/demo $ tree /demo
/demo
└── files
    ├── run.sh
    ├── sessions.csv
    └── theme_aliases.csv

2 directories, 3 files

/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $ cd /demo/projects
/demo/projects $ : box = storage for beads
/demo/projects $ mkdir /demo/bead-box
/demo/projects $ bead box add demo /demo/bead-box
```

/demo/projects

/demo/bead-box

bead

```
└── run.sh  
└── sessions.csv  
└── theme_aliases.csv
```

2 directories, 3 files

```
/demo $ : working directory  
/demo $ mkdir /demo/projects  
/demo $ cd /demo/projects  
/demo/projects $ : box = storage for beads  
/demo/projects $ mkdir /demo/bead-box  
/demo/projects $ bead box add demo /demo/bead-box
```

Will remember box demo

```
/demo/projects $
```

/demo/projects

/demo/bead-box

```
└── run.sh  
└── sessions.csv  
└── theme_aliases.csv
```

2 directories, 3 files

```
/demo $ : working directory  
/demo $ mkdir /demo/projects  
/demo $ cd /demo/projects  
/demo/projects $ : box = storage for beads  
/demo/projects $ mkdir /demo/bead-box  
/demo/projects $ bead box add demo /demo/bead-box
```

Will remember box demo

```
/demo/projects $ bead box list
```

/demo/projects

/demo/bead-box

bead

```
/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $ cd /demo/projects
/demo/projects $ : box = storage for beads
/demo/projects $ mkdir /demo/bead-box
/demo/projects $ bead box add demo /demo/bead-box
Will remember box demo

/demo/projects $ bead box list
Boxes:
-----
demo: /demo/bead-box

/demo/projects $
```

/demo/projects

/demo/bead-box

bead

```
/demo $ : working directory
/demo $ mkdir /demo/projects
/demo $ cd /demo/projects
/demo/projects $ : box = storage for beads
/demo/projects $ mkdir /demo/bead-box
/demo/projects $ bead box add demo /demo/bead-box
Will remember box demo

/demo/projects $ bead box list
Boxes:
-----
demo: /demo/bead-box

/demo/projects $ clear
```

/demo/projects

/demo/bead-box

bead

```
/demo/projects $
```

/demo/projects

/demo/bead-box

bead

```
/demo/projects $ : 📁 First bead
```

/demo/projects

/demo/bead-box

bead

```
/demo/projects $ : 📁 First bead  
/demo/projects $
```

/demo/projects

/demo/bead-box

bead

```
/demo/projects $ : 📁 First bead  
/demo/projects $ bead new sessions
```

/demo/projects

/demo/bead-box

bead

```
/demo/projects $ : 📁 First bead
/demo/projects $ bead new sessions
Created workspace "sessions"

/demo/projects $
```

```
/demo/projects
└── sessions
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
```

```
/demo/projects $ : 📁 First bead
/demo/projects $ bead new sessions
Created workspace "sessions"

/demo/projects $ cd sessions
```

```
/demo/projects
└── sessions
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
```

```
/demo/projects $ : 📁 First bead
/demo/projects $ bead new sessions
Created workspace "sessions"

/demo/projects $ cd sessions
/demo/projects/sessions $
```

```
/demo/projects
└── sessions
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
```

```
/demo/projects $ : 📁 First bead
/demo/projects $ bead new sessions
Created workspace "sessions"

/demo/projects $ cd sessions
/demo/projects/sessions $ cp -v /demo/files/sessions.csv output
```

```
/demo/projects
└── sessions
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
```

```
/demo/projects $ : 📁 First bead
/demo/projects $ bead new sessions
Created workspace "sessions"

/demo/projects $ cd sessions
/demo/projects/sessions $ cp -v /demo/files/sessions.csv output
'/demo/files/sessions.csv' -> 'output/sessions.csv'

/demo/projects/sessions $
```

```
/demo/projects
└── sessions
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
```

```
/demo/projects $ : 📁 First bead
/demo/projects $ bead new sessions
Created workspace "sessions"

/demo/projects $ cd sessions
/demo/projects/sessions $ cp -v /demo/files/sessions.csv output
'/demo/files/sessions.csv' -> 'output/sessions.csv'

/demo/projects/sessions $ csvlook output/sessions.csv
```

```
/demo/projects
└── sessions
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
```

```
Created workspace "sessions"

/demoprojects $ cd sessions
/demoprojects/sessions $ cp -v /demo/files/sessions.csv output
'/demo/files/sessions.csv' -> 'output/sessions.csv'

/demoprojects/sessions $ csvlook output/sessions.csv
| title | speaker |
| ----- | ----- |
| AI in Healthcare | Alice |
| Blockchain for Banking | Bob |
| Solar Panel Efficiency | Charlie |
| Team Building Workshop | Diana |
```

```
/demoprojects
└── sessions
    ├── input
    ├── output
    └── temp
```

```
/demobead-box
```

```
Created workspace "sessions"

/demoprojects $ cd sessions
/demoprojects/sessions $ cp -v /demo/files/sessions.csv output
'/demo/files/sessions.csv' -> 'output/sessions.csv'

/demoprojects/sessions $ csvlook output/sessions.csv
| title | speaker |
| ----- | ----- |
| AI in Healthcare | Alice |
| Blockchain for Banking | Bob |
| Solar Panel Efficiency | Charlie |
| Team Building Workshop | Diana |

/demoprojects/sessions $ bead save
```

```
/demoprojects
└── sessions
    ├── input
    ├── output
    └── temp
        └── sessions.csv
```

```
/demobead-box
```

```
/demo/projects/sessions $ cp -v /demo/files/sessions.csv output
'/demo/files/sessions.csv' -> 'output/sessions.csv'

/demoprojects/sessions $ csvlook output/sessions.csv
| title | speaker |
| ----- | ----- |
| AI in Healthcare | Alice |
| Blockchain for Banking | Bob |
| Solar Panel Efficiency | Charlie |
| Team Building Workshop | Diana |
```

```
/demoprojects/sessions $ bead save
Successfully stored bead at /demo/bead-box/sessions_20250910T150420886649+0000.zip.
```

```
/demoprojects/sessions $
```

```
/demoprojects
└── sessions
    ├── input
    ├── output
    └── temp
        └── sessions.csv
```

```
/demobead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects/sessions $ cp -v /demo/files/sessions.csv output
'/demo/files/sessions.csv' -> 'output/sessions.csv'

/demoprojects/sessions $ csvlook output/sessions.csv
| title | speaker |
| ----- | ----- |
| AI in Healthcare | Alice |
| Blockchain for Banking | Bob |
| Solar Panel Efficiency | Charlie |
| Team Building Workshop | Diana |
```

```
/demoprojects/sessions $ bead save
Successfully stored bead at /demo/bead-box/sessions_20250910T150420886649+0000.zip.
```

```
/demoprojects/sessions $ bead discard
```

```
/demoprojects
└── sessions
    ├── input
    ├── output
    │   └── sessions.csv
    └── temp
```

```
/demobead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects/sessions $ csvlook output/sessions.csv
| title           | speaker |
| -----          | ----- |
| AI in Healthcare | Alice |
| Blockchain for Banking | Bob |
| Solar Panel Efficiency | Charlie |
| Team Building Workshop | Diana |
```

```
/demo/projects/sessions $ bead save
```

```
Successfully stored bead at /demo/bead-box/sessions_20250910T150420886649+0000.zip.
```

```
/demo/projects/sessions $ bead discard
```

```
Deleted workspace /demo/projects/sessions
```

```
/demo/projects/sessions $
```

```
/demo/projects
```

```
/demo/bead-box
```

```
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects/sessions $ csvlook output/sessions.csv
| title           | speaker |
| -----          | ----- |
| AI in Healthcare | Alice |
| Blockchain for Banking | Bob |
| Solar Panel Efficiency | Charlie |
| Team Building Workshop | Diana |
```

```
/demo/projects/sessions $ bead save
```

```
Successfully stored bead at /demo/bead-box/sessions_20250910T150420886649+0000.zip.
```

```
/demo/projects/sessions $ bead discard
```

```
Deleted workspace /demo/projects/sessions
```

```
/demo/projects/sessions $ cd ..
```

```
/demo/projects
```

```
/demo/bead-box
```

```
└── sessions_20250910T150420886649+0000.zip
```

title	speaker
AI in Healthcare	Alice
Blockchain for Banking	Bob
Solar Panel Efficiency	Charlie
Team Building Workshop	Diana

```
/demo/projects/sessions $ bead save
```

```
Successfully stored bead at /demo/bead-box/sessions_20250910T150420886649+0000.zip.
```

```
/demo/projects/sessions $ bead discard
```

```
Deleted workspace /demo/projects/sessions
```

```
/demo/projects/sessions $ cd ..
```

```
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box
```

```
└── sessions_20250910T150420886649+0000.zip
```

title	speaker
AI in Healthcare	Alice
Blockchain for Banking	Bob
Solar Panel Efficiency	Charlie
Team Building Workshop	Diana

```
/demo/projects/sessions $ bead save
```

```
Successfully stored bead at /demo/bead-box/sessions_20250910T150420886649+0000.zip.
```

```
/demo/projects/sessions $ bead discard
```

```
Deleted workspace /demo/projects/sessions
```

```
/demo/projects/sessions $ cd ..
```

```
/demo/projects $ clear
```

```
/demo/projects
```

```
/demo/bead-box
```

```
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box
```

```
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ : 📁 Second bead
```

```
/demo/projects
```

```
/demo/bead-box
```

```
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ : 📁 Second bead  
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box  
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ : 📁 Second bead  
/demo/projects $ bead new theme-aliases
```

```
/demo/projects
```

```
/demo/bead-box  
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ : 📁 Second bead
/demo/projects $ bead new theme-aliases
Created workspace "theme-aliases"

/demo/projects $
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ : 📁 Second bead
/demo/projects $ bead new theme-aliases
Created workspace "theme-aliases"

/demo/projects $ cd theme-aliases
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ : 📁 Second bead
/demo/projects $ bead new theme-aliases
Created workspace "theme-aliases"

/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ : 📁 Second bead
/demo/projects $ bead new theme-aliases
Created workspace "theme-aliases"

/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $ cp -v /demo/files/theme_aliases.csv output
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ : 📁 Second bead
/demo/projects $ bead new theme-aliases
Created workspace "theme-aliases"

/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $ cp -v /demo/files/theme_aliases.csv output
'/demo/files/theme_aliases.csv' -> 'output/theme_aliases.csv'

/demo/projects/theme-aliases $
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    │   └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ : 📁 Second bead
/demo/projects $ bead new theme-aliases
Created workspace "theme-aliases"

/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $ cp -v /demo/files/theme_aliases.csv output
'/demo/files/theme_aliases.csv' -> 'output/theme_aliases.csv'

/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    │   └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ bead new theme-aliases
Created workspace "theme-aliases"

/demoprojects $ cd theme-aliases
/demoprojects/theme-aliases $ cp -v /demo/files/theme_aliases.csv output
'/demo/files/theme_aliases.csv' -> 'output/theme_aliases.csv'

/demoprojects/theme-aliases $ csvlook output/theme_aliases.csv
| alias      | canonical_theme      |
| ----- | ----- |
| ai        | artificial intelligence |
| blockchain | blockchain |
| solar     | sustainability |
```

```
/demoprojects
└── theme-aliases
    ├── input
    ├── output
    └── └── theme_aliases.csv
    └── temp

/demobead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ bead new theme-aliases
Created workspace "theme-aliases"

/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $ cp -v /demo/files/theme_aliases.csv output
'/demo/files/theme_aliases.csv' -> 'output/theme_aliases.csv'

/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
| alias      | canonical_theme      |
| ----- | ----- |
| ai        | artificial intelligence |
| blockchain | blockchain |
| solar     | sustainability |
```

/demo/projects/theme-aliases \$ bead save

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    │   └── theme_aliases.csv
    └── temp

/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
```

```
/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $ cp -v /demo/files/theme_aliases.csv output
'/demo/files/theme_aliases.csv' -> 'output/theme_aliases.csv'

/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
+ alias      | canonical_theme      +
+ -----+-----+
| ai        | artificial intelligence |
| blockchain | blockchain           |
| solar     | sustainability          |

/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip.

/demo/projects/theme-aliases $
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    │   └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $ cp -v /demo/files/theme_aliases.csv output
'/demo/files/theme_aliases.csv' -> 'output/theme_aliases.csv'

/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
| alias      | canonical_theme      |
| -----      | -----      |
| ai          | artificial intelligence |
| blockchain  | blockchain      |
| solar        | sustainability      |

/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip.

/demo/projects/theme-aliases $ bead discard
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    │   └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
+-----+-----+
| alias | canonical_theme |
+-----+-----+
| ai    | artificial intelligence |
| blockchain | blockchain |
| solar | sustainability |
```

```
/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip.
```

```
/demo/projects/theme-aliases $ bead discard
Deleted workspace /demo/projects/theme-aliases
```

```
/demo/projects/theme-aliases $
```

/demo/projects

/demo/bead-box

```
|── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
+-----+-----+
| alias | canonical_theme |
+-----+-----+
| ai    | artificial intelligence |
| blockchain | blockchain |
| solar | sustainability |
```

```
/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip.
```

```
/demo/projects/theme-aliases $ bead discard
Deleted workspace /demo/projects/theme-aliases
```

```
/demo/projects/theme-aliases $ cd ..
```

```
/demo/projects
```

```
/demo/bead-box
```

```
|── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
+-----+-----+
| alias | canonical_theme |
+-----+-----+
| ai    | artificial intelligence |
| blockchain | blockchain |
| solar | sustainability |
```

```
/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip.
```

```
/demo/projects/theme-aliases $ bead discard
Deleted workspace /demo/projects/theme-aliases
```

```
/demo/projects/theme-aliases $ cd ..
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box
```

```
|── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
+ alias      | canonical_theme      +
+ -----      +-----+
| ai         | artificial intelligence |
| blockchain | blockchain          |
| solar       | sustainability        |

/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip.

/demo/projects/theme-aliases $ bead discard
Deleted workspace /demo/projects/theme-aliases

/demo/projects/theme-aliases $ cd ..
/demo/projects $ clear
```

```
/demo/projects
```

```
/demo/bead-box
├── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box
```

```
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : 🔗 Computation
```

```
/demo/projects
```

```
/demo/bead-box
```

```
|__ sessions_20250910T150420886649+0000.zip  
|__ theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : 🔗 Computation  
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : 🔗 Computation  
/demo/projects $ bead new possible-tracks
```

/demo/projects

/demo/bead-box  
└── sessions\_20250910T150420886649+0000.zip  
└── theme-aliases\_20250910T150620502609+0000.zip

```
/demo/projects $ : Computation
/demo/projects $ bead new possible-tracks
Created workspace "possible-tracks"

/demo/projects $
```

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : Computation
/demo/projects $ bead new possible-tracks
Created workspace "possible-tracks"

/demo/projects $ cd possible-tracks
```

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : 🔗 Computation
/demo/projects $ bead new possible-tracks
Created workspace "possible-tracks"

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $
```

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : 🔗 Computation
/demo/projects $ bead new possible-tracks
Created workspace "possible-tracks"

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $ bead input add sessions
```

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : 🔗 Computation
/demo/projects $ bead new possible-tracks
Created workspace "possible-tracks"

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $ bead input add sessions
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK
Loading new data to sessions ... Done

/demo/projects/possible-tracks $
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : 🔗 Computation
/demo/projects $ bead new possible-tracks
Created workspace "possible-tracks"

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $ bead input add sessions
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK
Loading new data to sessions ... Done

/demo/projects/possible-tracks $ bead input add theme-aliases
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── output
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : 🔗 Computation
/demo/projects $ bead new possible-tracks
Created workspace "possible-tracks"

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $ bead input add sessions
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK
Loading new data to sessions ... Done

/demo/projects/possible-tracks $ bead input add theme-aliases
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK
Loading new data to theme-aliases ... Done

/demo/projects/possible-tracks $
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    │   └── theme-aliases
    │       └── theme_aliases.csv
    ├── output
    └── temp

/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : 🔗 Computation
/demo/projects $ bead new possible-tracks
Created workspace "possible-tracks"

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $ bead input add sessions
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK
Loading new data to sessions ... Done

/demo/projects/possible-tracks $ bead input add theme-aliases
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK
Loading new data to theme-aliases ... Done

/demo/projects/possible-tracks $ cp -v /demo/files/run.sh .
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    │   └── theme-aliases
    │       └── theme_aliases.csv
    ├── output
    └── temp

/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
Created workspace "possible-tracks"

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $ bead input add sessions
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK
Loading new data to sessions ... Done

/demo/projects/possible-tracks $ bead input add theme-aliases
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK
Loading new data to theme-aliases ... Done

/demo/projects/possible-tracks $ cp -v /demo/files/run.sh .
'./demo/files/run.sh' -> './run.sh'

/demo/projects/possible-tracks $
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   ├── sessions
    │   │   └── sessions.csv
    │   └── theme-aliases
    │       └── theme_aliases.csv
    ├── output
    ├── run.sh
    └── temp

/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
Created workspace "possible-tracks"

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $ bead input add sessions
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK
Loading new data to sessions ... Done

/demo/projects/possible-tracks $ bead input add theme-aliases
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK
Loading new data to theme-aliases ... Done

/demo/projects/possible-tracks $ cp -v /demo/files/run.sh .
'./demo/files/run.sh' -> './run.sh'

/demo/projects/possible-tracks $ nl run.sh
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    │   └── theme-aliases
    │       └── theme_aliases.csv
    ├── output
    ├── run.sh
    └── temp

/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
1 duckdb <<SQL
2 COPY (
3     SELECT DISTINCT
4         s.*,
5         a.canonical_theme AS theme
6     FROM
7         read_csv_auto('input/sessions/sessions.csv') AS s
8     LEFT JOIN
9         read_csv_auto('input/theme-aliases/theme_aliases.csv') AS a
10    ON      '' || lower(s.title) || '' ILIKE '%' || lower(a.alias) || '%'
11    ORDER BY speaker, title, theme
12 ) TO 'output/classified_sessions.csv';
13 SQL
```

/demo/projects/possible-tracks \$

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    └── theme-aliases
        └── theme_aliases.csv
    ├── output
    └── run.sh
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
1 duckdb <<SQL
2 COPY (
3     SELECT DISTINCT
4         s.*,
5         a.canonical_theme AS theme
6     FROM
7         read_csv_auto('input/sessions/sessions.csv') AS s
8     LEFT JOIN
9         read_csv_auto('input/theme-aliases/theme_aliases.csv') AS a
10    ON      '' || lower(s.title) || '' ILIKE '%' || lower(a.alias) || '%'
11    ORDER BY speaker, title, theme
12 ) TO 'output/classified_sessions.csv';
13 SQL
```

```
/demo/projects/possible-tracks $ bash run.sh
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    └── theme-aliases
        └── theme_aliases.csv
    ├── output
    ├── run.sh
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
2 COPY (
3     SELECT DISTINCT
4         s.*,
5         a.canonical_theme AS theme
6     FROM
7         read_csv_auto('input/sessions/sessions.csv') AS s
8     LEFT JOIN
9         read_csv_auto('input/theme-aliases/theme_aliases.csv') AS a
10    ON      ' ' || lower(s.title) || ' ' ILIKE '% ' || lower(a.alias) || ' %'
11    ORDER BY speaker, title, theme
12 ) TO 'output/classified_sessions.csv';
13 SQL
```

```
/demo/projects/possible-tracks $ bash run.sh
/demo/projects/possible-tracks $
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    └── theme-aliases
        └── theme_aliases.csv
    └── output
        └── classified_sessions.csv
    └── run.sh
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
2 COPY (
3     SELECT DISTINCT
4         s.*,
5         a.canonical_theme AS theme
6     FROM
7         read_csv_auto('input/sessions/sessions.csv') AS s
8     LEFT JOIN
9         read_csv_auto('input/theme-aliases/theme_aliases.csv') AS a
10    ON      ' ' || lower(s.title) || ' ' ILIKE '% ' || lower(a.alias) || ' %'
11    ORDER BY speaker, title, theme
12 ) TO 'output/classified_sessions.csv';
13 SQL
```

```
/demo/projects/possible-tracks $ bash run.sh
/demo/projects/possible-tracks $ : No arguments: script, not a tool!
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    └── theme-aliases
        └── theme_aliases.csv
    ├── output
    │   └── classified_sessions.csv
    ├── run.sh
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```

```
3   SELECT DISTINCT
4     s.*,
5       a.canonical_theme AS theme
6   FROM
7     read_csv_auto('input/sessions/sessions.csv') AS s
8   LEFT JOIN
9     read_csv_auto('input/theme-aliases/theme_aliases.csv') AS a
10  ON  ' ' || lower(s.title) || ' ' ILIKE '% ' || lower(a.alias) || ' %'
11  ORDER BY speaker, title, theme
12 ) TO 'output/classified_sessions.csv';
13 SQL
```

```
/demo/projects/possible-tracks $ bash run.sh
/demo/projects/possible-tracks $ : No arguments: script, not a tool!
/demo/projects/possible-tracks $
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    └── theme-aliases
        └── theme_aliases.csv
    ├── output
    │   └── classified_sessions.csv
    └── run.sh
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```

```
3  SELECT DISTINCT
4      s.*,
5      a.canonical_theme AS theme
6  FROM
7      read_csv_auto('input/sessions/sessions.csv') AS s
8  LEFT JOIN
9      read_csv_auto('input/theme-aliases/theme_aliases.csv') AS a
10     ON  ' ' || lower(s.title) || ' ' ILIKE '% ' || lower(a.alias) || ' %'
11  ORDER BY speaker, title, theme
12 ) TO 'output/classified_sessions.csv';
13 SQL
```

```
/demo/projects/possible-tracks $ bash run.sh
/demo/projects/possible-tracks $ : No arguments: script, not a tool!
/demo/projects/possible-tracks $ csvlook output/classified_sessions.csv
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    └── theme-aliases
        └── theme_aliases.csv
    └── output
        └── classified_sessions.csv
    └── run.sh
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```

11 ORDER BY speaker, title, theme
12 ) TO 'output/classified_sessions.csv';
13 SQL

/demo/projects/possible-tracks $ bash run.sh
/demo/projects/possible-tracks $ : No arguments: script, not a tool!
/demo/projects/possible-tracks $ csvlook output/classified_sessions.csv
| title           | speaker | theme          |
| -----           | -----   | -----          |
| AI in Healthcare | Alice    | artificial intelligence |
| Blockchain for Banking | Bob     | blockchain      |
| Solar Panel Efficiency | Charlie  | sustainability |
| Team Building Workshop | Diana   |               |
|-----           |-----   |-----          |

/demo/projects/possible-tracks $

```

```

/demo/projects
└── possible-tracks
    ├── input
    │   ├── sessions
    │   │   └── sessions.csv
    │   └── theme-aliases
    │       └── theme_aliases.csv
    ├── output
    │   └── classified_sessions.csv
    ├── run.sh
    └── temp

```

```

/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip

```

```

12 ) TO 'output/classified_sessions.csv';
13 SQL

/demo/projects/possible-tracks $ bash run.sh
/demo/projects/possible-tracks $ : No arguments: script, not a tool!
/demo/projects/possible-tracks $ csvlook output/classified_sessions.csv
+-----+-----+-----+
| title          | speaker | theme      |
+-----+-----+-----+
| AI in Healthcare | Alice   | artificial intelligence |
| Blockchain for Banking | Bob     | blockchain |
| Solar Panel Efficiency | Charlie | sustainability |
| Team Building Workshop | Diana  |           |
+-----+-----+-----+

/demo/projects/possible-tracks $ cowsay -f hellokitty "Diana did not get a
theme assigned!"

```

```

/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── output
    │   └── classified_sessions.csv
    ├── run.sh
    └── temp

```

```

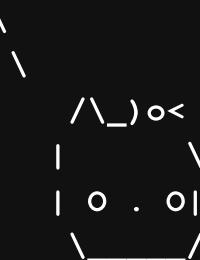
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip

```

| Team Building Workshop | Diana |

```
/demo/projects/possible-tracks $ cowsay -f hellokitty "Diana did not get a  
theme assigned!"
```

```
< Diana did not get a theme assigned! >
```



```
/demo/projects/possible-tracks $
```

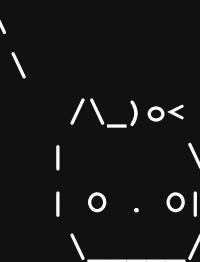
```
/demo/projects  
└── possible-tracks  
    ├── input  
    │   └── sessions  
    │       └── sessions.csv  
    ├── output  
    │   └── classified_sessions.csv  
    ├── run.sh  
    └── temp
```

```
/demo/bead-box  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

| Team Building Workshop | Diana |

```
/demo/projects/possible-tracks $ cowsay -f hellokitty "Diana did not get a theme assigned!"
```

```
< Diana did not get a theme assigned! >
```



```
/demo/projects/possible-tracks $ bead save
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── output
    │   └── classified_sessions.csv
    ├── run.sh
    └── temp
```

```
/demo/bead-box
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
theme assigned!"
```

```
< Diana did not get a theme assigned! >
```



```
/demo/projects/possible-tracks $ bead save
```

```
Successfully stored bead at /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip.
```

```
/demo/projects/possible-tracks $
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── theme-aliases
    │   └── theme_aliases.csv
    ├── output
    │   └── classified_sessions.csv
    └── run.sh
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
    ├── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```

```
theme assigned!"
```

```
< Diana did not get a theme assigned! >
```



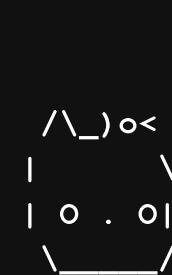
```
/demo/projects/possible-tracks $ bead save
```

```
Successfully stored bead at /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip.
```

```
/demo/projects/possible-tracks $ bead discard
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── theme-aliases
    │   └── theme_aliases.csv
    ├── output
    │   └── classified_sessions.csv
    └── run.sh
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
    ├── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```



```
/demo/projects/possible-tracks $ bead save
```

```
Successfully stored bead at /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip.
```

```
/demo/projects/possible-tracks $ bead discard
```

```
Deleted workspace /demo/projects/possible-tracks
```

```
/demo/projects/possible-tracks $
```

```
/demo/projects
```

```
/demo/bead-box
```

```
|   └── possible-tracks_20250910T151020490163+0000.zip  
|   └── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
\_ 
  \_) o<
   |   \
   | o . o|
   \____/
```

```
/demo/projects/possible-tracks $ bead save
Successfully stored bead at /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip.

/demo/projects/possible-tracks $ bead discard
Deleted workspace /demo/projects/possible-tracks

/demo/projects/possible-tracks $ cd ..
```

```
/demo/projects
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```



```
/demo/projects/possible-tracks $ bead save
Successfully stored bead at /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip.

/demo/projects/possible-tracks $ bead discard
Deleted workspace /demo/projects/possible-tracks

/demo/projects/possible-tracks $ cd ..
/demo/projects $
```

/demo/projects

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
\ 
  / \_)o<
  |     \
  | o . o|
  \_____|

/demo/projects/possible-tracks $ bead save
Successfully stored bead at /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip.

/demo/projects/possible-tracks $ bead discard
Deleted workspace /demo/projects/possible-tracks

/demo/projects/possible-tracks $ cd ..
/demo/projects $ clear
```

/demo/projects

/demo/bead-box

- ├── possible-tracks\_20250910T151020490163+0000.zip
- ├── sessions\_20250910T150420886649+0000.zip
- └── theme-aliases\_20250910T150620502609+0000.zip

```
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box
```

```
|   └── possible-tracks_20250910T151020490163+0000.zip  
|   └── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.
```

```
/demo/projects
```

```
/demo/bead-box
```

```
|   └── possible-tracks_20250910T151020490163+0000.zip  
|   └── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.  
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box  
└── possible-tracks_20250910T151020490163+0000.zip  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.  
/demo/projects $ bead edit theme-aliases --review
```

```
/demo/projects
```

```
/demo/bead-box  
├── possible-tracks_20250910T151020490163+0000.zip  
├── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.  
/demo/projects $ bead edit theme-aliases --review  
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK  
Extracted source into /demo/projects/theme-aliases  
  
/demo/projects $
```

```
/demo/projects  
└── theme-aliases  
    ├── input  
    ├── output  
    └── └── theme_aliases.csv  
    └── temp
```

```
/demo/bead-box  
└── possible-tracks_20250910T151020490163+0000.zip  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.  
/demo/projects $ bead edit theme-aliases --review  
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK  
Extracted source into /demo/projects/theme-aliases  
  
/demo/projects $ cd theme-aliases
```

```
/demo/projects  
└── theme-aliases  
    ├── input  
    ├── output  
    └── └── theme_aliases.csv  
    └── temp
```

```
/demo/bead-box  
└── possible-tracks_20250910T151020490163+0000.zip  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.  
/demo/projects $ bead edit theme-aliases --review  
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK  
Extracted source into /demo/projects/theme-aliases  
  
/demo/projects $ cd theme-aliases  
/demo/projects/theme-aliases $
```

```
/demo/projects  
└── theme-aliases  
    ├── input  
    ├── output  
    └── └── theme_aliases.csv  
    └── temp
```

```
/demo/bead-box  
└── possible-tracks_20250910T151020490163+0000.zip  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.  
/demo/projects $ bead edit theme-aliases --review  
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK  
Extracted source into /demo/projects/theme-aliases  
  
/demo/projects $ cd theme-aliases  
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
```

```
/demo/projects  
└── theme-aliases  
    ├── input  
    ├── output  
    │   └── theme_aliases.csv  
    └── temp
```

```
/demo/bead-box  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.  
/demo/projects $ bead edit theme-aliases --review  
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK  
Extracted source into /demo/projects/theme-aliases  
  
/demo/projects $ cd theme-aliases  
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv  
| alias      | canonical_theme |  
| ----- | ----- |  
| ai        | artificial intelligence |  
| blockchain | blockchain |  
| solar      | sustainability |  
  
/demo/projects/theme-aliases $
```

```
/demo/projects  
└── theme-aliases  
    ├── input  
    ├── output  
    │   └── theme_aliases.csv  
    └── temp  
  
/demo/bead-box  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.  
/demo/projects $ bead edit theme-aliases --review  
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK  
Extracted source into /demo/projects/theme-aliases  
  
/demo/projects $ cd theme-aliases  
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv  
| alias      | canonical_theme      |  
| ----- | ----- |  
| ai        | artificial intelligence |  
| blockchain | blockchain      |  
| solar      | sustainability    |  
  
/demo/projects/theme-aliases $ : Diana - "Team Building Workshop"
```

```
/demo/projects  
└── theme-aliases  
    ├── input  
    ├── output  
    │   └── theme_aliases.csv  
    └── temp
```

```
/demo/bead-box  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ : New version of theme-aliases bead.  
/demo/projects $ bead edit theme-aliases --review  
Verifying archive /demo/bead-box/theme-aliases_20250910T150620502609+0000.zip ... OK  
Extracted source into /demo/projects/theme-aliases  
  
/demo/projects $ cd theme-aliases  
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv  
| alias | canonical_theme |  
| ----- | ----- |  
| ai | artificial intelligence |  
| blockchain | blockchain |  
| solar | sustainability |  
  
/demo/projects/theme-aliases $ : Diana - "Team Building Workshop"  
/demo/projects/theme-aliases $
```

```
/demo/projects  
└── theme-aliases  
    ├── input  
    ├── output  
    │   └── theme_aliases.csv  
    └── temp
```

```
/demo/bead-box  
├── possible-tracks_20250910T151020490163+0000.zip  
├── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
| alias      | canonical_theme      |
| ----- | ----- |
| ai        | artificial intelligence |
| blockchain | blockchain      |
| solar     | sustainability      |

/demo/projects/theme-aliases $ : Diana - "Team Building Workshop"
/demo/projects/theme-aliases $ cat >> output/theme_aliases.csv <<EOF
team,collaboration
workshop,collaboration
healthcare,healthcare
EOF
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
+ alias      | canonical_theme      +
+ -----      +-----+
| ai          | artificial intelligence |
| blockchain | blockchain           |
| solar       | sustainability        |

/demo/projects/theme-aliases $ : Diana - "Team Building Workshop"
/demo/projects/theme-aliases $ cat >> output/theme_aliases.csv <<EOF
team,collaboration
workshop,collaboration
healthcare,healthcare
EOF
/demo/projects/theme-aliases $
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
└── sessions_20250910T150420886649+0000.zip
    └── theme-aliases_20250910T150620502609+0000.zip
```

```

/demo/projects $ cd theme-aliases
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
+ alias | canonical_theme |
+ -----+-----+
| ai | artificial intelligence |
| blockchain | blockchain |
| solar | sustainability |

/demo/projects/theme-aliases $ : Diana - "Team Building Workshop"
/demo/projects/theme-aliases $ cat >> output/theme_aliases.csv <<EOF
team,collaboration
workshop,collaboration
healthcare,healthcare
EOF
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv

```

```

/demo/projects
└── theme-aliases
    ├── input
    ├── output
    │   └── theme_aliases.csv
    └── temp

```

```

/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip

```

```
team, collaboration
workshop, collaboration
healthcare, healthcare
EOF
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
+ alias      | canonical_theme      +
+ -----+-----+
| ai        | artificial intelligence |
| blockchain | blockchain           |
| solar      | sustainability          |
| team       | collaboration           |
| workshop    | collaboration           |
| healthcare | healthcare            |
```

/demo/projects/theme-aliases \$

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
    └── sessions_20250910T150420886649+0000.zip
        └── theme-aliases_20250910T150620502609+0000.zip
```

```
team, collaboration
workshop, collaboration
healthcare, healthcare
EOF
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
+ alias | canonical_theme |
+ -----+-----+
| ai | artificial intelligence |
| blockchain | blockchain |
| solar | sustainability |
| team | collaboration |
| workshop | collaboration |
| healthcare | healthcare |
```

```
/demo/projects/theme-aliases $ bead save
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
```

```
EOF
```

```
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
```

alias	canonical_theme
ai	artificial intelligence
blockchain	blockchain
solar	sustainability
team	collaboration
workshop	collaboration
healthcare	healthcare

```
/demo/projects/theme-aliases $ bead save
```

```
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip.
```

```
/demo/projects/theme-aliases $
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
EOF
```

```
/demo/projects/theme-aliases $ csvlook output/theme_aliases.csv
```

alias	canonical_theme
ai	artificial intelligence
blockchain	blockchain
solar	sustainability
team	collaboration
workshop	collaboration
healthcare	healthcare

```
/demo/projects/theme-aliases $ bead save
```

```
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip.
```

```
/demo/projects/theme-aliases $ bead discard
```

```
/demo/projects
└── theme-aliases
    ├── input
    ├── output
    └── └── theme_aliases.csv
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
| ----- | ----- |
| ai      | artificial intelligence |
| blockchain | blockchain |
| solar    | sustainability |
| team     | collaboration |
| workshop  | collaboration |
| healthcare | healthcare |

/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip.

/demo/projects/theme-aliases $ bead discard
Deleted workspace /demo/projects/theme-aliases

/demo/projects/theme-aliases $
```

/demo/projects

/demo/bead-box

- ├── possible-tracks\_20250910T151020490163+0000.zip
- ├── sessions\_20250910T150420886649+0000.zip
- ├── theme-aliases\_20250910T150620502609+0000.zip
- └── theme-aliases\_20250910T151300218788+0000.zip

```
| ----- | ----- |
| ai      | artificial intelligence |
| blockchain | blockchain |
| solar    | sustainability |
| team     | collaboration |
| workshop  | collaboration |
| healthcare | healthcare |

/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip.

/demo/projects/theme-aliases $ bead discard
Deleted workspace /demo/projects/theme-aliases

/demo/projects/theme-aliases $ cd ..
```

/demo/projects

/demo/bead-box

- ├── possible-tracks\_20250910T151020490163+0000.zip
- ├── sessions\_20250910T150420886649+0000.zip
- ├── theme-aliases\_20250910T150620502609+0000.zip
- └── theme-aliases\_20250910T151300218788+0000.zip

```
| ai           | artificial intelligence |
| blockchain  | blockchain                 |
| solar        | sustainability             |
| team         | collaboration              |
| workshop     | collaboration              |
| healthcare   | healthcare                 |

/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip.

/demo/projects/theme-aliases $ bead discard
Deleted workspace /demo/projects/theme-aliases

/demo/projects/theme-aliases $ cd ..
/demo/projects $
```

/demo/projects

/demo/bead-box

- ├── possible-tracks\_20250910T151020490163+0000.zip
- ├── sessions\_20250910T150420886649+0000.zip
- ├── theme-aliases\_20250910T150620502609+0000.zip
- └── theme-aliases\_20250910T151300218788+0000.zip

```
| ai           | artificial intelligence |
| blockchain  | blockchain                 |
| solar        | sustainability             |
| team         | collaboration              |
| workshop     | collaboration              |
| healthcare   | healthcare                 |

/demo/projects/theme-aliases $ bead save
Successfully stored bead at /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip.

/demo/projects/theme-aliases $ bead discard
Deleted workspace /demo/projects/theme-aliases

/demo/projects/theme-aliases $ cd ..
/demo/projects $ clear
```

```
/demo/projects
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box
```

```
├── possible-tracks_20250910T151020490163+0000.zip  
├── sessions_20250910T150420886649+0000.zip  
├── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : Use the improved input to re-classify sessions
```

```
/demo/projects
```

```
/demo/bead-box
```

```
|   └── possible-tracks_20250910T151020490163+0000.zip  
|   └── sessions_20250910T150420886649+0000.zip  
|   └── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : Use the improved input to re-classify sessions  
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box  
├── possible-tracks_20250910T151020490163+0000.zip  
├── sessions_20250910T150420886649+0000.zip  
├── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : Use the improved input to re-classify sessions  
/demo/projects $ bead edit possible-tracks
```

/demo/projects

/demo/bead-box

- └── possible-tracks\_20250910T151020490163+0000.zip
- └── sessions\_20250910T150420886649+0000.zip
- └── theme-aliases\_20250910T150620502609+0000.zip
- └── theme-aliases\_20250910T151300218788+0000.zip

```
/demo/projects $ : Use the improved input to re-classify sessions
/demo/projects $ bead edit possible-tracks
Verifying archive /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip ... OK
Extracted source into /demo/projects/possible-tracks
Input data not loaded, update if needed and load manually

/demo/projects $
```

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    ├── run.sh
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
    ├── sessions_20250910T150420886649+0000.zip
    ├── theme-aliases_20250910T150620502609+0000.zip
    └── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : Use the improved input to re-classify sessions
/demo/projects $ bead edit possible-tracks
Verifying archive /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip ... OK
Extracted source into /demo/projects/possible-tracks
Input data not loaded, update if needed and load manually

/demo/projects $ cd possible-tracks
```

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    ├── run.sh
    └── temp
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : Use the improved input to re-classify sessions
/demo/projects $ bead edit possible-tracks
Verifying archive /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip ... OK
Extracted source into /demo/projects/possible-tracks
Input data not loaded, update if needed and load manually

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $
```

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    ├── run.sh
    └── temp
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : Use the improved input to re-classify sessions
/demo/projects $ bead edit possible-tracks
Verifying archive /demo/bead-box/possible-tracks_20250910T151020490163+0000.zip ... OK
Extracted source into /demo/projects/possible-tracks
Input data not loaded, update if needed and load manually

/demo/projects $ cd possible-tracks
/demo/projects/possible-tracks $ nl run.sh
```

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    ├── run.sh
    └── temp
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
1 duckdb <<SQL
2 COPY (
3     SELECT DISTINCT
4         s.*,
5         a.canonical_theme AS theme
6     FROM
7         read_csv_auto('input/sessions/sessions.csv') AS s
8     LEFT JOIN
9         read_csv_auto('input/theme-aliases/theme_aliases.csv') AS a
10    ON      '' || lower(s.title) || '' ILIKE '%' || lower(a.alias) || '%'
11    ORDER BY speaker, title, theme
12 ) TO 'output/classified_sessions.csv';
13 SQL
```

/demo/projects/possible-tracks \$

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    ├── run.sh
    └── temp
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
1 duckdb <<SQL
2   COPY (
3     SELECT DISTINCT
4       s.*,
5       a.canonical_theme AS theme
6     FROM
7       read_csv_auto('input/sessions/sessions.csv') AS s
8     LEFT JOIN
9       read_csv_auto('input/theme-aliases/theme_aliases.csv') AS a
10    ON      '' || lower(s.title) || '' ILIKE '%' || lower(a.alias) || '%'
11    ORDER BY speaker, title, theme
12  ) TO 'output/classified_sessions.csv';
13 SQL
```

```
/demo/projects/possible-tracks $ bead status
```

```
/demo/projects
└── possible-tracks
    ├── input
    ├── output
    ├── run.sh
    └── temp
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
Status:      **NOT LOADED**  
Bead:       sessions # 20250910T150420886649+0000  
Box(es):  
* -r demo # 20250910T150420886649+0000
```

#### input/theme-aliases

```
Status:      **NOT LOADED**  
Bead:       theme-aliases # 20250910T150620502609+0000  
Box(es):  
* -r demo # 20250910T150620502609+0000
```

Some inputs are currently not loaded.  
You can "load" or "update" them manually.

/demo/projects/possible-tracks \$

```
/demo/projects  
└── possible-tracks  
    ├── input  
    ├── output  
    ├── run.sh  
    └── temp
```

```
/demo/bead-box  
└── possible-tracks_20250910T151020490163+0000.zip  
    ├── sessions_20250910T150420886649+0000.zip  
    ├── theme-aliases_20250910T150620502609+0000.zip  
    └── theme-aliases_20250910T151300218788+0000.zip
```

```
Status:      **NOT LOADED**  
Bead:       sessions # 20250910T150420886649+0000  
Box(es):  
* -r demo # 20250910T150420886649+0000
```

#### input/theme-aliases

```
Status:      **NOT LOADED**  
Bead:       theme-aliases # 20250910T150620502609+0000  
Box(es):  
* -r demo # 20250910T150620502609+0000
```

Some inputs are currently not loaded.

You can "load" or "update" them manually.

```
/demo/projects/possible-tracks $ bead input update theme-aliases
```

```
/demo/projects  
└── possible-tracks  
    ├── input  
    ├── output  
    ├── run.sh  
    └── temp
```

```
/demo/bead-box  
├── possible-tracks_20250910T151020490163+0000.zip  
├── sessions_20250910T150420886649+0000.zip  
├── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
input/theme-aliases
  Status:      **NOT LOADED**
  Bead:        theme-aliases # 20250910T150620502609+0000
  Box[es]:
    * -r demo # 20250910T150620502609+0000
```

```
Some inputs are currently not loaded.
You can "load" or "update" them manually.
```

```
/demo/projects/possible-tracks $ bead input update theme-aliases
Verifying archive /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip ... OK
Loading new data to theme-aliases ... Done
```

```
/demo/projects/possible-tracks $
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── theme-aliases
    │       └── theme_aliases.csv
    ├── output
    ├── run.sh
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
    ├── sessions_20250910T150420886649+0000.zip
    ├── theme-aliases_20250910T150620502609+0000.zip
    └── theme-aliases_20250910T151300218788+0000.zip
```

```
input/theme-aliases
  Status:      **NOT LOADED**
  Bead:        theme-aliases # 20250910T150620502609+0000
  Box[es]:
    * -r demo # 20250910T150620502609+0000
```

```
Some inputs are currently not loaded.
You can "load" or "update" them manually.
```

```
/demo/projects/possible-tracks $ bead input update theme-aliases
Verifying archive /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip ... OK
Loading new data to theme-aliases ... Done
```

```
/demo/projects/possible-tracks $ bead input load
```

```
/demo/projects
└── possible-tracks
    ├── input
    │   └── theme-aliases
    │       └── theme_aliases.csv
    ├── output
    ├── run.sh
    └── temp
```

```
/demo/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
    ├── sessions_20250910T150420886649+0000.zip
    ├── theme-aliases_20250910T150620502609+0000.zip
    └── theme-aliases_20250910T151300218788+0000.zip
```

```
* -r demo # 20250910T150620502609+0000
```

```
Some inputs are currently not loaded.  
You can "load" or "update" them manually.
```

```
/demo/projects/possible-tracks $ bead input update theme-aliases  
Verifying archive /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip ... OK  
Loading new data to theme-aliases ... Done
```

```
/demo/projects/possible-tracks $ bead input load  
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK  
Loading new data to sessions ... Done  
"theme-aliases" is already loaded - skipping
```

```
/demo/projects/possible-tracks $
```

```
/demo/projects  
└── possible-tracks  
    ├── input  
    │   └── sessions  
    │       └── sessions.csv  
    └── theme-aliases  
        └── theme_aliases.csv  
    └── output  
    └── run.sh  
    └── temp
```

```
/demo/bead-box  
└── possible-tracks_20250910T151020490163+0000.zip  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
* -r demo # 20250910T150620502609+0000
```

```
Some inputs are currently not loaded.  
You can "load" or "update" them manually.
```

```
/demo/projects/possible-tracks $ bead input update theme-aliases  
Verifying archive /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip ... OK  
Loading new data to theme-aliases ... Done
```

```
/demo/projects/possible-tracks $ bead input load  
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK  
Loading new data to sessions ... Done  
"theme-aliases" is already loaded - skipping
```

```
/demo/projects/possible-tracks $ bash run.sh
```

```
/demo/projects  
└── possible-tracks  
    ├── input  
    │   └── sessions  
    │       └── sessions.csv  
    └── theme-aliases  
        └── theme_aliases.csv  
    └── output  
    └── run.sh  
    └── temp
```

```
/demo/bead-box  
└── possible-tracks_20250910T151020490163+0000.zip  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
Some inputs are currently not loaded.  
You can "load" or "update" them manually.
```

```
/demo/projects/possible-tracks $ bead input update theme-aliases  
Verifying archive /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip ... OK  
Loading new data to theme-aliases ... Done
```

```
/demo/projects/possible-tracks $ bead input load  
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK  
Loading new data to sessions ... Done  
"theme-aliases" is already loaded - skipping
```

```
/demo/projects/possible-tracks $ bash run.sh  
/demo/projects/possible-tracks $
```

```
/demo/projects  
└── possible-tracks  
    ├── input  
    │   └── sessions  
    │       └── sessions.csv  
    ├── theme-aliases  
    │   └── theme_aliases.csv  
    ├── output  
    │   └── classified_sessions.csv  
    ├── run.sh  
    └── temp
```

```
/demo/bead-box  
└── possible-tracks_20250910T151020490163+0000.zip  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
Some inputs are currently not loaded.  
You can "load" or "update" them manually.
```

```
/demo/projects/possible-tracks $ bead input update theme-aliases  
Verifying archive /demo/bead-box/theme-aliases_20250910T151300218788+0000.zip ... OK  
Loading new data to theme-aliases ... Done
```

```
/demo/projects/possible-tracks $ bead input load  
Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK  
Loading new data to sessions ... Done  
"theme-aliases" is already loaded - skipping
```

```
/demo/projects/possible-tracks $ bash run.sh  
/demo/projects/possible-tracks $ csvlook output/classified_sessions.csv
```

```
/demo/projects  
└── possible-tracks  
    ├── input  
    │   └── sessions  
    │       └── sessions.csv  
    ├── theme-aliases  
    │   └── theme_aliases.csv  
    ├── output  
    │   └── classified_sessions.csv  
    ├── run.sh  
    └── temp
```

```
/demo/bead-box  
└── possible-tracks_20250910T151020490163+0000.zip  
└── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```

Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK
Loading new data to sessions ... Done
"theme-aliases" is already loaded - skipping

/dem/projects/possible-tracks $ bash run.sh
/dem/projects/possible-tracks $ csvlook output/classified_sessions.csv
| title | speaker | theme |
| ----- | ----- | ----- |
| AI in Healthcare | Alice | artificial intelligence |
| AI in Healthcare | Alice | healthcare |
| Blockchain for Banking | Bob | blockchain |
| Solar Panel Efficiency | Charlie | sustainability |
| Team Building Workshop | Diana | collaboration |

/dem/projects/possible-tracks $

```

```

/dem/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── output
    │   └── classified_sessions.csv
    ├── run.sh
    └── temp

```

```

/dem/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip

```

```

Verifying archive /demo/bead-box/sessions_20250910T150420886649+0000.zip ... OK
Loading new data to sessions ... Done
"theme-aliases" is already loaded - skipping

/dem/projects/possible-tracks $ bash run.sh
/dem/projects/possible-tracks $ csvlook output/classified_sessions.csv
| title | speaker | theme |
| ----- | ----- | ----- |
| AI in Healthcare | Alice | artificial intelligence |
| AI in Healthcare | Alice | healthcare |
| Blockchain for Banking | Bob | blockchain |
| Solar Panel Efficiency | Charlie | sustainability |
| Team Building Workshop | Diana | collaboration |

/dem/projects/possible-tracks $ : ✨ Yay!

```

```

/demo/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── output
    │   └── classified_sessions.csv
    ├── run.sh
    └── temp

```

```

/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip

```

```

Loading new data to sessions ... Done
"theme-aliases" is already loaded - skipping

/dem/projects/possible-tracks $ bash run.sh
/dem/projects/possible-tracks $ csvlook output/classified_sessions.csv
+-----+-----+-----+
| title | speaker | theme |
+-----+-----+-----+
| AI in Healthcare | Alice | artificial intelligence |
| AI in Healthcare | Alice | healthcare |
| Blockchain for Banking | Bob | blockchain |
| Solar Panel Efficiency | Charlie | sustainability |
| Team Building Workshop | Diana | collaboration |
+-----+-----+-----+

/dem/projects/possible-tracks $ : ✨ Yay!
/dem/projects/possible-tracks $

```

```

/dem/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── theme-aliases
    │   └── theme_aliases.csv
    ├── output
    │   └── classified_sessions.csv
    ├── run.sh
    └── temp

```

```

/dem/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip

```

```

Loading new data to sessions ... Done
"theme-aliases" is already loaded - skipping

/dem/projects/possible-tracks $ bash run.sh
/dem/projects/possible-tracks $ csvlook output/classified_sessions.csv
+-----+-----+-----+
| title | speaker | theme |
+-----+-----+-----+
| AI in Healthcare | Alice | artificial intelligence |
| AI in Healthcare | Alice | healthcare |
| Blockchain for Banking | Bob | blockchain |
| Solar Panel Efficiency | Charlie | sustainability |
| Team Building Workshop | Diana | collaboration |
+-----+-----+-----+

/dem/projects/possible-tracks $ : ✨ Yay!
/dem/projects/possible-tracks $ bead discard

```

```

/dem/projects
└── possible-tracks
    ├── input
    │   └── sessions
    │       └── sessions.csv
    ├── theme-aliases
    │   └── theme_aliases.csv
    ├── output
    │   └── classified_sessions.csv
    ├── run.sh
    └── temp

```

```

/dem/bead-box
└── possible-tracks_20250910T151020490163+0000.zip
└── sessions_20250910T150420886649+0000.zip
└── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip

```

```
/demo/projects/possible-tracks $ bash run.sh
/demo/projects/possible-tracks $ csvlook output/classified_sessions.csv
+-----+-----+-----+
| title | speaker | theme |
+-----+-----+-----+
| AI in Healthcare | Alice | artificial intelligence |
| AI in Healthcare | Alice | healthcare |
| Blockchain for Banking | Bob | blockchain |
| Solar Panel Efficiency | Charlie | sustainability |
| Team Building Workshop | Diana | collaboration |
+-----+-----+-----+
/demo/projects/possible-tracks $ : ✨ Yay!
/demo/projects/possible-tracks $ bead discard
Deleted workspace /demo/projects/possible-tracks

/demo/projects/possible-tracks $
```

/demo/projects

/demo/bead-box

```
|── possible-tracks_20250910T151020490163+0000.zip
|── sessions_20250910T150420886649+0000.zip
|── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects/possible-tracks $ bash run.sh
/demo/projects/possible-tracks $ csvlook output/classified_sessions.csv
+-----+-----+-----+
| title | speaker | theme |
+-----+-----+-----+
| AI in Healthcare | Alice | artificial intelligence |
| AI in Healthcare | Alice | healthcare |
| Blockchain for Banking | Bob | blockchain |
| Solar Panel Efficiency | Charlie | sustainability |
| Team Building Workshop | Diana | collaboration |
+-----+-----+-----+
/demo/projects/possible-tracks $ : ✨ Yay!
/demo/projects/possible-tracks $ bead discard
Deleted workspace /demo/projects/possible-tracks

/demo/projects/possible-tracks $ cd ..
```

```
/demo/projects
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects/possible-tracks $ csvlook output/classified_sessions.csv
| title           | speaker | theme          |
| -----           | -----   | -----          |
| AI in Healthcare | Alice   | artificial intelligence |
| AI in Healthcare | Alice   | healthcare      |
| Blockchain for Banking | Bob    | blockchain     |
| Solar Panel Efficiency | Charlie | sustainability |
| Team Building Workshop | Diana  | collaboration  |

/demo/projects/possible-tracks $ : ✨ Yay!
/demo/projects/possible-tracks $ bead discard
Deleted workspace /demo/projects/possible-tracks

/demo/projects/possible-tracks $ cd ..
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects/possible-tracks $ csvlook output/classified_sessions.csv
| title           | speaker | theme          |
| -----          | -----   | -----          |
| AI in Healthcare | Alice   | artificial intelligence |
| AI in Healthcare | Alice   | healthcare      |
| Blockchain for Banking | Bob    | blockchain     |
| Solar Panel Efficiency | Charlie | sustainability |
| Team Building Workshop | Diana  | collaboration  |

/demo/projects/possible-tracks $ : ✨ Yay!
/demo/projects/possible-tracks $ bead discard
Deleted workspace /demo/projects/possible-tracks

/demo/projects/possible-tracks $ cd ..
/demo/projects $ clear
```

```
/demo/projects
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── sessions_20250910T150420886649+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box
```

```
|   └── possible-tracks_20250910T151020490163+0000.zip  
|   └── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip  
    └── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : 📸 Visual Overview
```

```
/demo/projects
```

```
/demo/bead-box
```

```
|   └── possible-tracks_20250910T151020490163+0000.zip  
|   └── sessions_20250910T150420886649+0000.zip  
|   └── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : 📸 Visual Overview  
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box  
├── possible-tracks_20250910T151020490163+0000.zip  
├── sessions_20250910T150420886649+0000.zip  
└── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : 🌐 Visual Overview  
/demo/projects $ rm /demo/bead-box/sessions*
```

/demo/projects

/demo/bead-box

- ├── possible-tracks\_20250910T151020490163+0000.zip
- ├── sessions\_20250910T150420886649+0000.zip
- ├── theme-aliases\_20250910T150620502609+0000.zip
- └── theme-aliases\_20250910T151300218788+0000.zip

```
/demo/projects $ : 🌐 Visual Overview  
/demo/projects $ rm /demo/bead-box/sessions*  
/demo/projects $
```

```
/demo/projects
```

```
/demo/bead-box  
├── possible-tracks_20250910T151020490163+0000.zip  
├── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : 🌐 Visual Overview  
/demo/projects $ rm /demo/bead-box/sessions*  
/demo/projects $ bead box sync
```

/demo/projects

/demo/bead-box

- └── possible-tracks\_20250910T151020490163+0000.zip
- └── theme-aliases\_20250910T150620502609+0000.zip
- └── theme-aliases\_20250910T151300218788+0000.zip

```
/demo/projects $ : 🌐 Visual Overview
/demo/projects $ rm /demo/bead-box/sessions*
/demo/projects $ bead box sync
Syncing box "demo" at /demo/bead-box
✓ Success

/demo/projects $
```

/demo/projects

/demo/bead-box

- └── possible-tracks\_20250910T151020490163+0000.zip
- └── theme-aliases\_20250910T150620502609+0000.zip
- └── theme-aliases\_20250910T151300218788+0000.zip

```
/demo/projects $ : 🌐 Visual Overview
/demo/projects $ rm /demo/bead-box/sessions*
/demo/projects $ bead box sync
Syncing box "demo" at /demo/bead-box
✓ Success

/demo/projects $ bead web color svg session-themes.svg
```

/demo/projects

/demo/bead-box

- ├── possible-tracks\_20250910T151020490163+0000.zip
- ├── theme-aliases\_20250910T150620502609+0000.zip
- └── theme-aliases\_20250910T151300218788+0000.zip

```
/demo/projects $ rm /demo/bead-box/sessions*
/demo/projects $ bead box sync
Syncing box "demo" at /demo/bead-box
✓ Success

/demo/projects $ bead web color svg session-themes.svg

Loaded bead 1 (demo : theme-aliases @ 20250910T150620502609+0000)
Loaded bead 2 (demo : possible-tracks @ 20250910T151020490163+0000)
Loaded bead 3 (demo : theme-aliases @ 20250910T151300218788+0000)

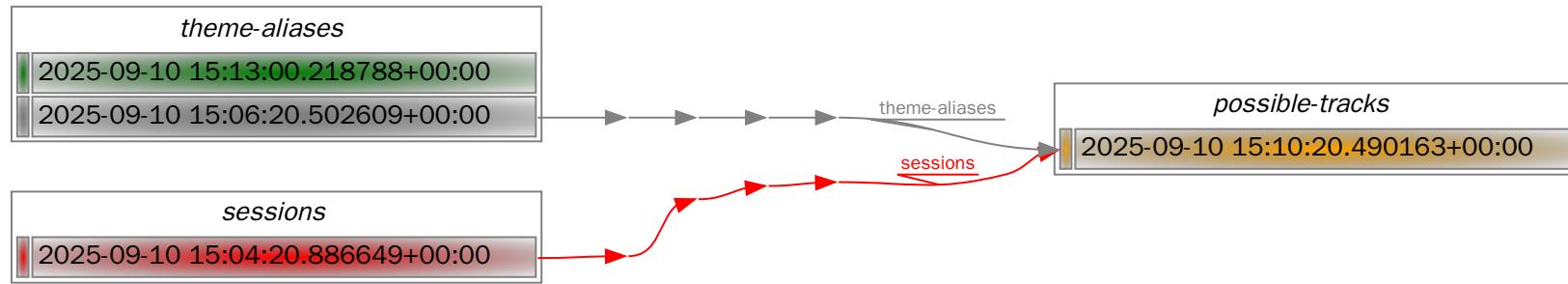
Loaded 3 beads
Creating SVG: session-themes.svg

/demo/projects $
```

```
/demo/projects
└── session-themes.svg
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

# session-themes.svg



```
/demo/projects $
```

```
/demo/projects
└── session-themes.svg
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : ⚙ Internals
```

```
/demo/projects
└── session-themes.svg
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : ⚙ Internals  
/demo/projects $
```

```
/demo/projects  
└── session-themes.svg
```

```
/demo/bead-box  
├── possible-tracks_20250910T151020490163+0000.zip  
├── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : ⚙ Internals  
/demo/projects $ unzip -v /demo/bead-box/possible-tracks_*.zip | tail -8
```

```
/demo/projects  
└── session-themes.svg
```

```
/demo/bead-box  
├── possible-tracks_20250910T151020490163+0000.zip  
├── theme-aliases_20250910T150620502609+0000.zip  
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : 🛡 Internals
/demo/projects $ unzip -v /demo/bead-box/possible-tracks_*.zip | tail -8
  Length Method    Size Cmpr      Date    Time   CRC-32   Name
-----  -----  -----  ---  -----  -----  -----  -----
        181 Defl:N     139  23% 2025-09-05 13:37 af1dd6c0  data/classified_sessions.csv
        370 Defl:N     232  37% 2025-09-05 13:37 e1c1f982  code/run.sh
       941 Defl:N     481  49% 2025-09-10 15:10 b6fe215c  meta/bead
       470 Defl:N     299  36% 2025-09-10 15:10 5e951697  meta/manifest
-----  -----  -----  ---  -----  -----  -----  -----
      1962                    1151  41%
                                         4 files
```

```
/demo/projects $
```

```
/demo/projects
└── session-themes.svg
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : 🛡 Internals
/demos/projects $ unzip -v /demo/bead-box/possible-tracks_*.zip | tail -8
  Length Method     Size Cmpr Date       Time    CRC-32   Name
-----  -----  -----  ---  -----  -----  -----  -----
      181 Defl:N      139  23% 2025-09-05 13:37 af1dd6c0  data/classified_sessions.csv
      370 Defl:N      232  37% 2025-09-05 13:37 e1c1f982  code/run.sh
      941 Defl:N      481  49% 2025-09-10 15:10 b6fe215c  meta/bead
      470 Defl:N      299  36% 2025-09-10 15:10 5e951697  meta/manifest
-----  -----  -----  ---  -----
     1962                      1151  41%
                                         4 files

/demos/projects $ : end of demo
```

```
/demo/projects
└── session-themes.svg
```

```
/demo/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

```
/demo/projects $ : 🛡 Internals
/demos/projects $ unzip -v /demo/bead-box/possible-tracks_*.zip | tail -8
      Length   Method    Size   Cmpr      Date    Time    CRC-32   Name
-----  -----  -----  -----  -----  -----  -----  -----
        181  Defl:N     139   23%  2025-09-05 13:37 af1dd6c0  data/classified_sessions.csv
        370  Defl:N     232   37%  2025-09-05 13:37 e1c1f982  code/run.sh
       941  Defl:N     481   49%  2025-09-10 15:10 b6fe215c  meta/bead
       470  Defl:N     299   36%  2025-09-10 15:10 5e951697  meta/manifest
-----  -----  -----  -----  -----  -----  -----  -----
      1962                    1151   41%
                                         4 files

/demos/projects $ : end of demo
/demos/projects $
```

```
/demos/projects
└── session-themes.svg
```

```
/demos/bead-box
├── possible-tracks_20250910T151020490163+0000.zip
├── theme-aliases_20250910T150620502609+0000.zip
└── theme-aliases_20250910T151300218788+0000.zip
```

## Similar ideas

- kaggle notebook  
<https://www.kaggle.com/code>
- 



- nix flake  
[https://nixos.wiki/wiki/Flakes#Flake\\_schema](https://nixos.wiki/wiki/Flakes#Flake_schema)



## Similar ideas2

- orderly2 (RSECON24 talk)  
<https://youtu.be/lkPgihFQbrk>
- 

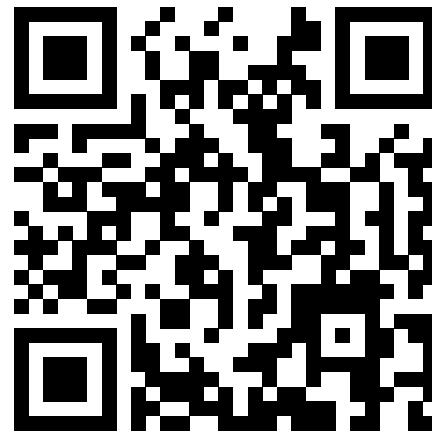


- orderly2 (Article) <https://mrc-ide.github.io/orderly2/articles/orderly2.html>





<https://github.com/e3krisztian/bead>



# Case Study From Our Research Lab

# Case Study From Our Research Lab

- Used since 2017 in our research groups: CEU MicroData, MACROMANAGERS.eu
  - internally
  - when sharing data with others
- Saved about 600+ beads, two versions on average
- Interquartile range of bead sizes: 10 to 500 MB, largest is 23 GB
- Median time between saving new versions: 51 days

# Practices We Adopted

- *Everything* is a bead: raw data, intermediate data, analysis sample, research results
- Never load data directly, from outside a bead
  - Side product: always use relative paths
- We don't often recompute everything, but good to know we *could*

# Lessons For Research Software Engineers

- Minimal learning curve for researchers
- No infrastructure requirements
- Works with existing workflows
- Complements version control
- Enables true reproducibility

# Key Takeaways

1. Data provenance is hard - especially with changing teams
2. Existing tools too complex - for heterogeneous research teams
3. bead keeps it simple - focuses on one thing well
4. Reproducibility becomes automatic - not an afterthought

# Contact and Acknowledgements

- Web: [bead.zip](#)
- Installation: <https://bead.zip/install>
- GitHub: [github.com/e3krisztian/bead](https://github.com/e3krisztian/bead)



1

1. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 313164). The views expressed are those of the authors and do not necessarily reflect those of the ERC or the European Commission.

# Slides

<bead.zip/rsecon25>

