

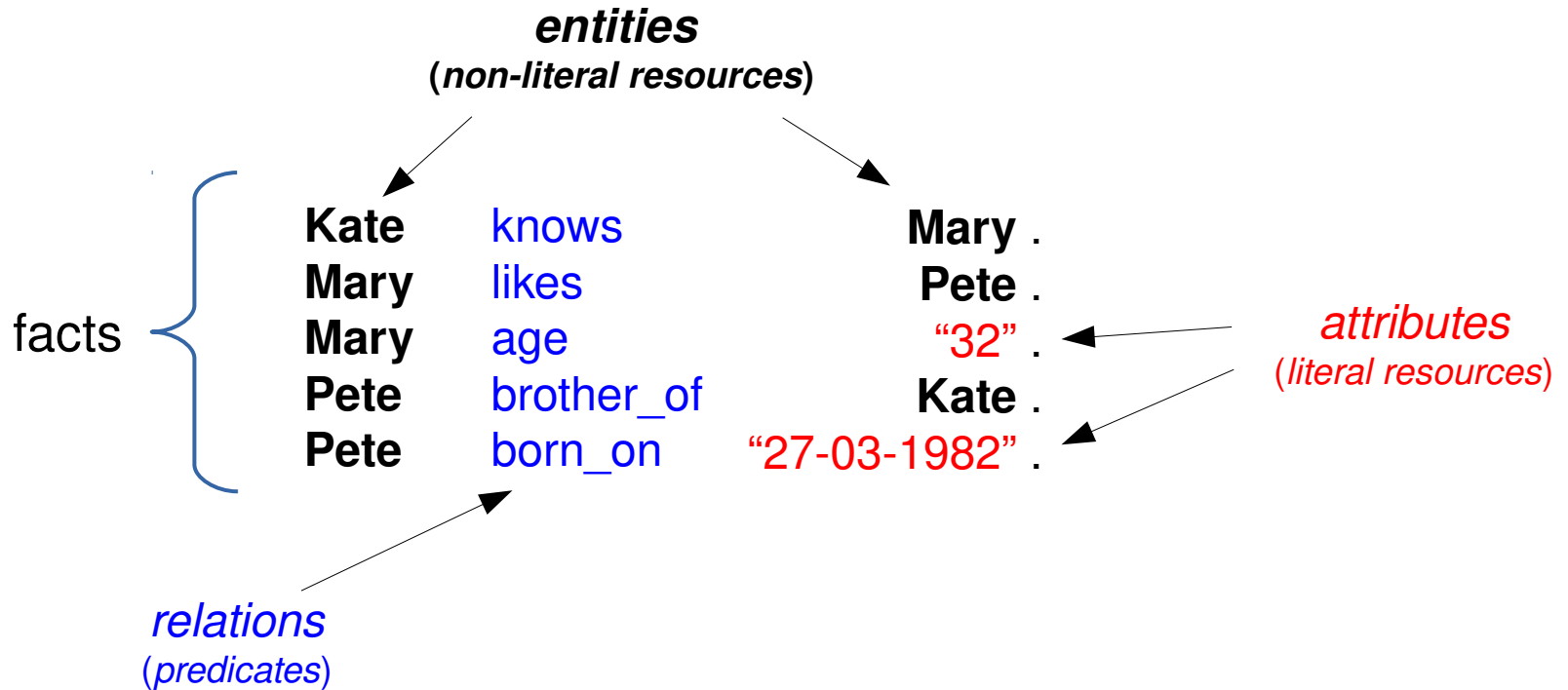
9 JUN 2017

# User-Driven Pattern Mining on Knowledge Graphs an Archaeological Case Study

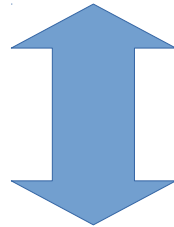
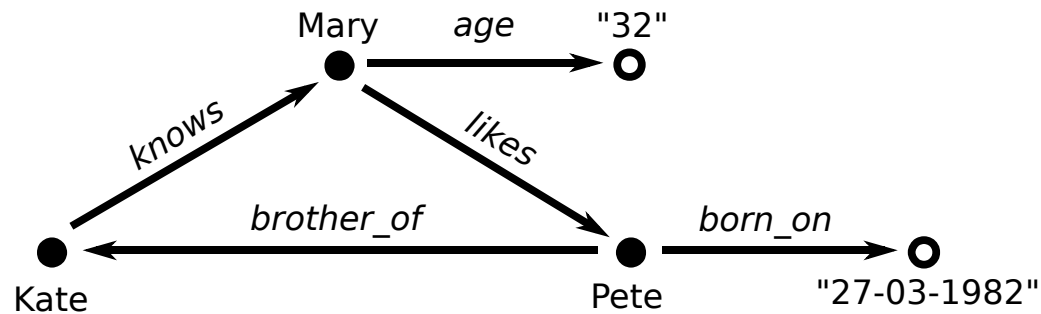
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Knowledge graphs encode facts as edges between vertices

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# Knowledge graphs in a nutshell



facts {

<b>Kate</b>	<b>knows</b>	<b>Mary</b>	.
<b>Mary</b>	<b>likes</b>	<b>Pete</b>	.
<b>Mary</b>	<b>age</b>	<b>"32"</b>	.
<b>Pete</b>	<b>brother_of</b>	<b>Kate</b>	.
<b>Pete</b>	<b>born_on</b>	<b>"27-03-1982"</b>	.

## Goal

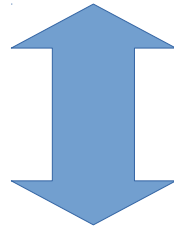
- Discover **regularities in knowledge graphs** that researchers can use
- as **starting point to form new research hypotheses**, or
  - as **support for existing research hypotheses**.

## Domain Requirements

- transparent models (glass box), and
- interpretable results.

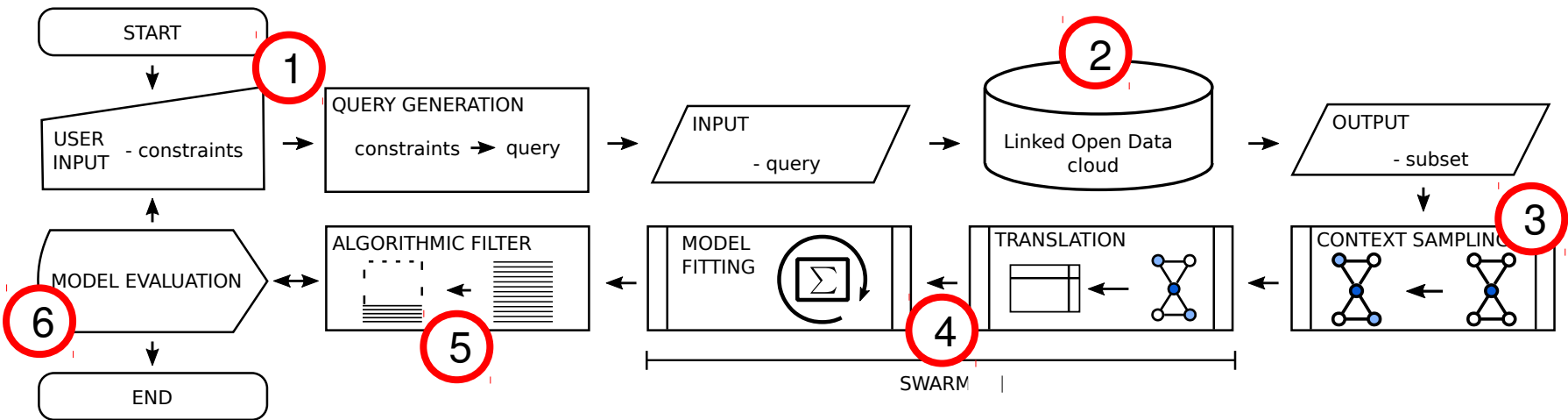
## Generalized Association Rules

$$\forall \chi (Type(\chi, t) \rightarrow (P(\chi, \phi) \rightarrow Q(\chi, \psi)))$$



*For every entity  $\chi$  of type  $t$  :  
if fact  $\chi P \phi$  holds,  
then fact  $\chi Q \psi$  holds as well*

# MinoS: Mining on Semantics pipeline



- 1) Generate graph query based on user input constraints
- 2) Retrieve subset of interest and store as in-memory graph
- 3) Sample context of target resources (instances)
- 4) Mine Generalized Association Rules (SWARM<sup>[1]</sup>)
- 5) Filter rule algorithmically (support, confidence, commonness...)
- 6) Present remaining rules in interactive facet browser

[1] Barati, M., Bai, Q., Liu, Q.: SWARM: An Approach for Mining Semantic Association Rules from Semantic Web Data, pp. 30–43. Springer International Publishing, Cham (2016), [http://dx.doi.org/10.1007/978-3-319-42911-3\\_3](http://dx.doi.org/10.1007/978-3-319-42911-3_3)

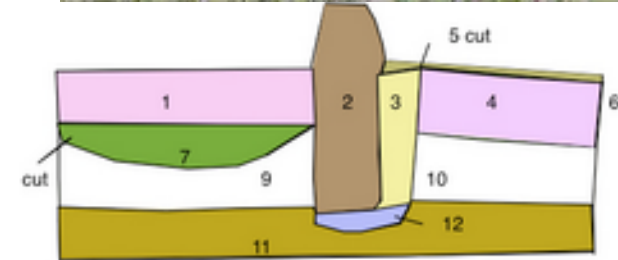


## PakbonLD:

- A knowledge graph
- ± 425k facts
- Archaeological projects in the Netherlands
- Contains 70+ *pakbonnen* ('package slips'@en)

includes

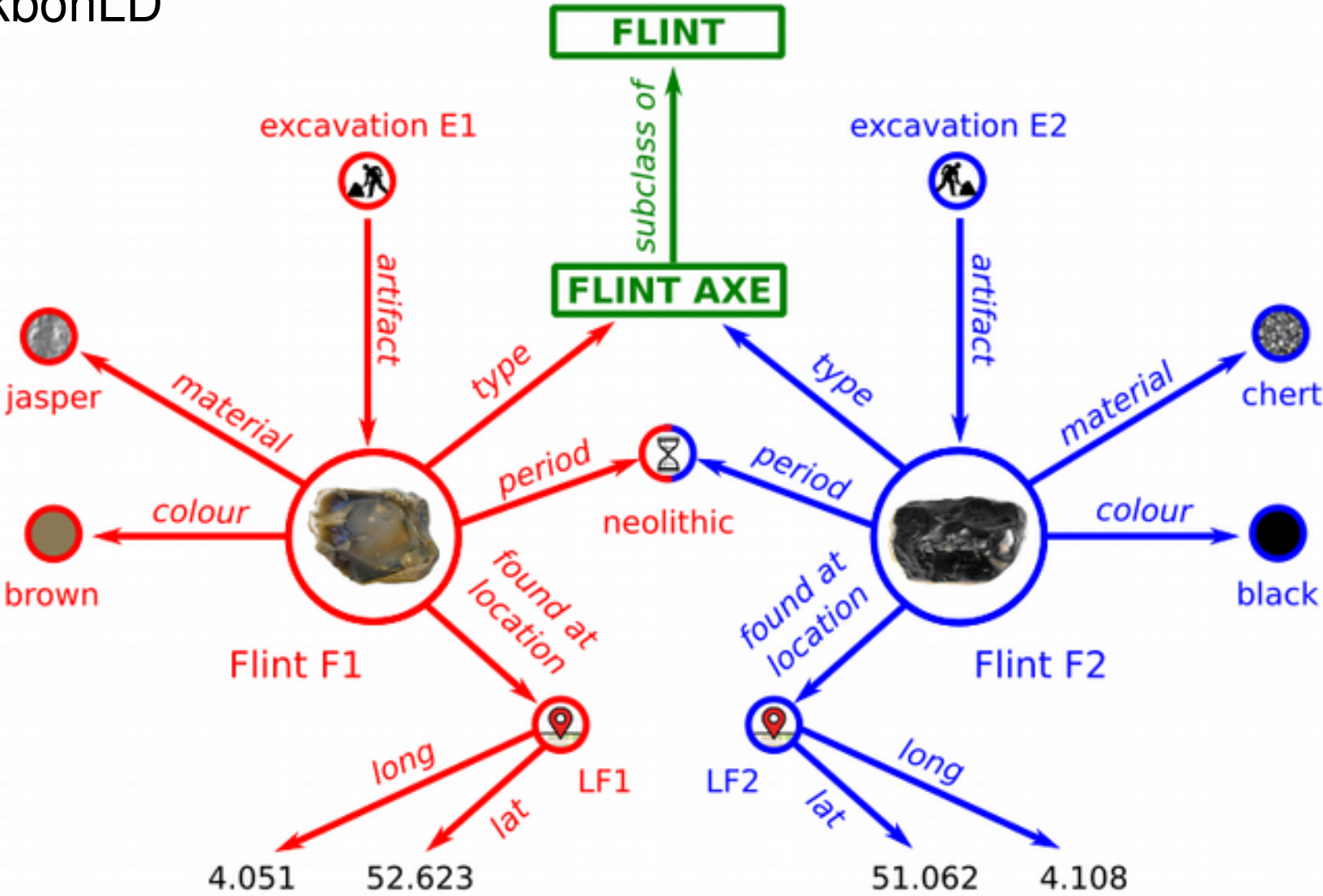
- Organisational structure
- People and companies involved
- Reports made
- Media created
- Artefacts discovered
  - Attributes
  - Archaeological contexts
- Locations and geometries





# An archaeological use case

## PakbonLD

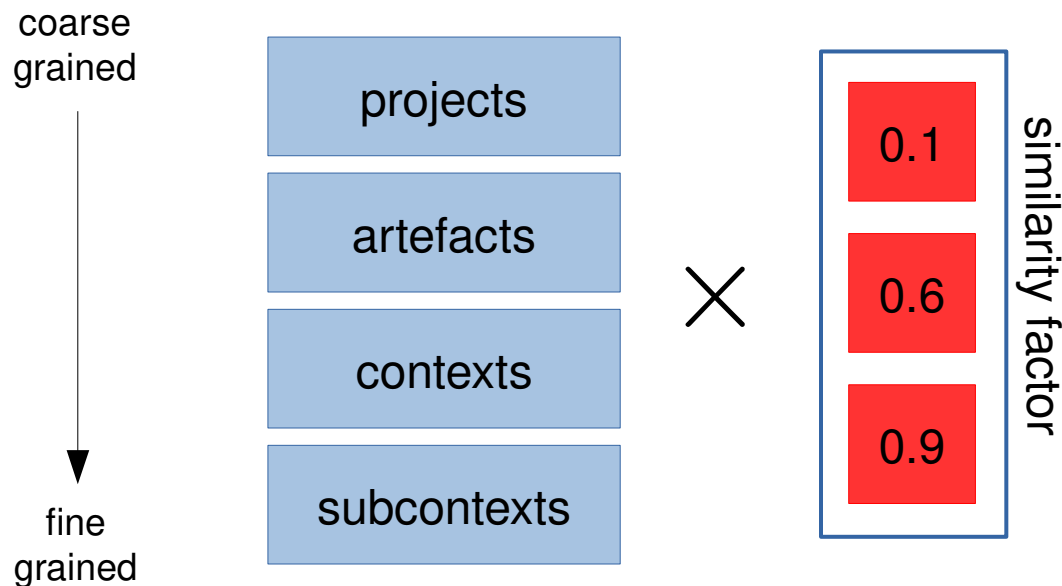


## Four experiments

- Four different granularities

## Per experiment

- Three runs with different similarity factors
- Rules produced by all three runs are aggregated to form the final rule set
- Filtered rule set evaluated by domain experts



For every **context filling** holds:  
if it **has color bright yellow**,  
then it **had purpose animal grave**.

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For every **site** holds:  
if it **underwent activity flint carving**,  
then its **dates from the mesolithic to neolithic period**.

For every **context filling** holds:  
if it **has color bright yellow**,  
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For every **site** holds:  
if it **underwent activity flint carving**,  
then its **dates from the mesolithic to neolithic period**.

For every **context** holds:  
if it **underwent activity burial**,  
and if it **dates from the prehistoric period**,  
then it **had purpose grave**.

For every **context filling** holds:  
if it **has color bright yellow**,  
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For every **site** holds:  
if it **underwent activity flint carving**,  
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For every **context** holds:  
if it **underwent activity burial**,  
and if it **dates from the prehistoric period**,  
then it **had purpose grave**.

For every **artefact** holds:  
if it **is of type charcoal**,  
then it **consists of material charcoal**.

- 10 candidate rules per experiment
- Sampled from filtered rule sets
- Evaluated by 3 domain experts

**Qualitative Evaluation**

**Personal information**

First Name:

Last Name:

Experience Level:  
 ▾

**Description**

Below you will find association rules that have Dutch archaeological excavations. These rules describe patterns of positive correlation between consolidating these patterns into interpretable new hypotheses or as support for existing ones.

**This rule is plausible**

Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

**This rule is new to me**

Disagree    Unsure    Agree

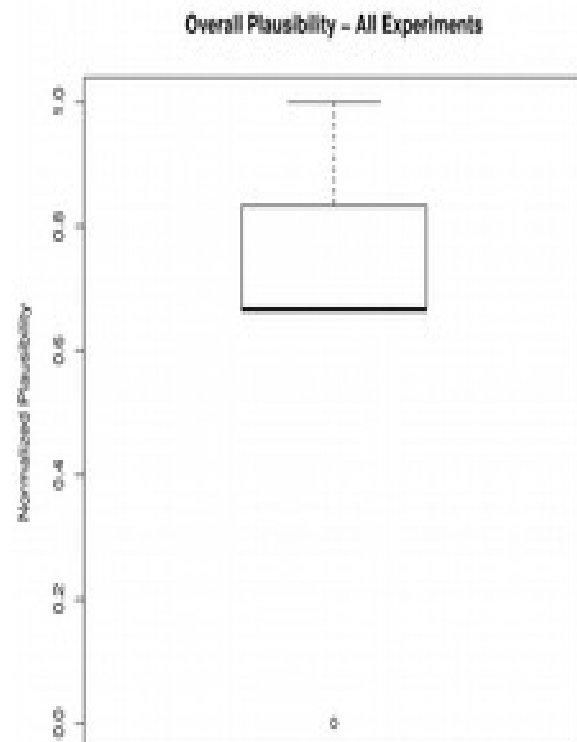
**Rules like this could be relevant to archaeological research**

Strongly Disagree    Disagree    Neutral    Agree    Strongly Agree

Optional remarks specific to this rule:

## Plausibility

Experiment	Rater			Mean
	1	2	3	
Projects	1.00	1.00	0.00	<b>0.67</b>
Artefacts	0.80	0.80	0.00	<b>0.53</b>
Context	0.80	0.80	0.20	<b>0.60</b>
Subcontexts	1.00	1.00	0.80	<b>0.93</b>
Mean	<b>0.90</b>	<b>0.90</b>	<b>0.25</b>	<b>0.68</b>



*68% found plausible on average*

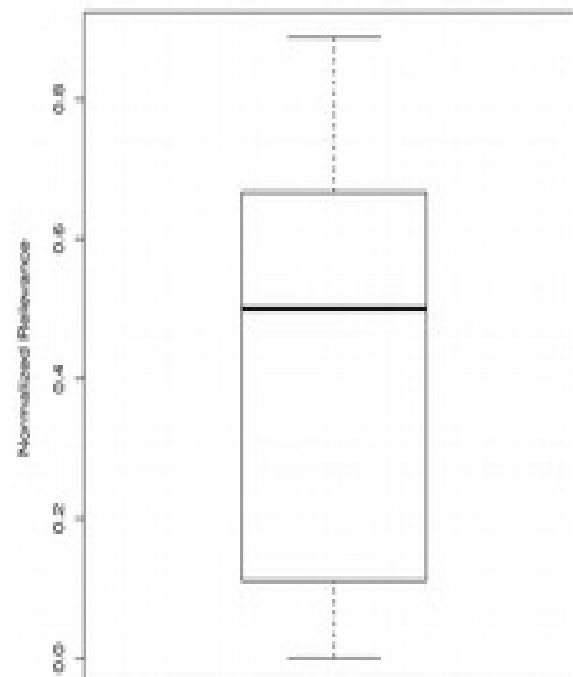


## Relevancy

Experiment

	Rater			Mean
	1	2	3	
Projects	0.13±0.18	0.13±0.18	0.00±0.00	<b>0.09±0.12</b>
Artefacts	0.53±0.30	0.53±0.30	0.33±0.47	<b>0.47±0.36</b>
Contexts	0.53±0.30	0.33±0.24	0.67±0.41	<b>0.51±0.32</b>
Subcontexts	0.60±0.28	0.47±0.18	0.80±0.45	<b>0.62±0.30</b>
Mean	<b>0.45±0.31</b>	<b>0.37±0.26</b>	<b>0.45±0.48</b>	<b>0.42±0.35</b>

Overall Relevancy - All Experiments



*slightly leaning to irrelevancy on average*

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*Subcontexts score best on both plausibility and relevancy*

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*Projects score very low on relevancy*

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$\kappa = -1.28e^{-3}$   
*poor agreement*

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$\kappa = 0.31$   
*fair agreement*

## Overall

Discovered patterns

- were **largely plausible** (68%), and
- some were relevant (20%).

Irrelevant patterns (40%) consisted of **trivialities** and **tautologies**

Domain experts

- were **positively surprised** by the discovered patterns, and
- **acknowledged the potential** for future archaeological research.

## Resources

- MinoS Pipeline (experimental)  
<https://github.com/wxwilcke/MinoS>
- Package slip knowledge graph  
<http://pakbon-ld.spider.d2s.labs.vu.nl>
- ARIADNE Project  
<http://ariadne-infrastructure.eu>



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