Alexander Lex
@alexander_lex
http://alexander-lex.net

THE UNIVERSITY OF UTAH

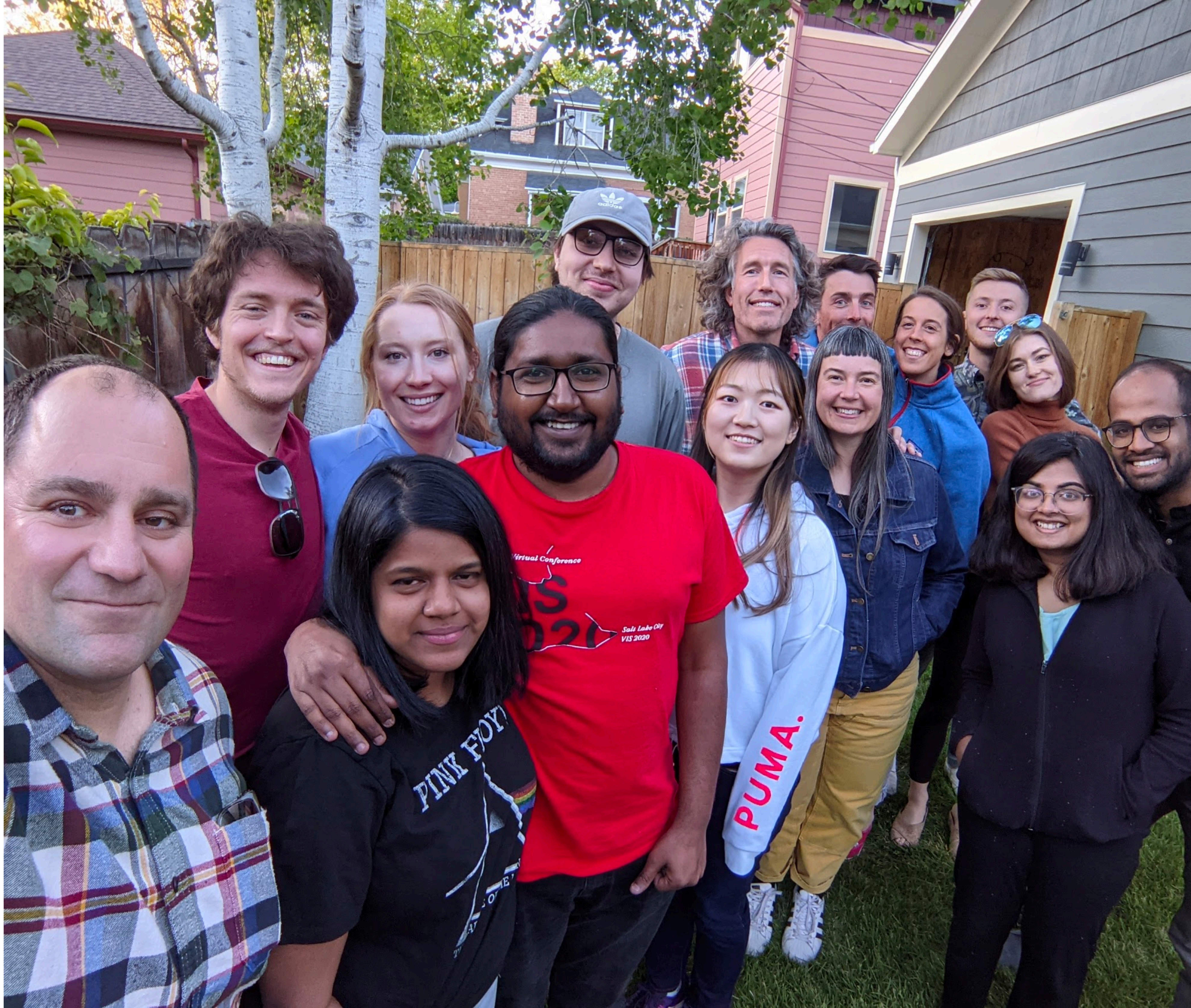
Empirical Evaluation of Complex Interactive Visualization Techniques

visualization design lab

www.sci.utah.edu

visualization
design lab

http://vdl.sci.utah.edu/



datavisyn

On sabbatical at datavisyn, in Linz

Data visualization solutions for **pharmaceutical industry**

20 people and growing!

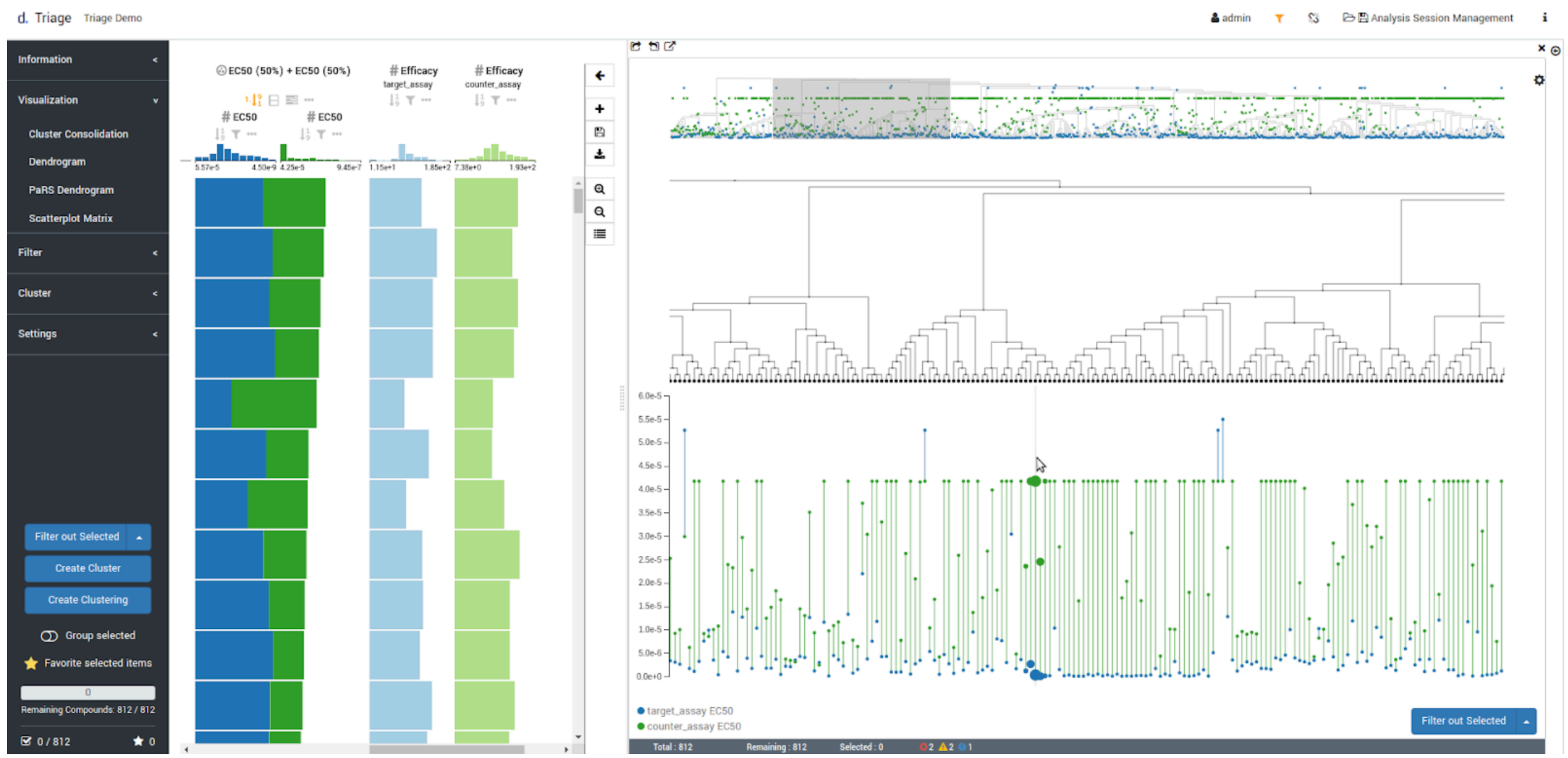
Marc Streit, CEO

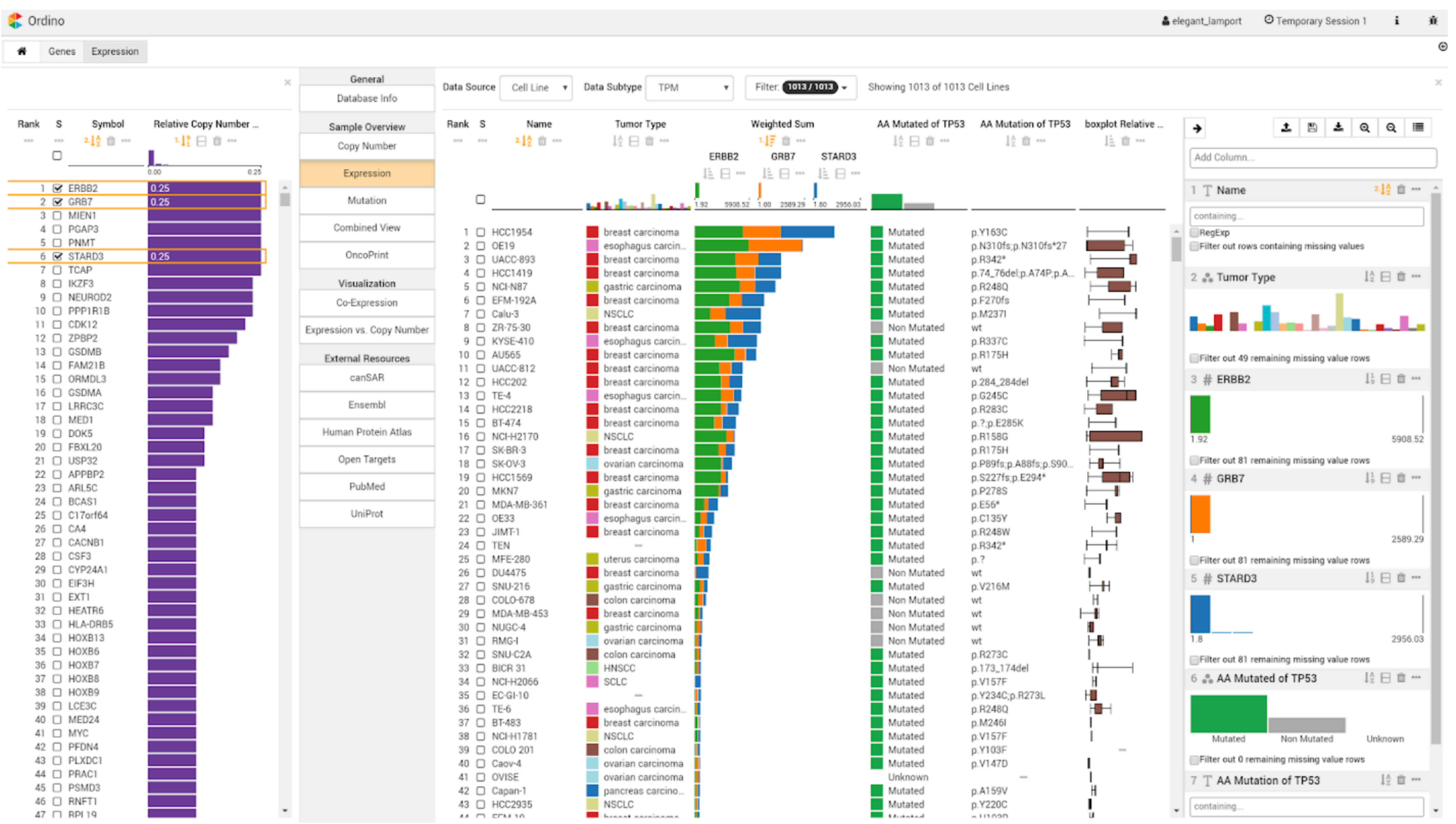
Dominic Giradi, CPO

Alexander Lex

Nils Gehlenborg

Samuel Gratzl





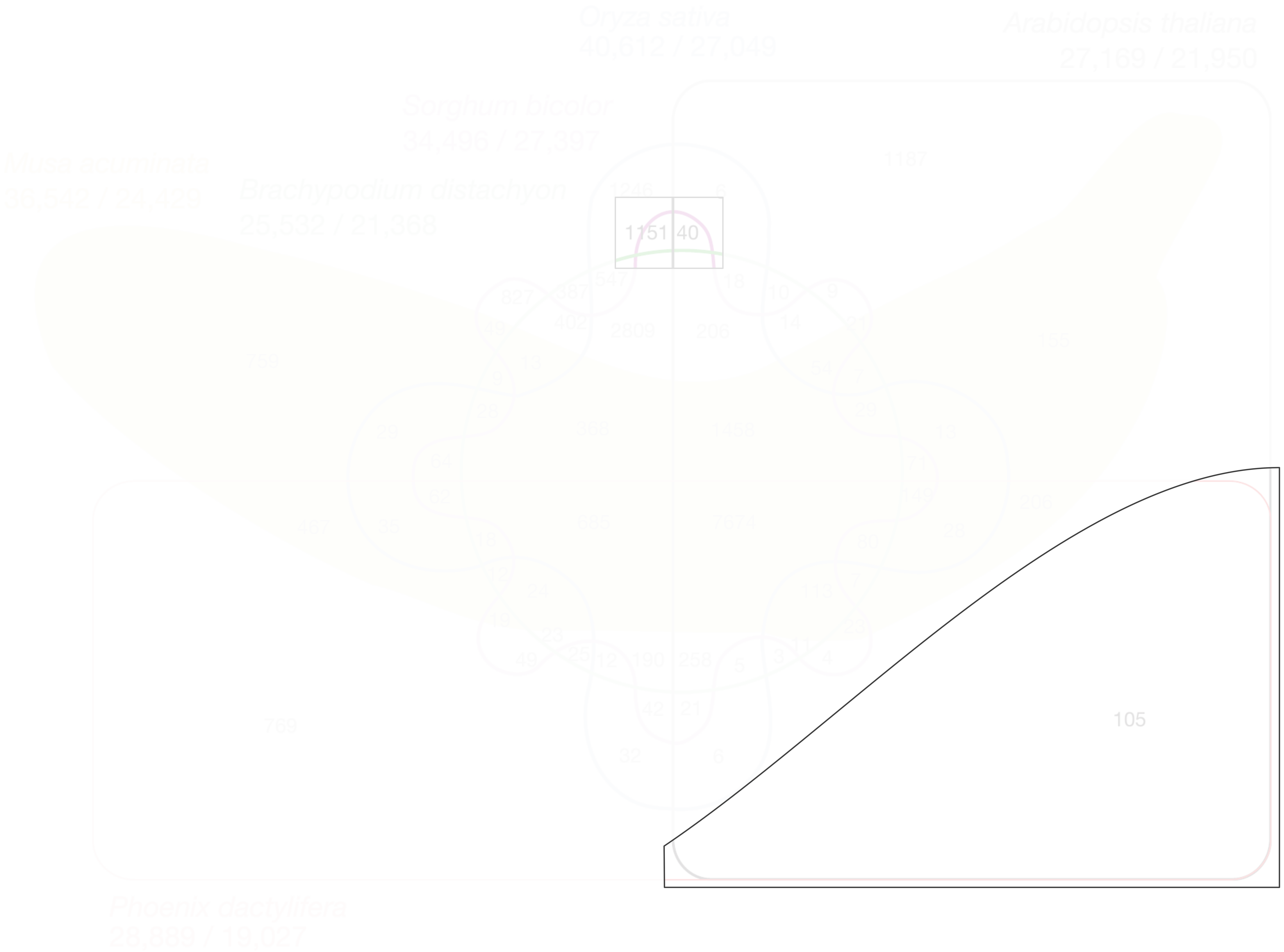
visualization

The purpose of computing is insight,
not numbers.

pictures

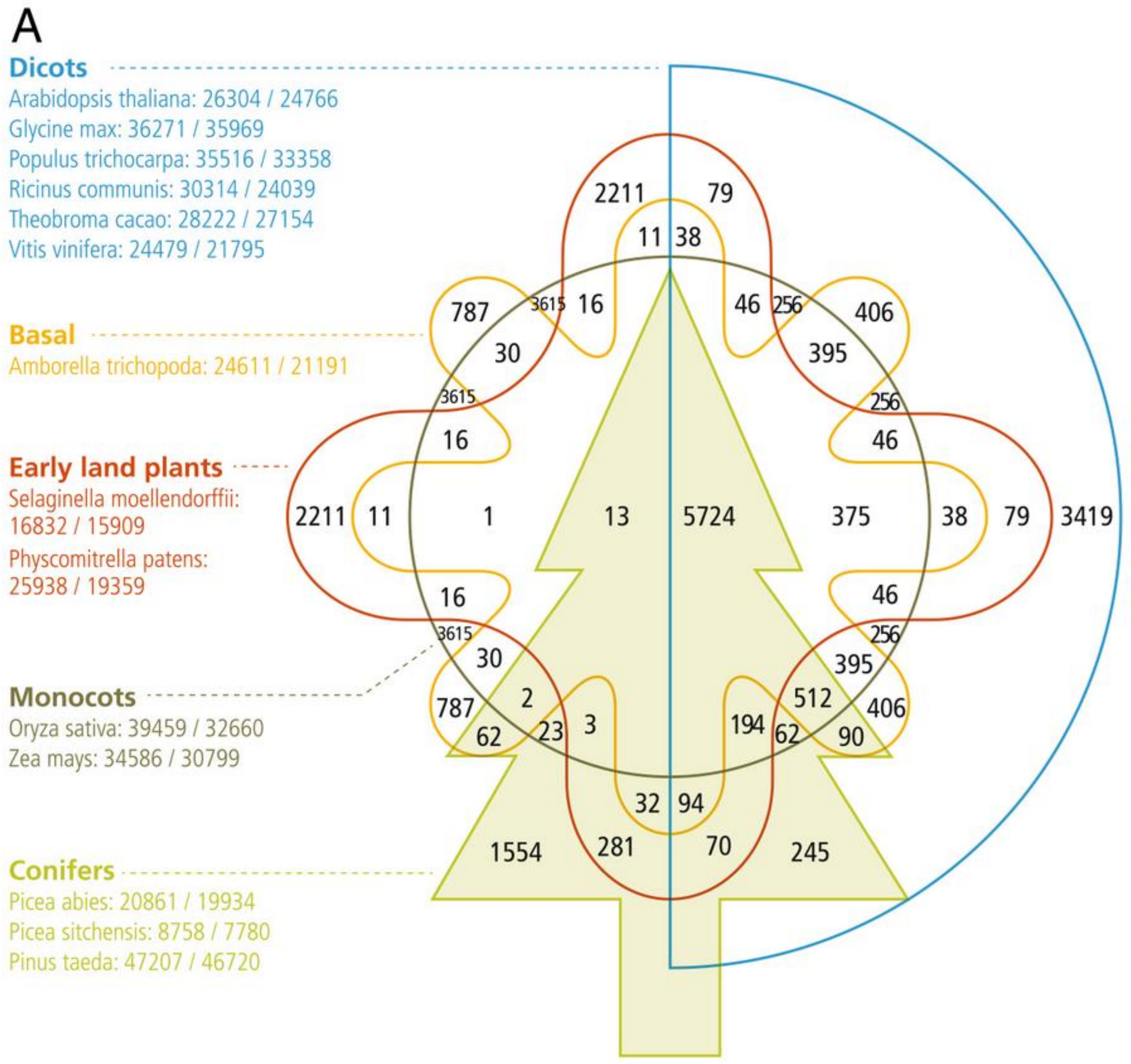
[Card, Mackinlay, Shneiderman]
[Richard Wesley Hamming]

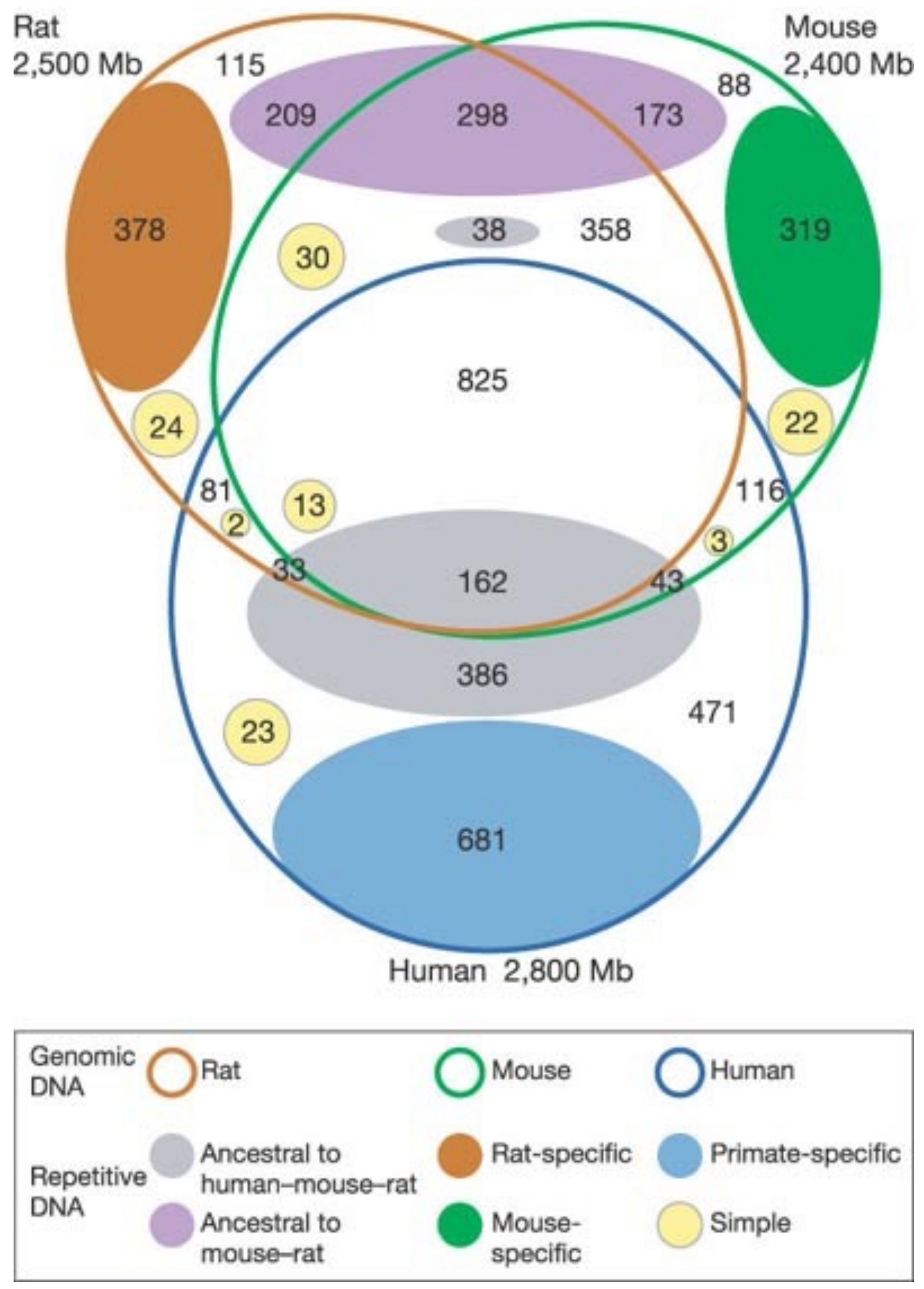
Banana	*M. acuminata*
Date	*P. dactylifera*
Cress	*Arabidopsis thaliana*
Rice	*Oryza sativa*
Sorghum	*Sorghum bicolor*
Brome	*Brachypodium distachyon*



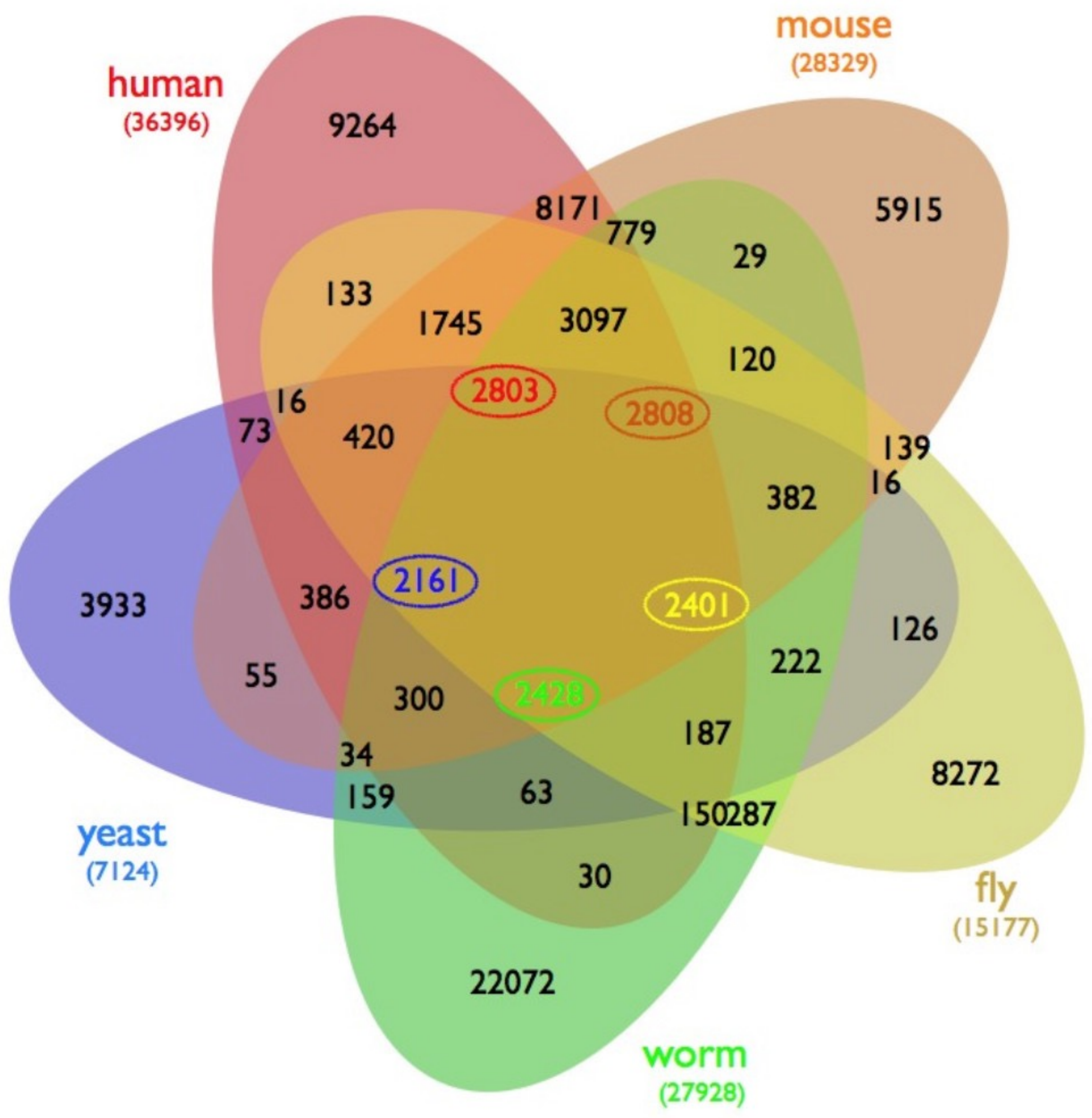
[D'Hont et al., Nature, 2012]

[Neale et al., BMC Genome Biology, 2014]

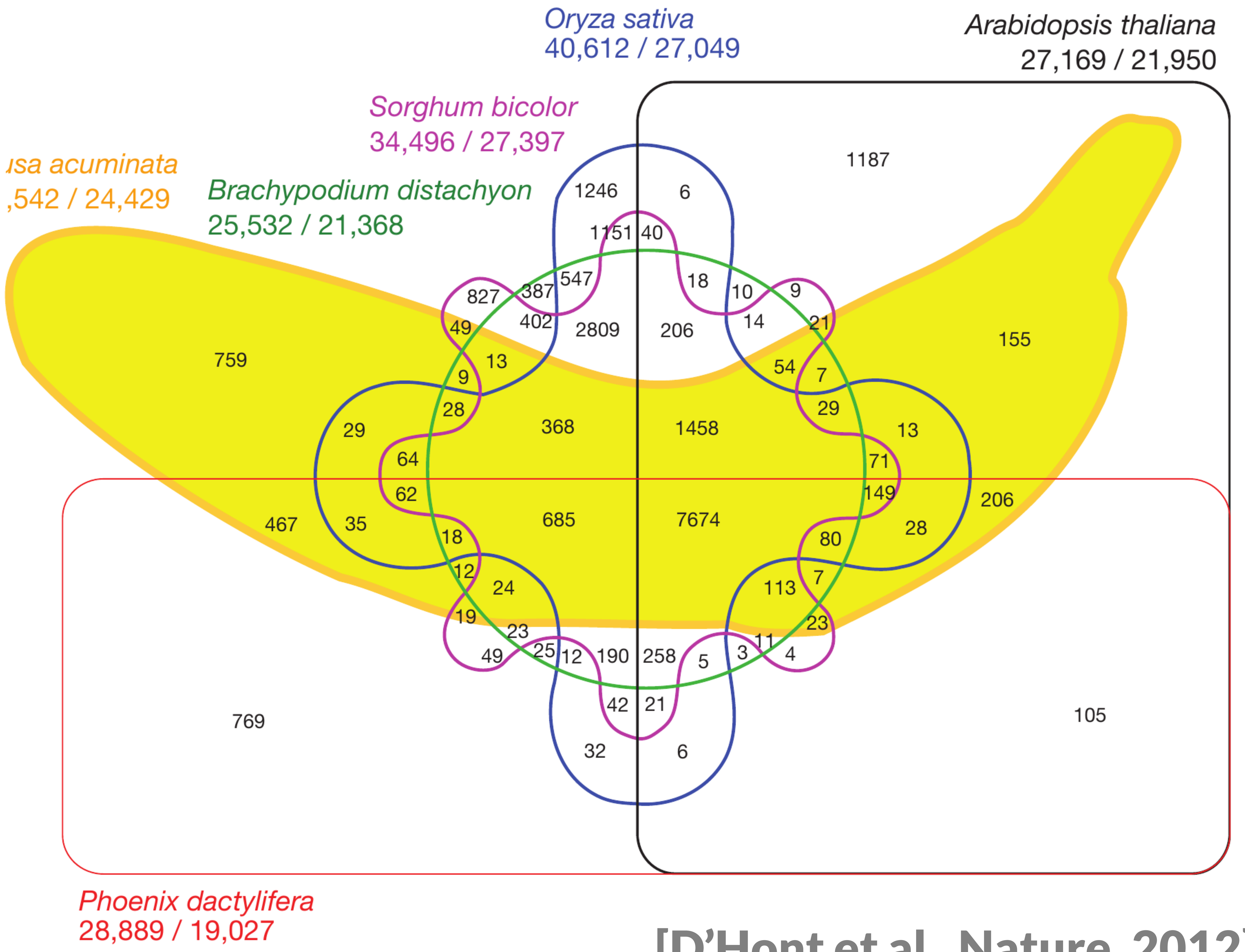




[Gibbs et al., Nature, 2004]

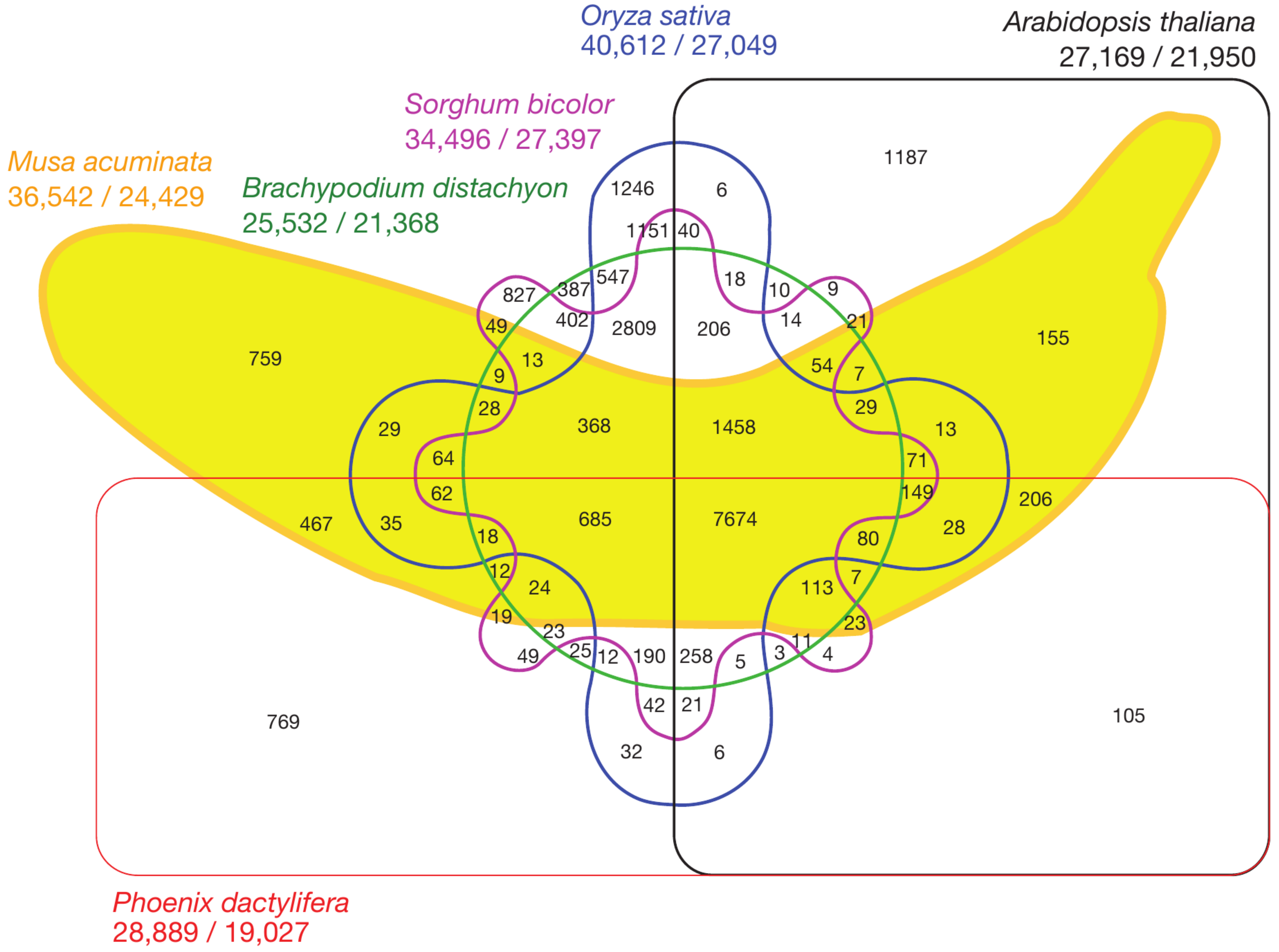


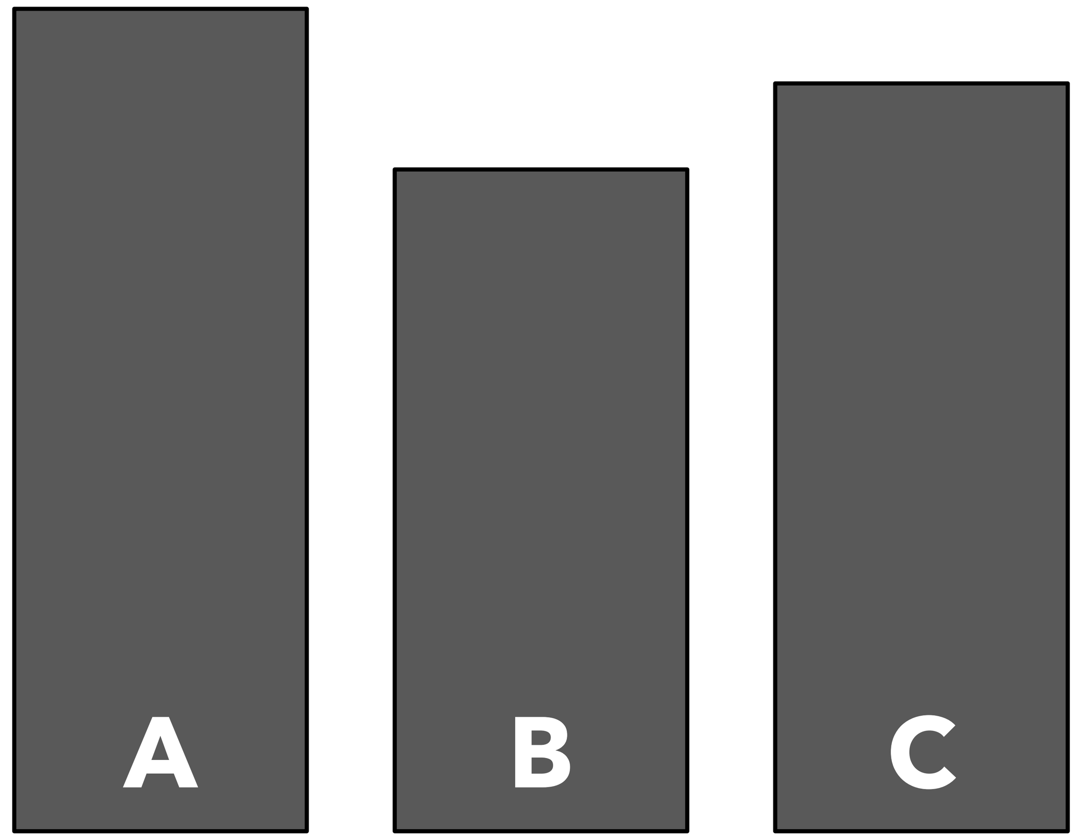
[Wiles et al., BMC Systems Biology]



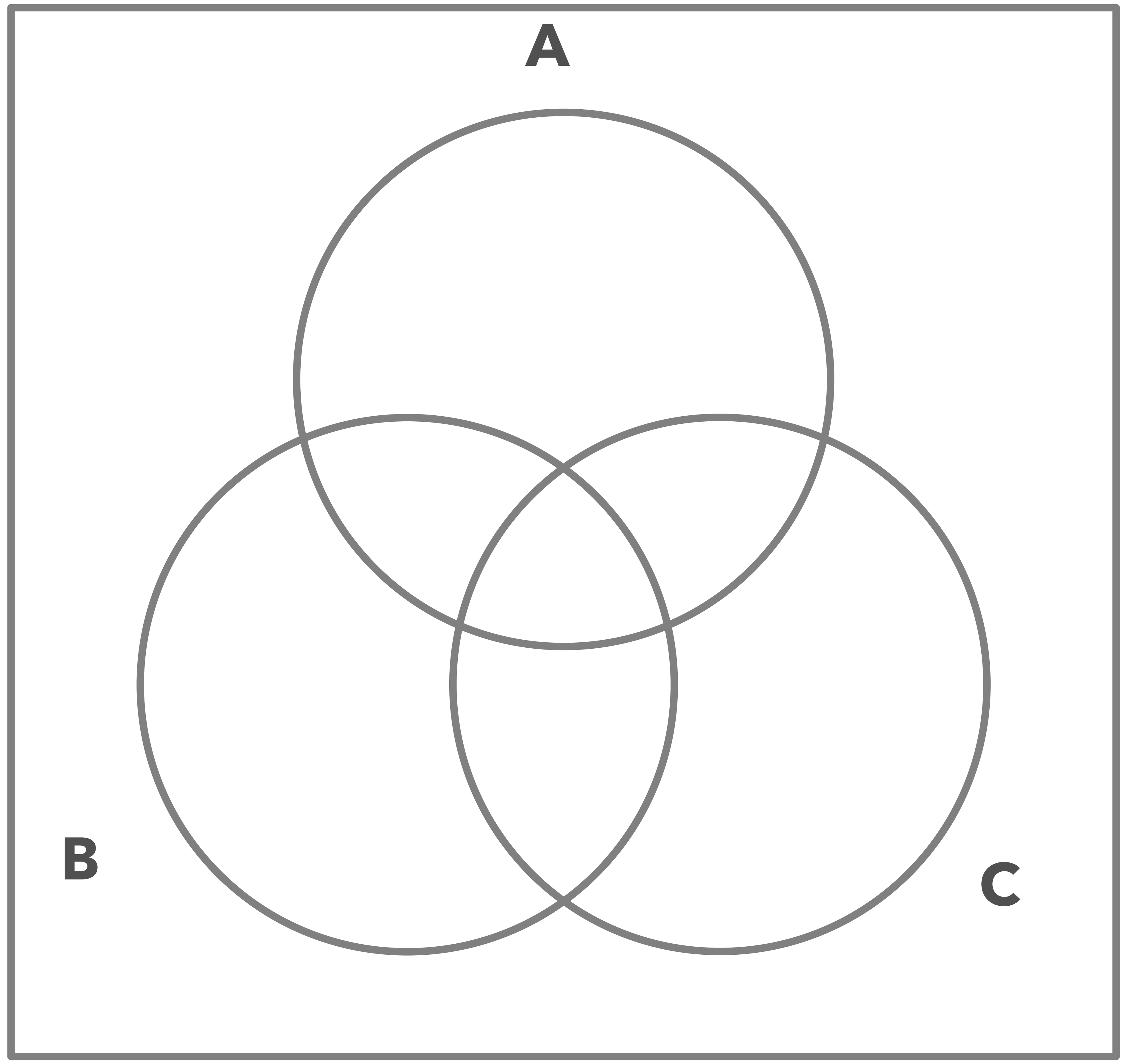
[D'Hont et al., Nature, 2012]

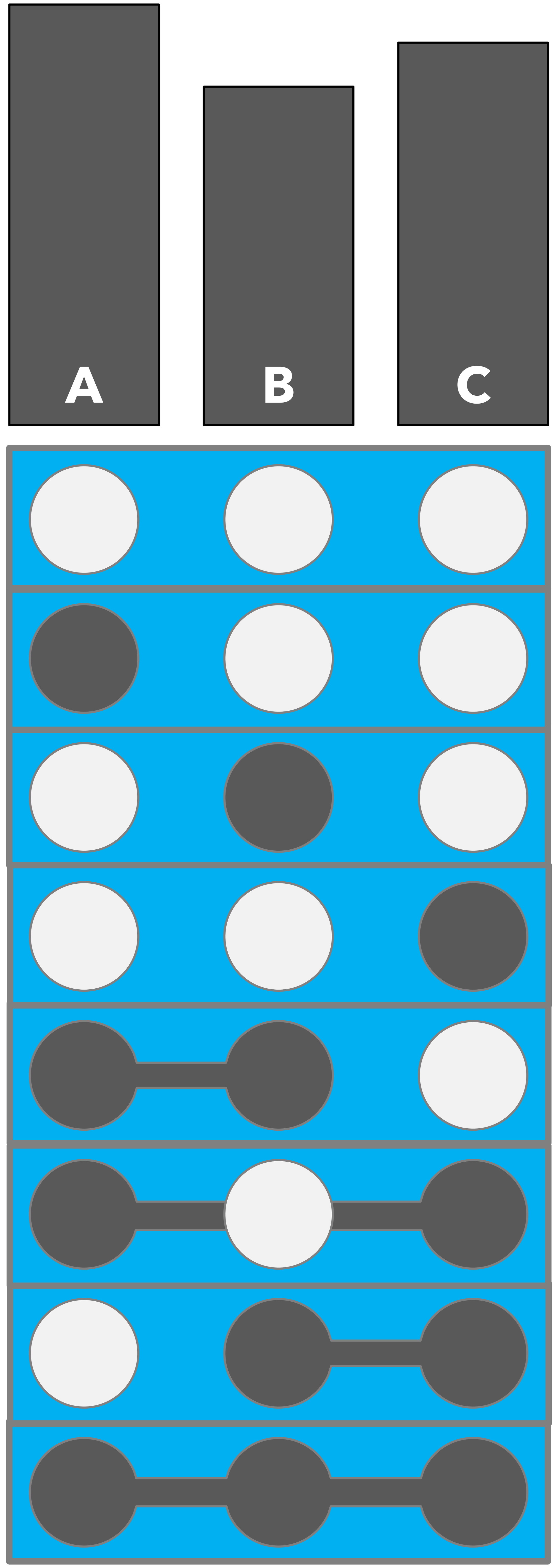
SO CAN WE DO BETTER?



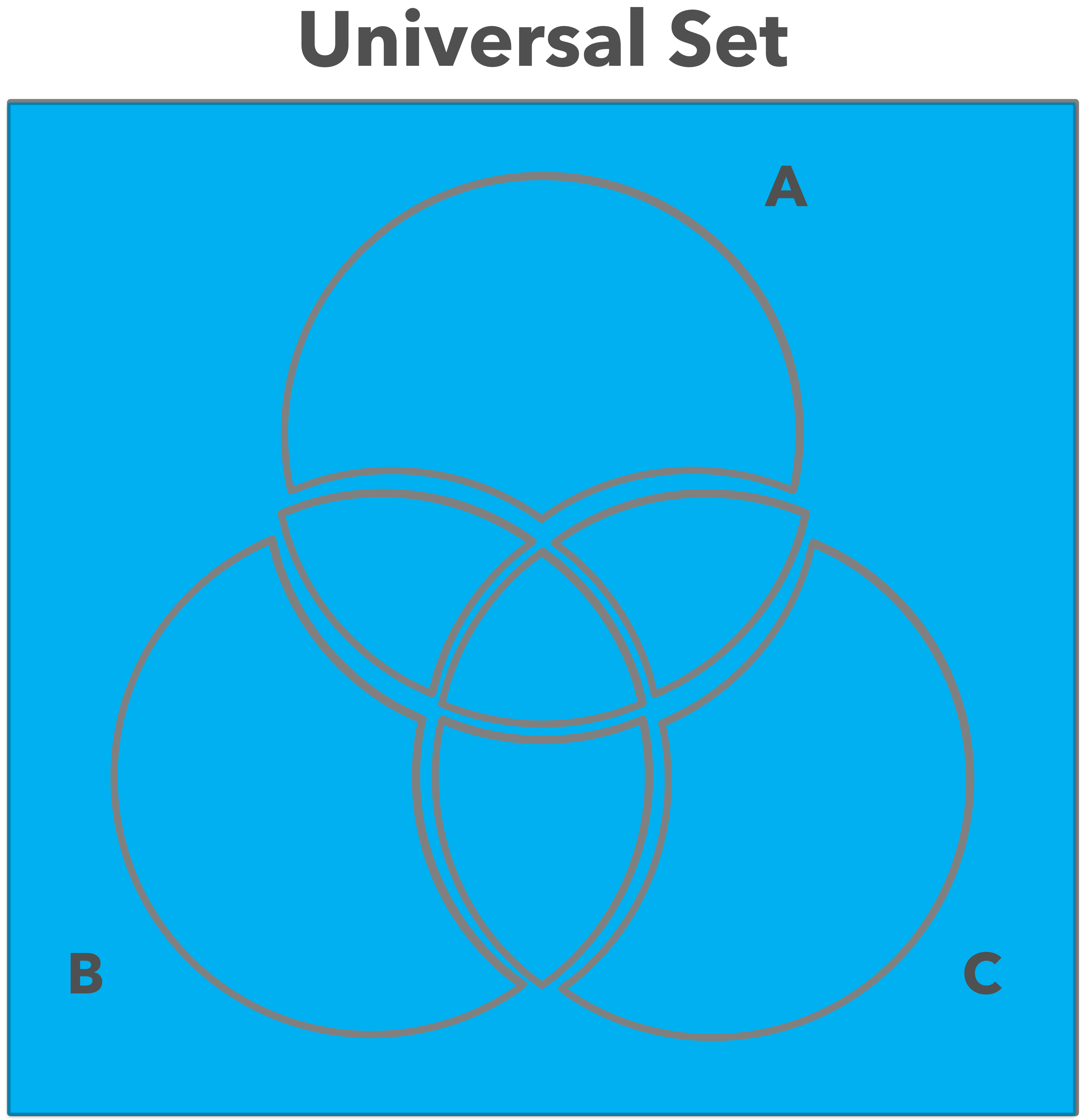


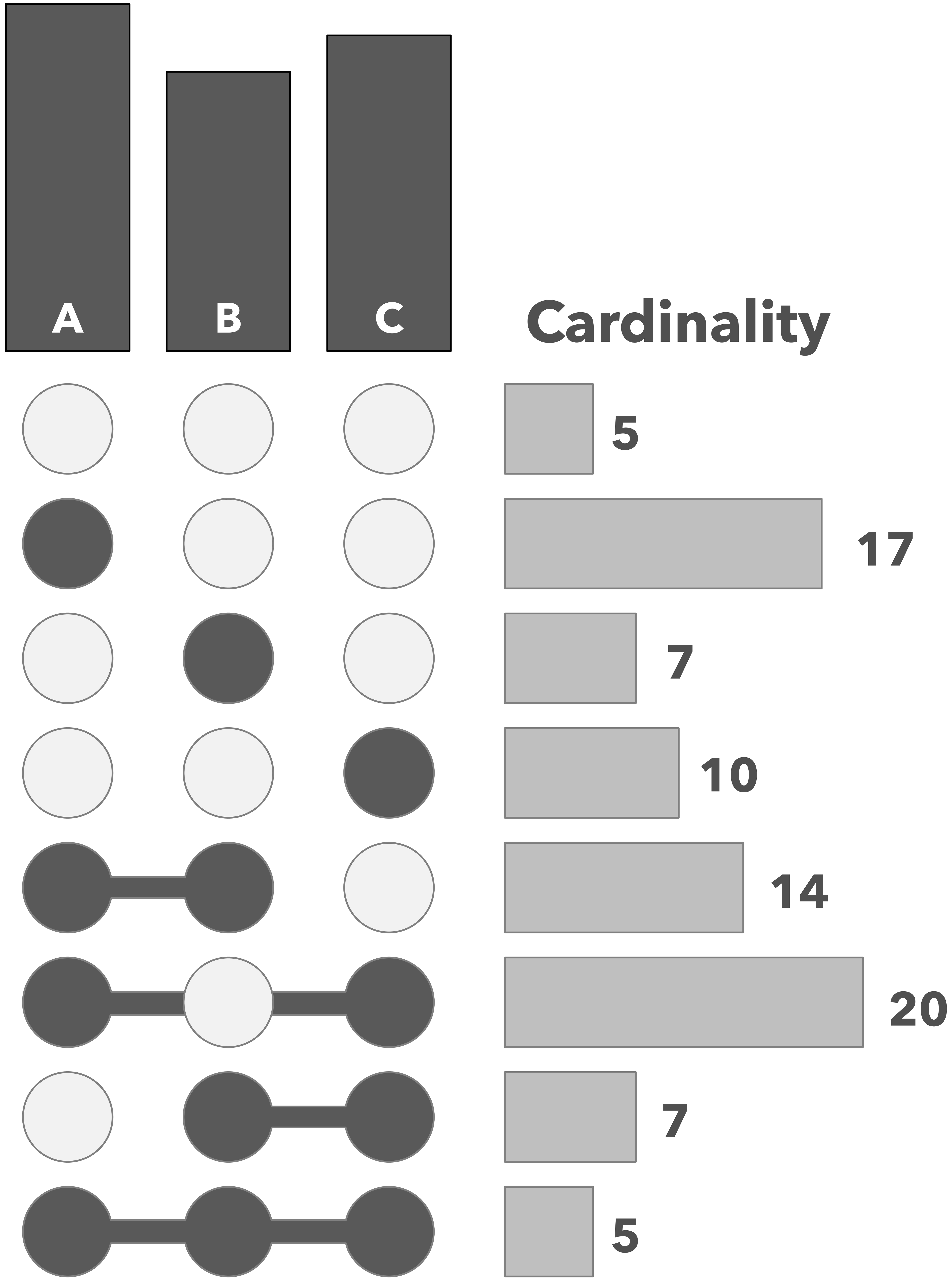
Universal Set

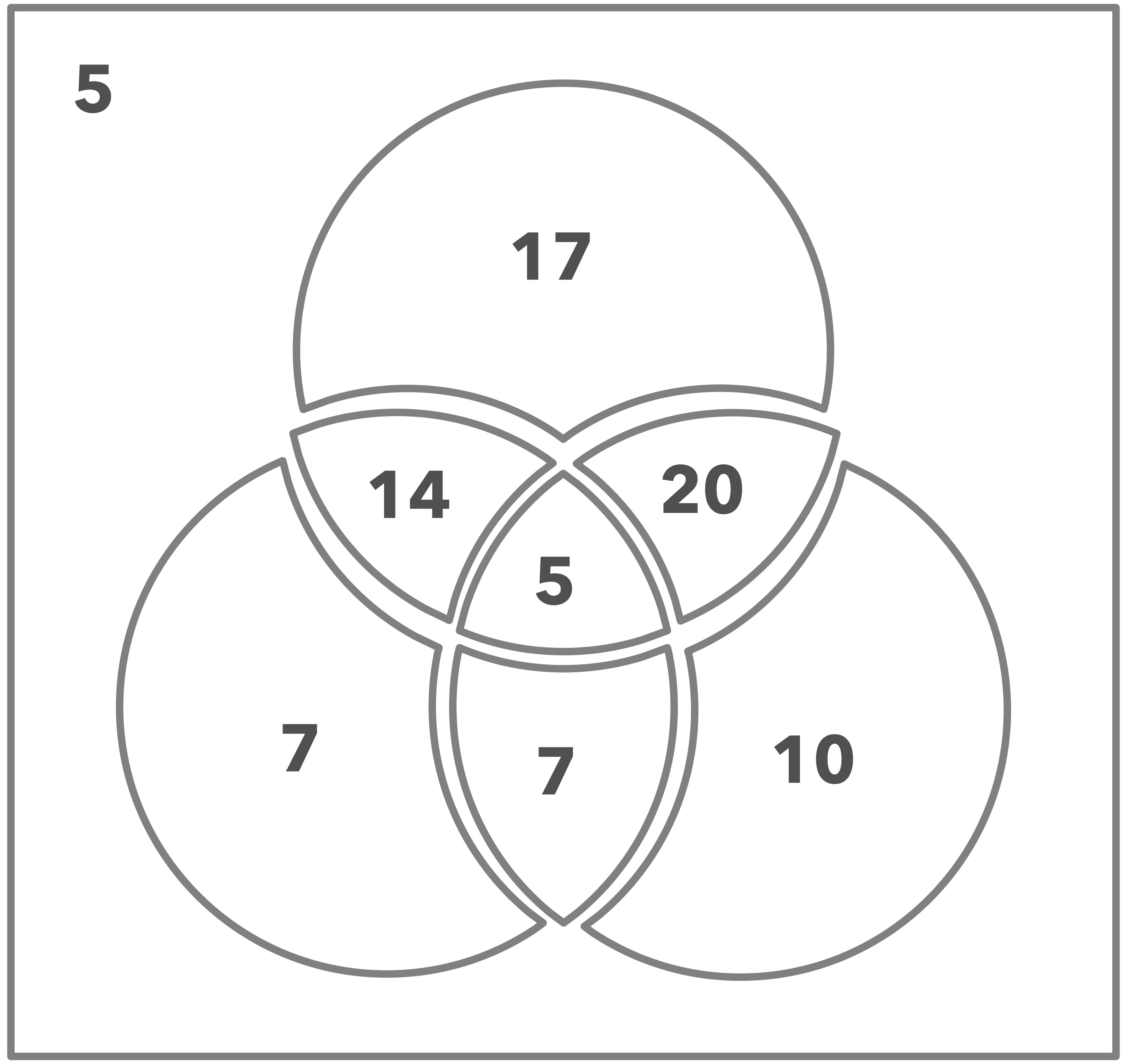



A
B
C

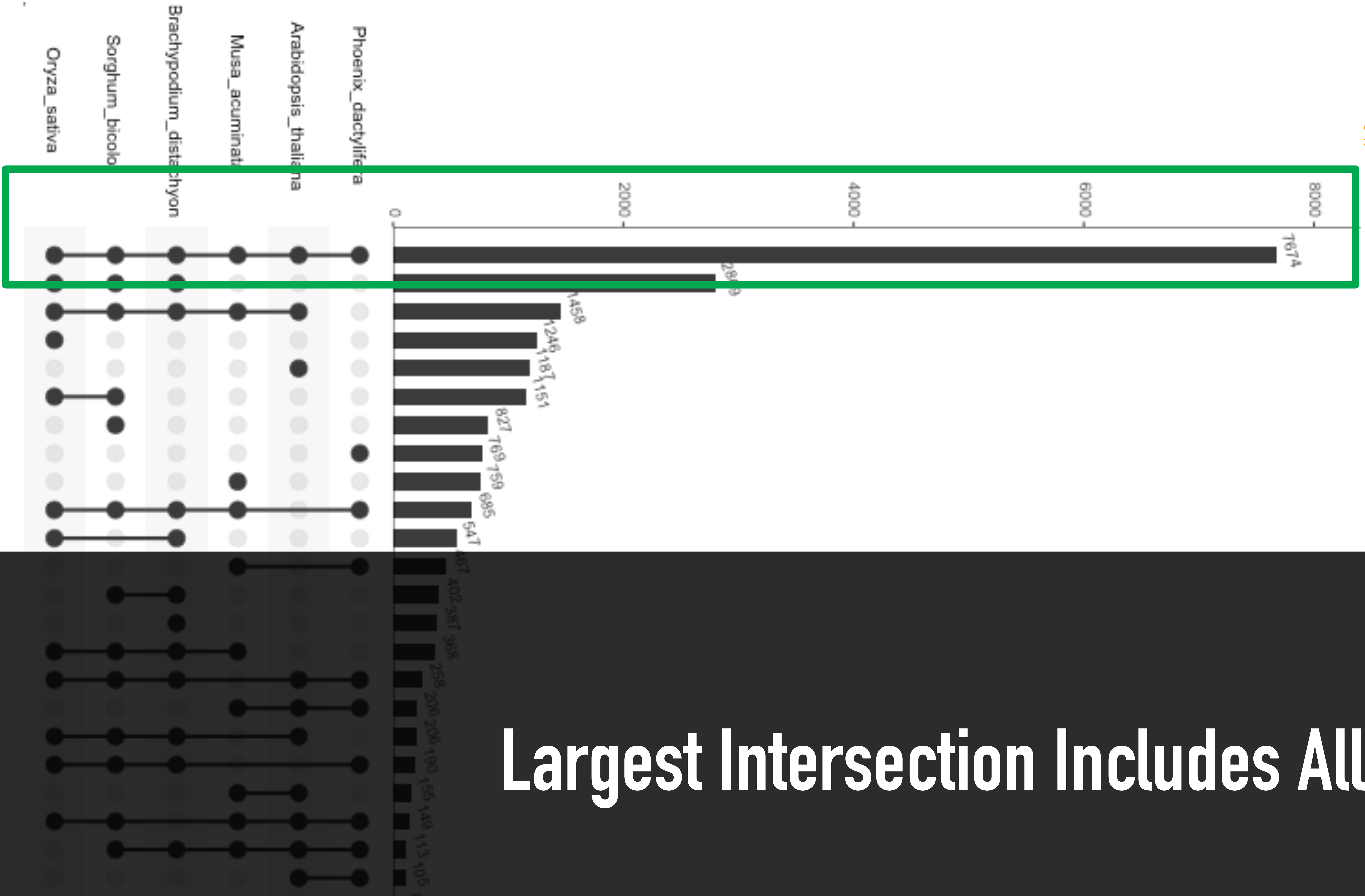

Must
Must Not

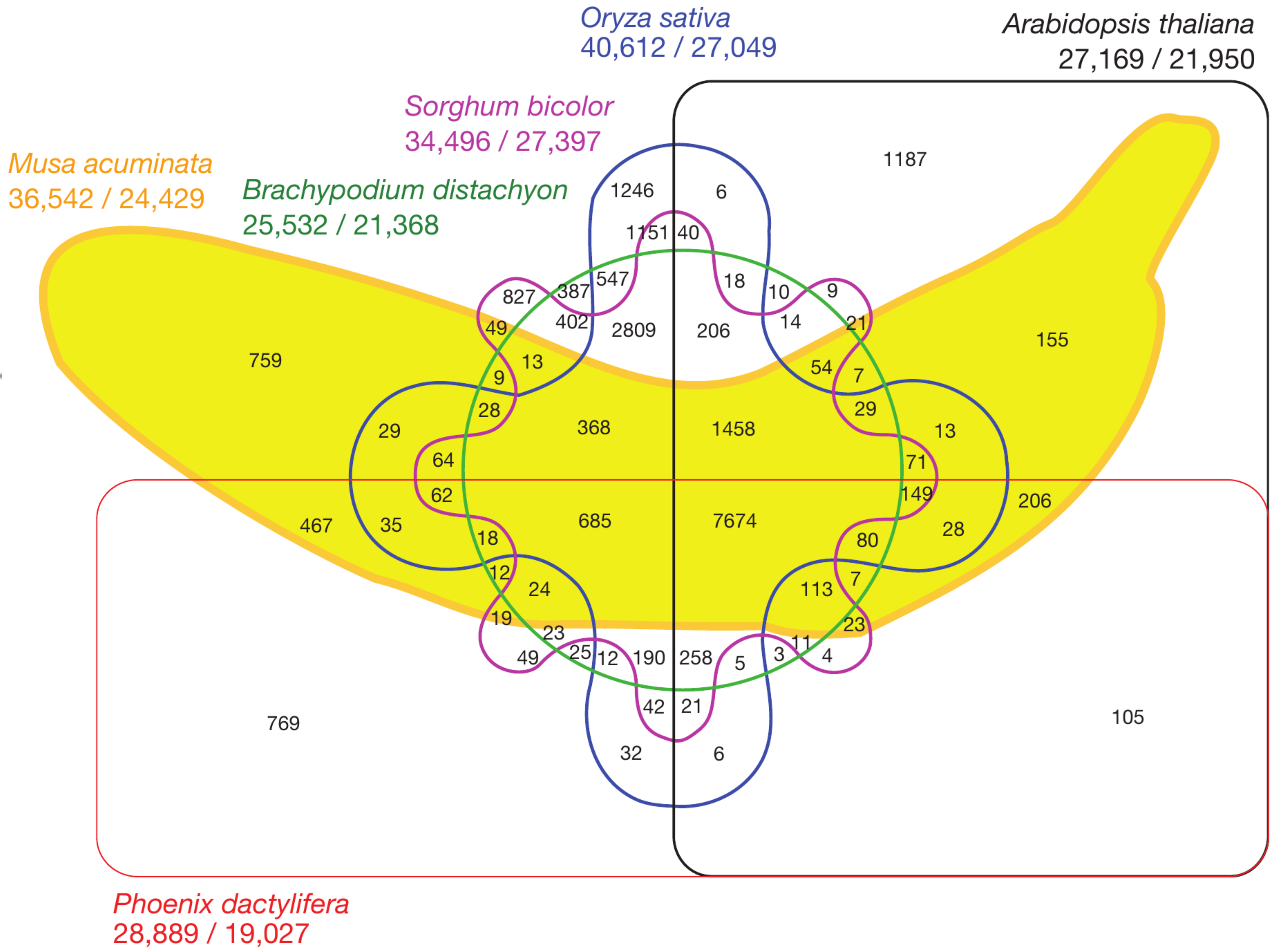

Universal Set
A
B
C


A
B
C
Cardinality
5
17
7
10
14
20
7
5


5
17
14
20
5
7
7
10

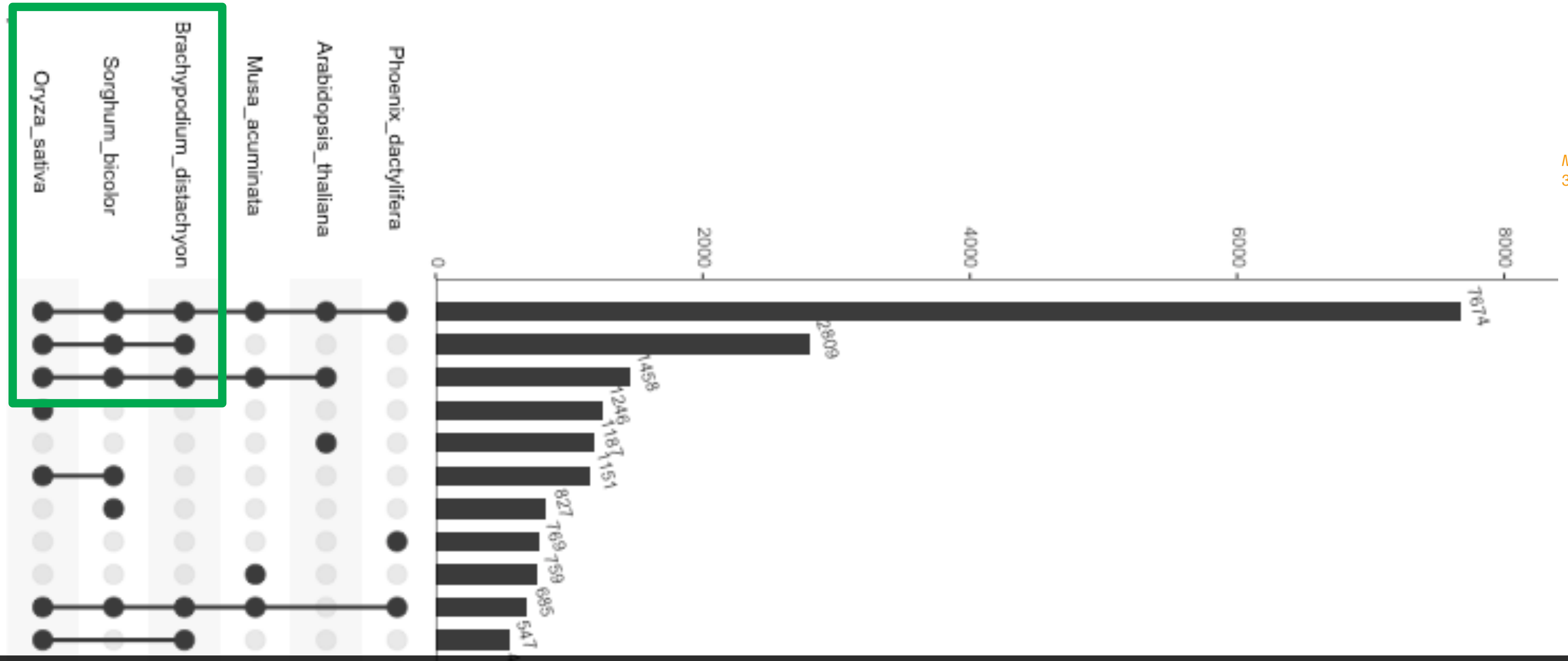
THE BANANA CHART REDESIGNED: UPSET

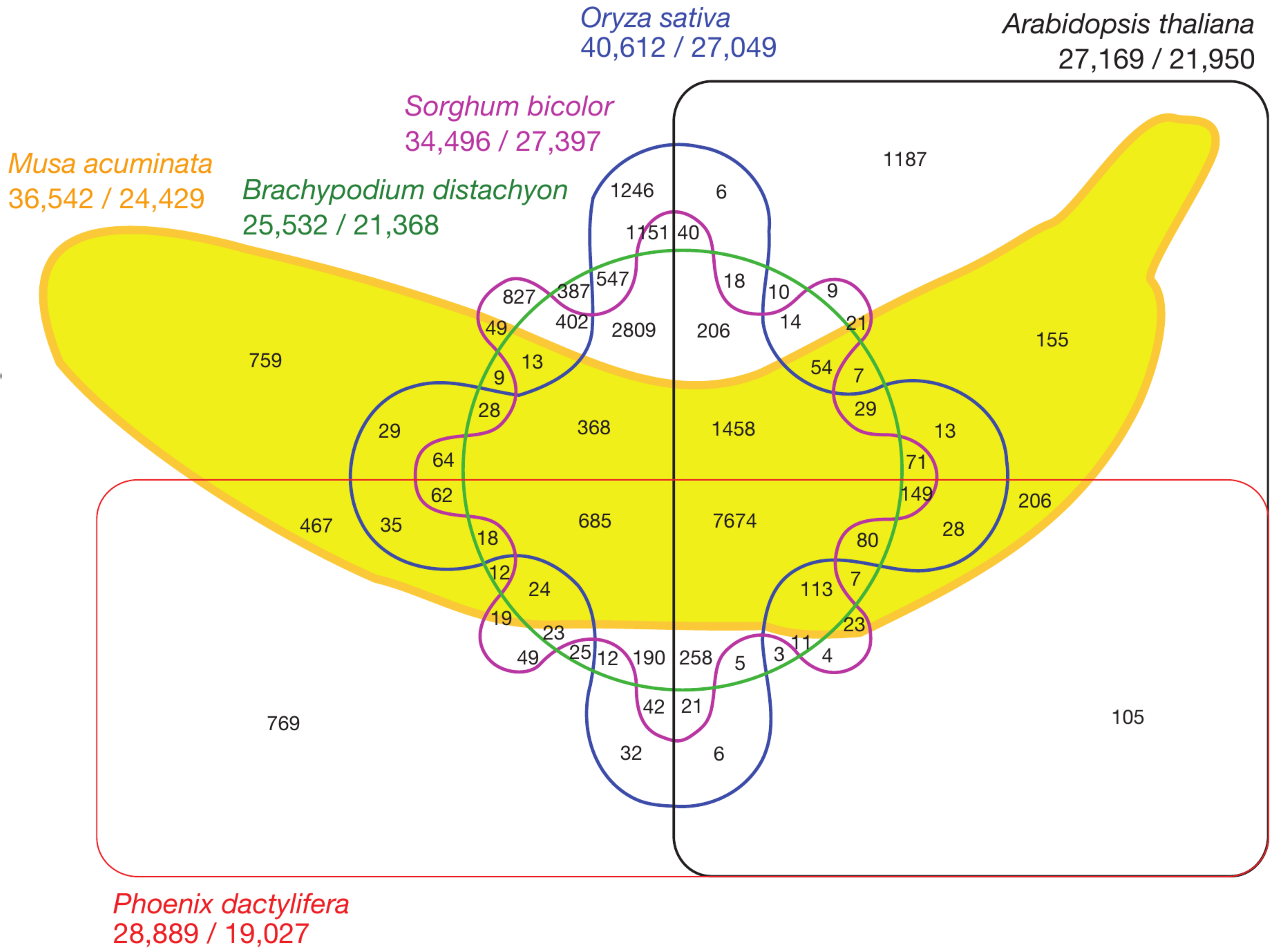




Largest Intersection Includes All Sets

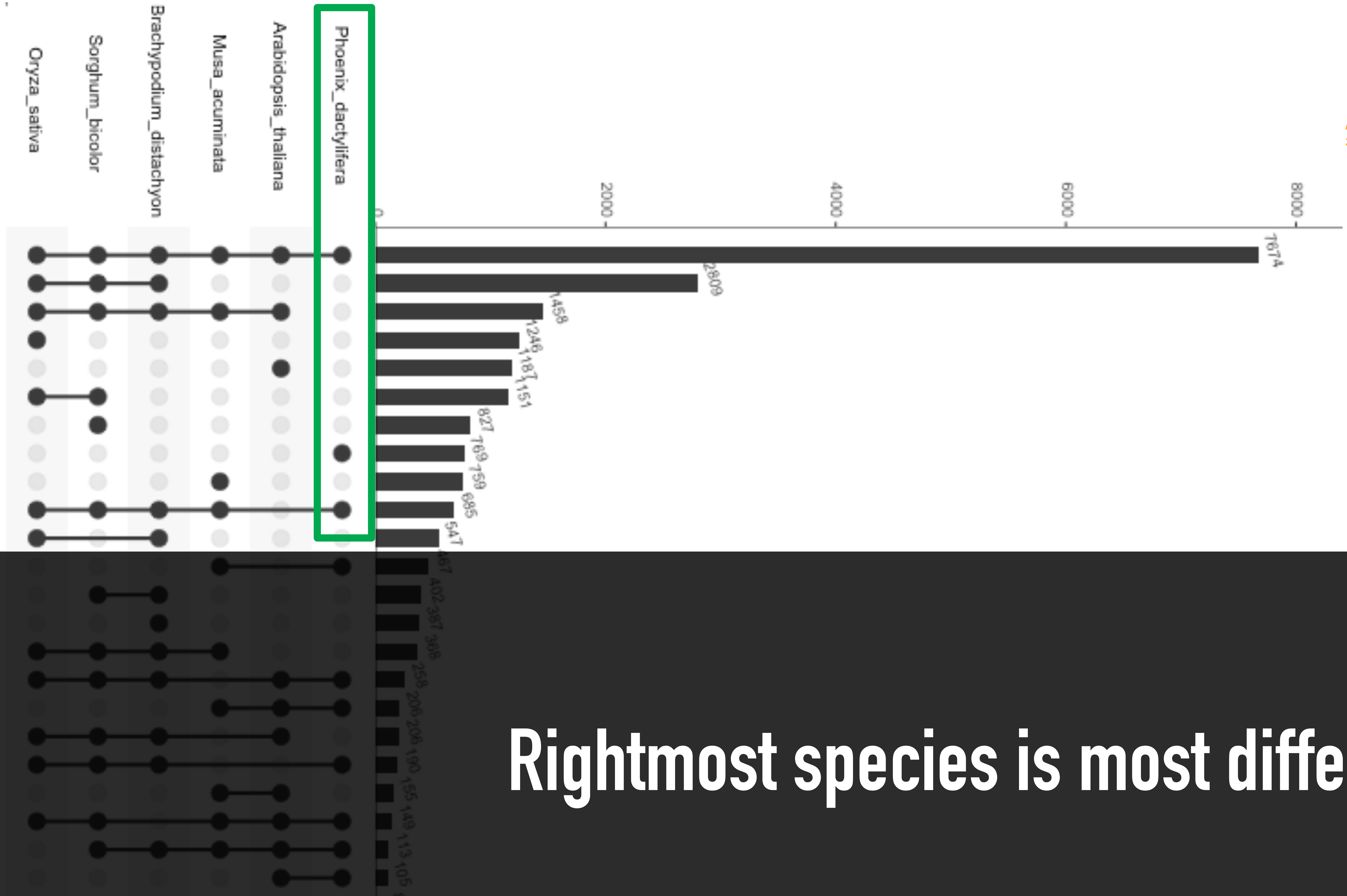
THE BANANA CHART REDESIGNED: UPSET

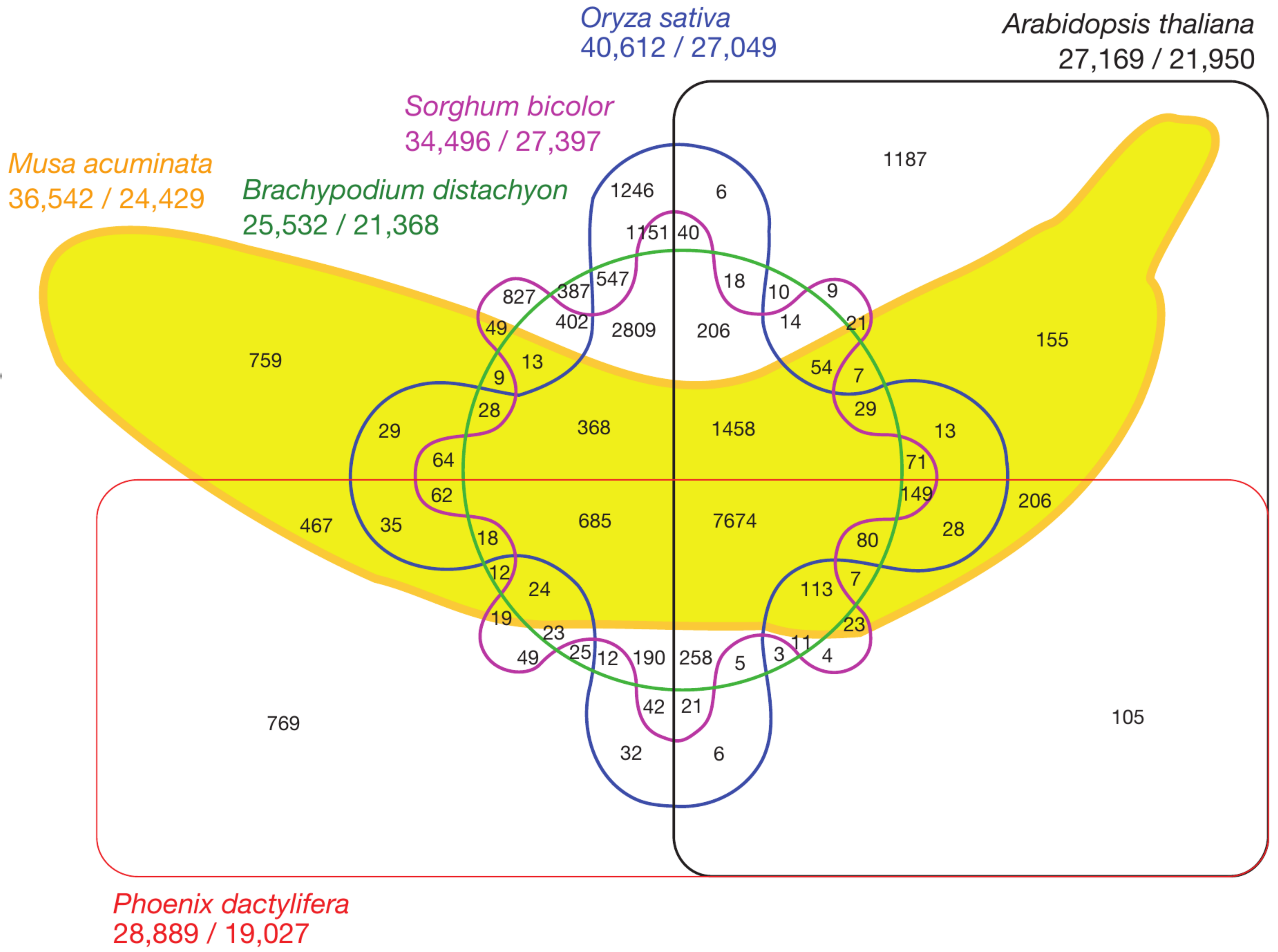




Three Leftmost Species Are Most Similar

THE BANANA CHART REDESIGNED: UPSET





Rightmost species is most different

http://vcg.github.io/upset/

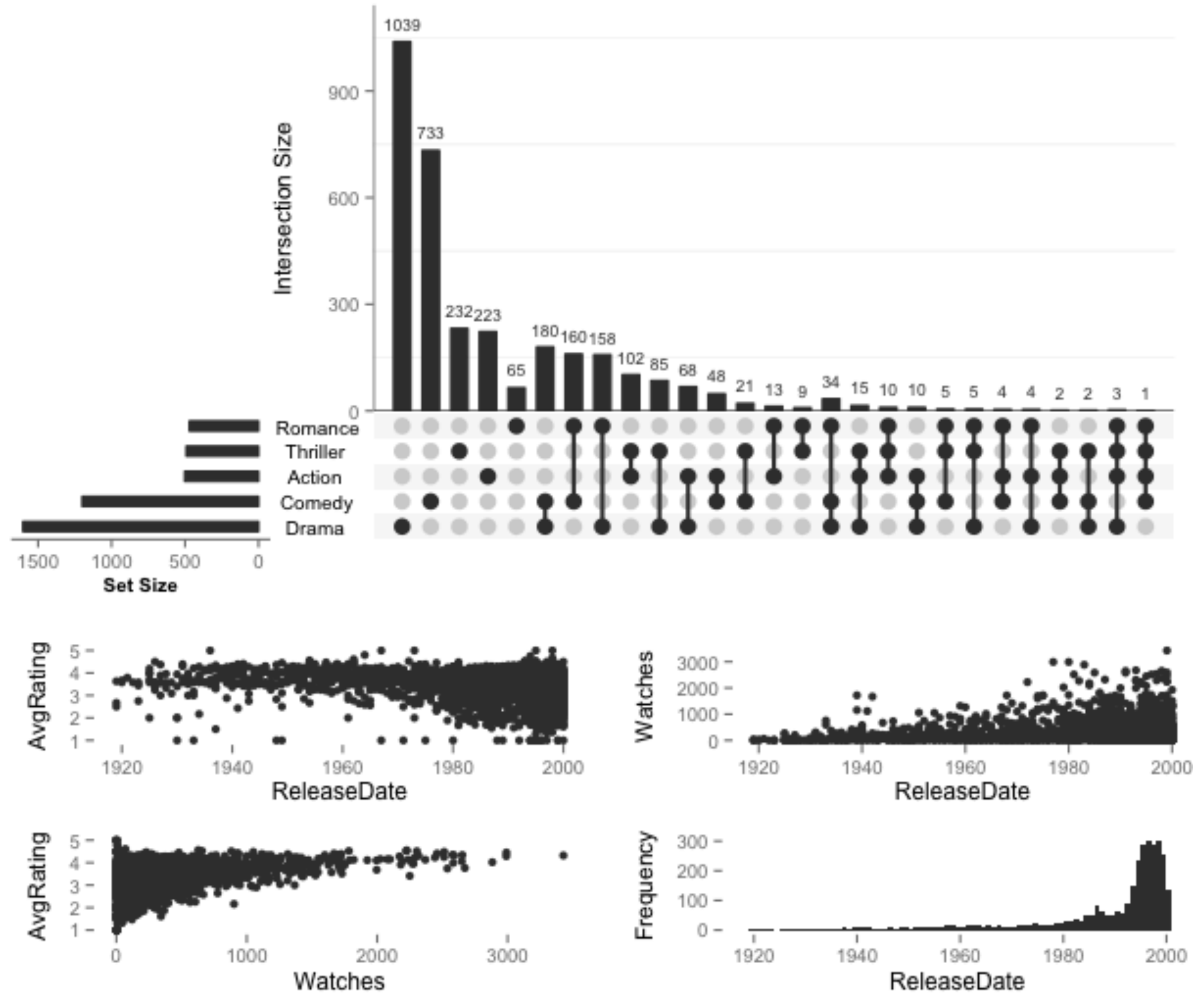
COMMUNITY IMPACT

The canonical way to show set data with > 3 sets

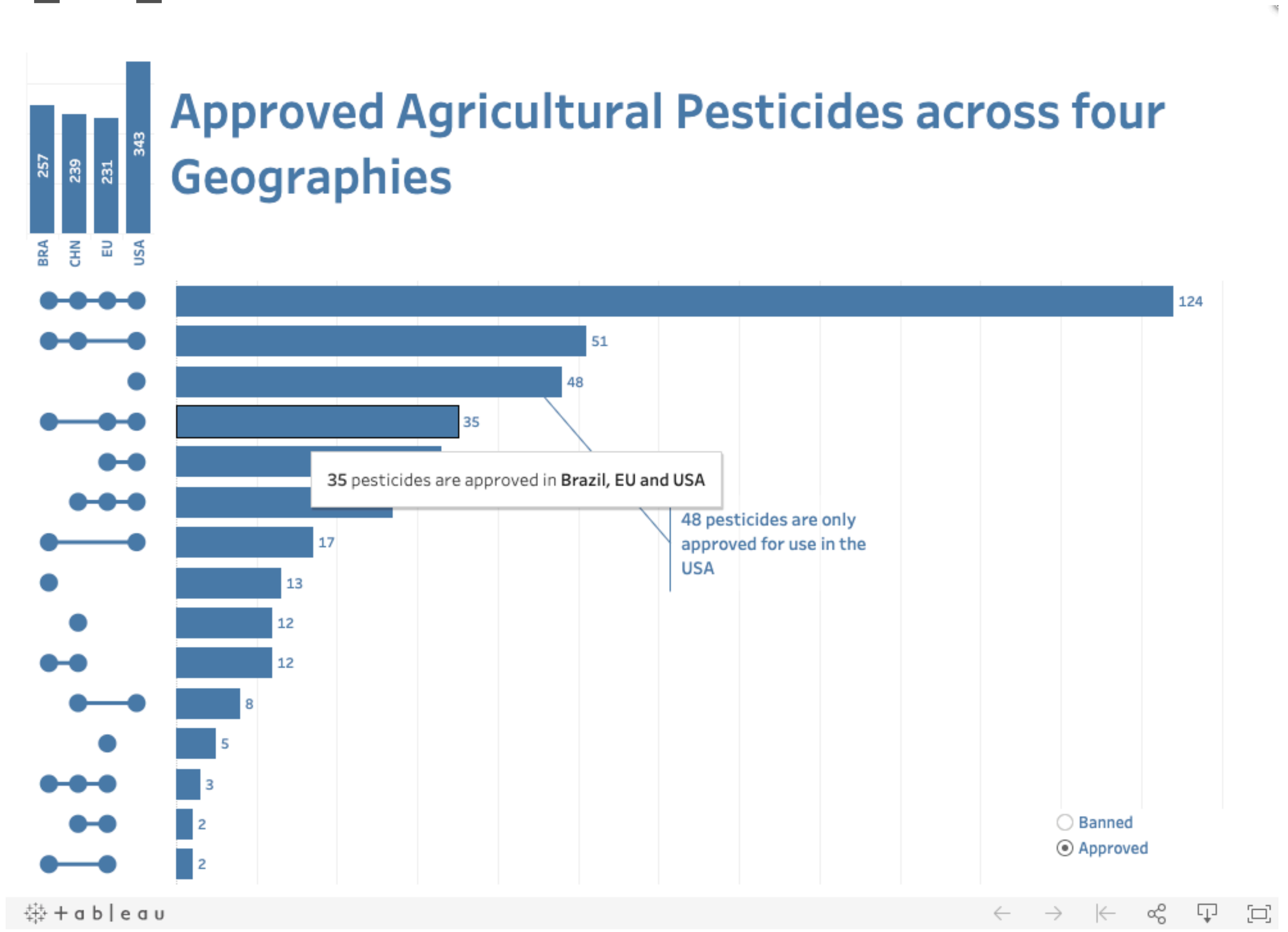
Second-most cited VIS paper of the last decade

> 11 implementations in various languages

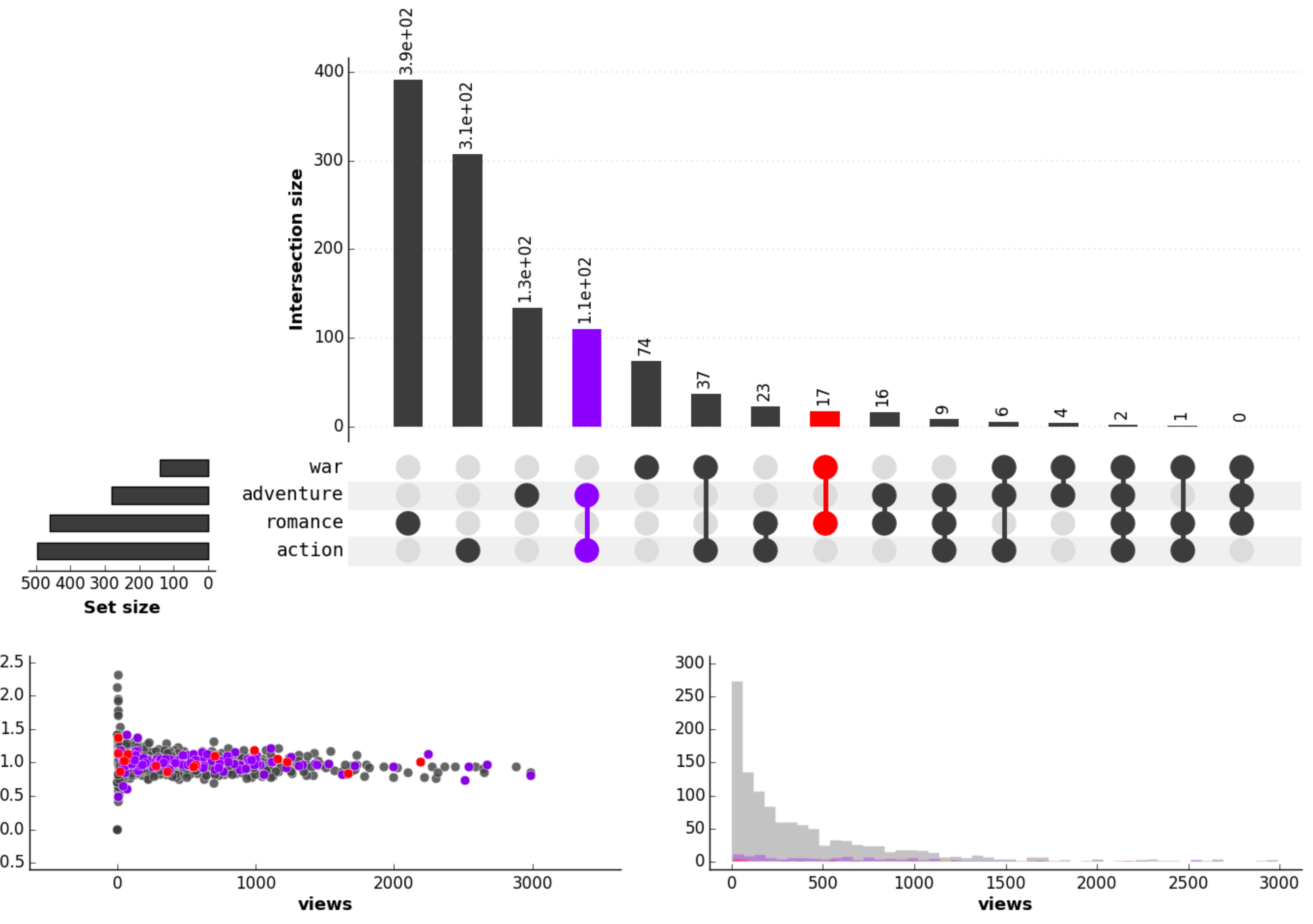
See https://upset.app



R



Tableau



Python

RESEARCH AREAS

TECHNICAL CONTRIBUTIONS

Novel Visualization Techniques

Visualization Process Innovations

Data Wrangling Methods

DOMAIN DRIVEN TECHNIQUES

Tailored Methods and Systems for High Impact Science Problems

EMPIRICAL & THEORETICAL WORK

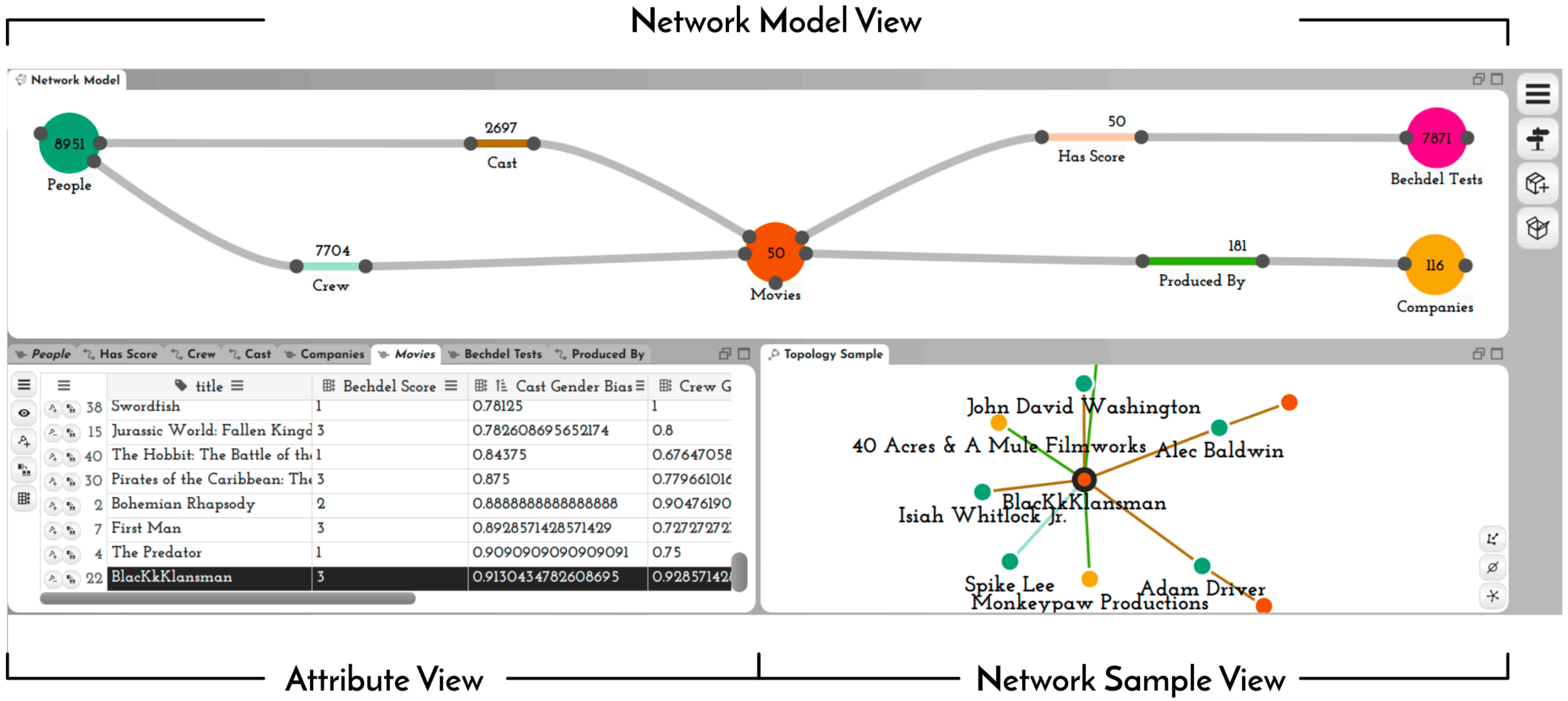
Evaluation Methodology

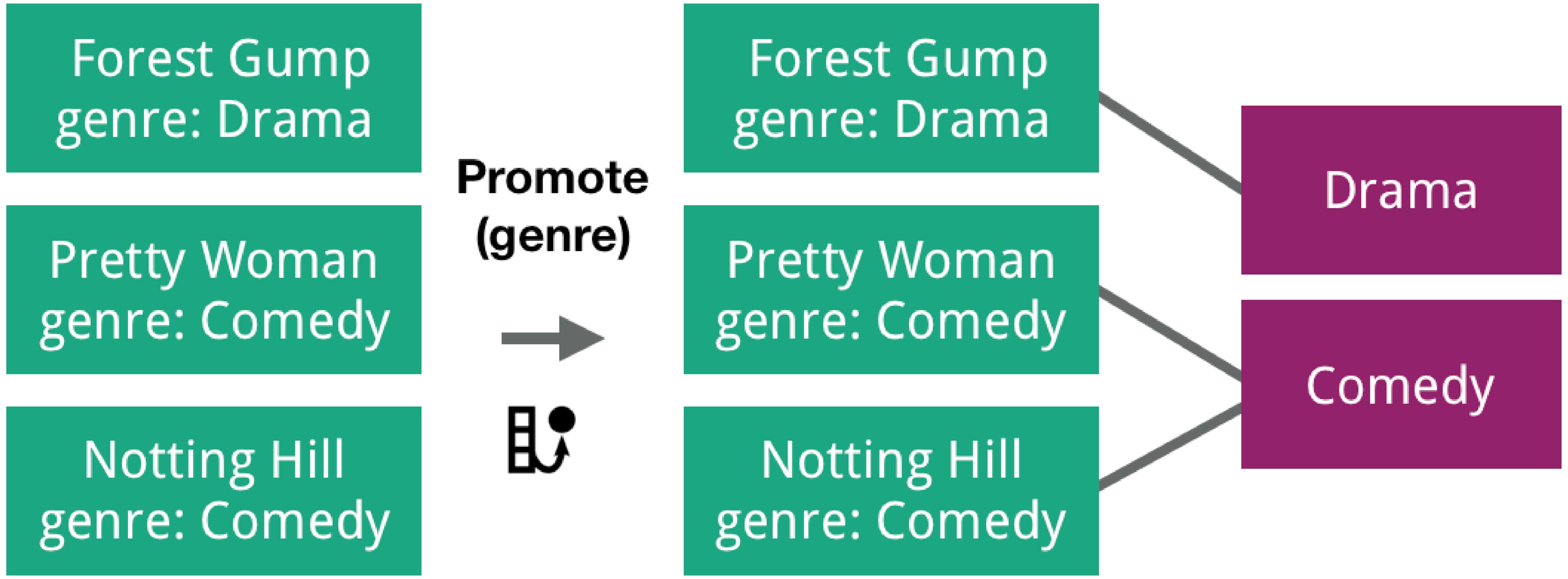
Design Spaces / Taxonomies

TECHNICAL CONTRIBUTIONS

Reshaping Networks

Data Wrangling Methods





TECHNICAL CONTRIBUTIONS

Data Wrangling Methods

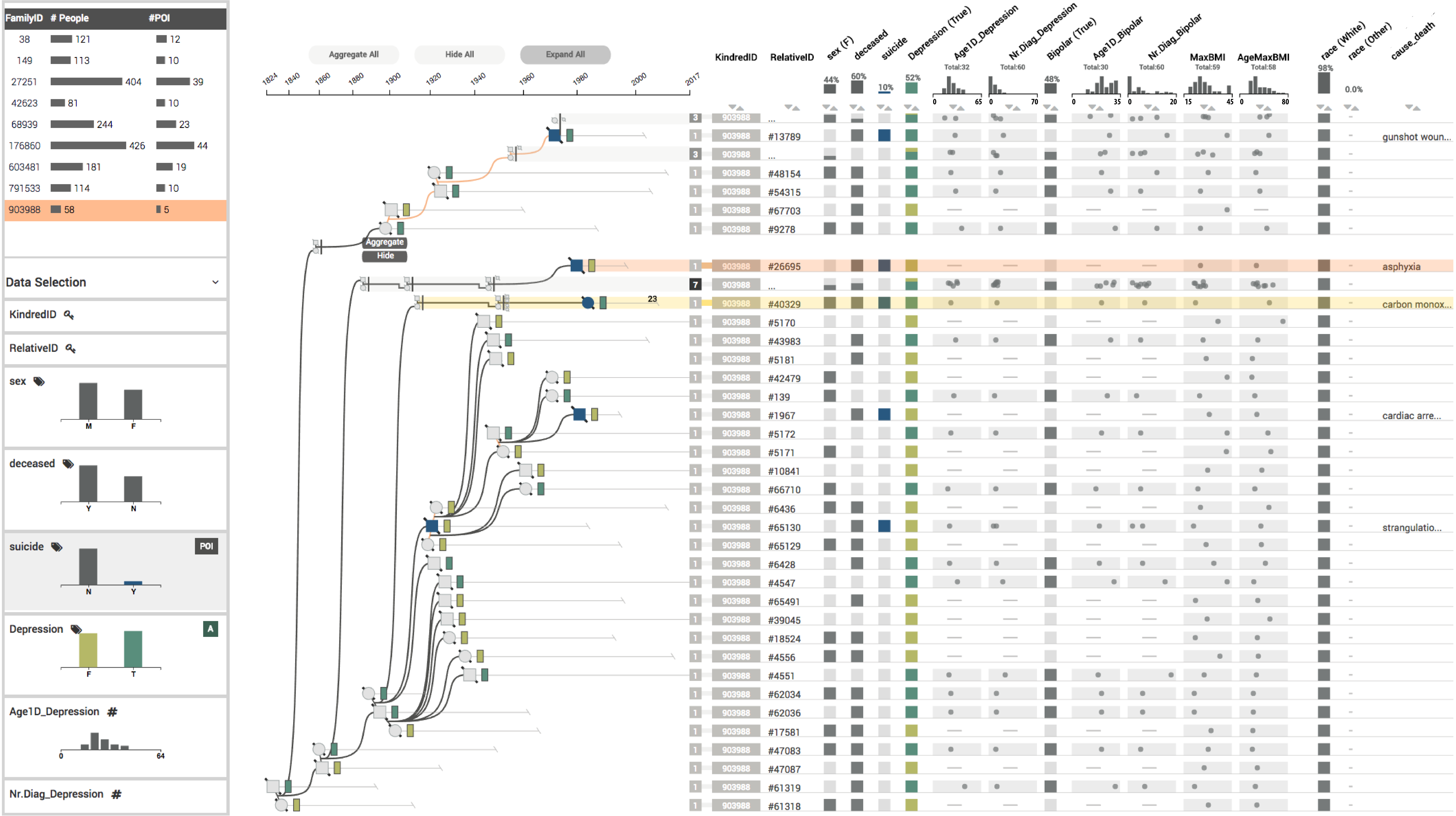
DOMAIN DRIVEN TECHNIQUES

Tailored Methods and Systems for High Impact Science Problems

DOMAIN DRIVEN TECHNIQUES

Genealogies for Clinical Data Analysis

Tailored Methods and Systems for High Impact Science Problems



DOMAIN DRIVEN TECHNIQUES

Tailored Methods and Systems for High Impact Science Problems

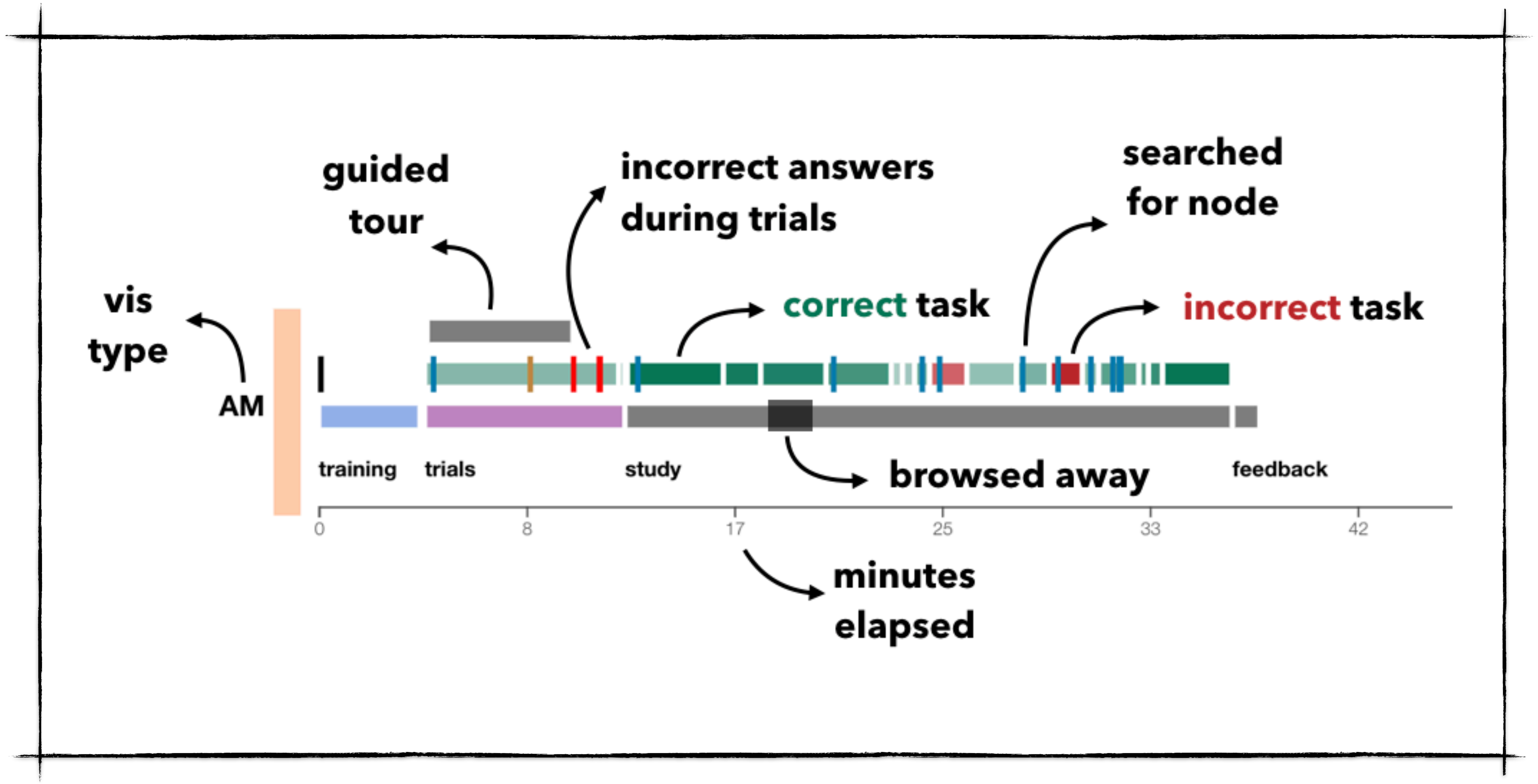
EMPIRICAL & THEORETICAL WORK

Evaluation Methodology

Design Spaces / Taxonomies

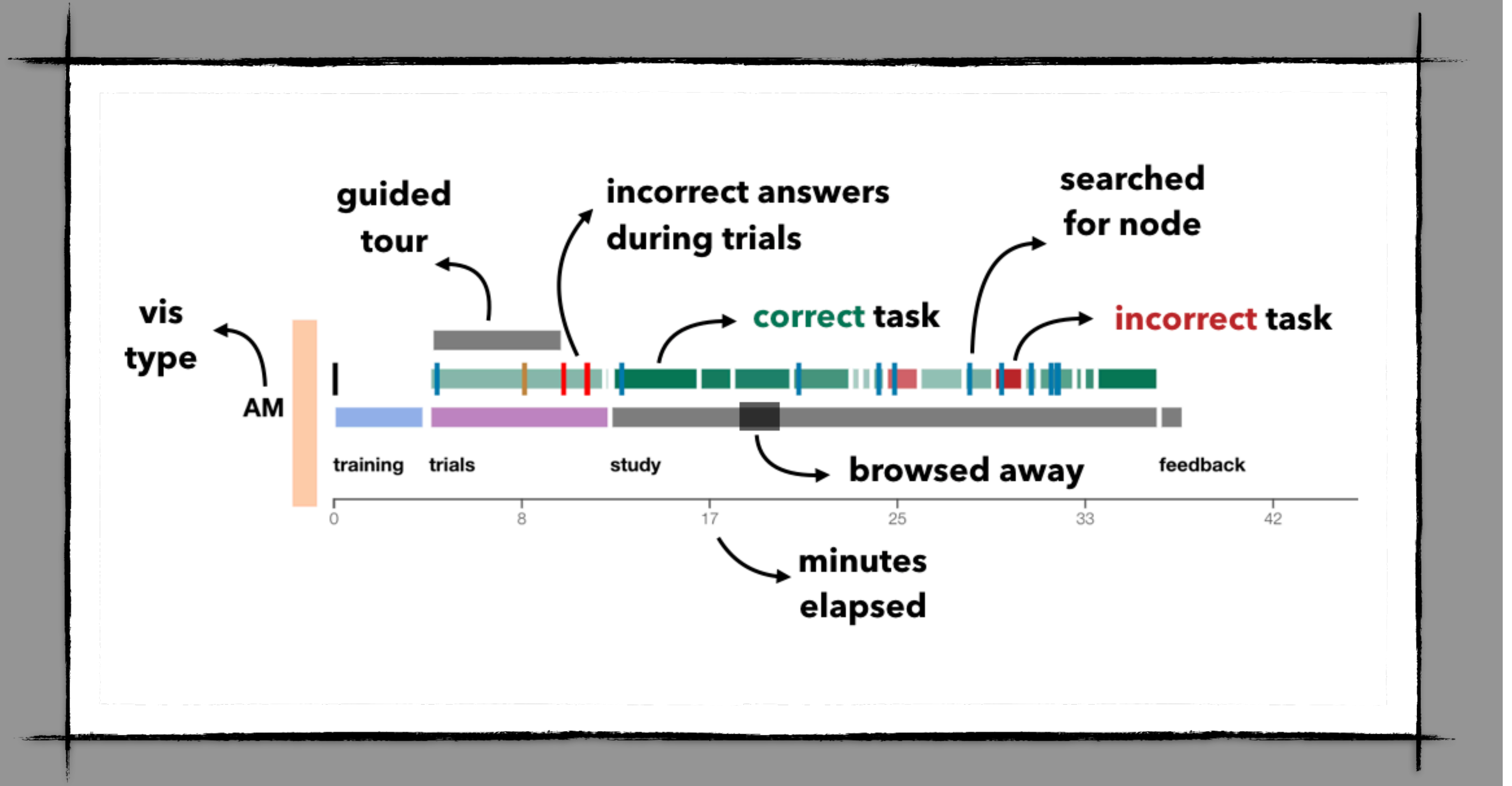
Evaluation Methodology

Design Spaces / Taxonomies



EMPIRICAL & THEORETICAL WORK

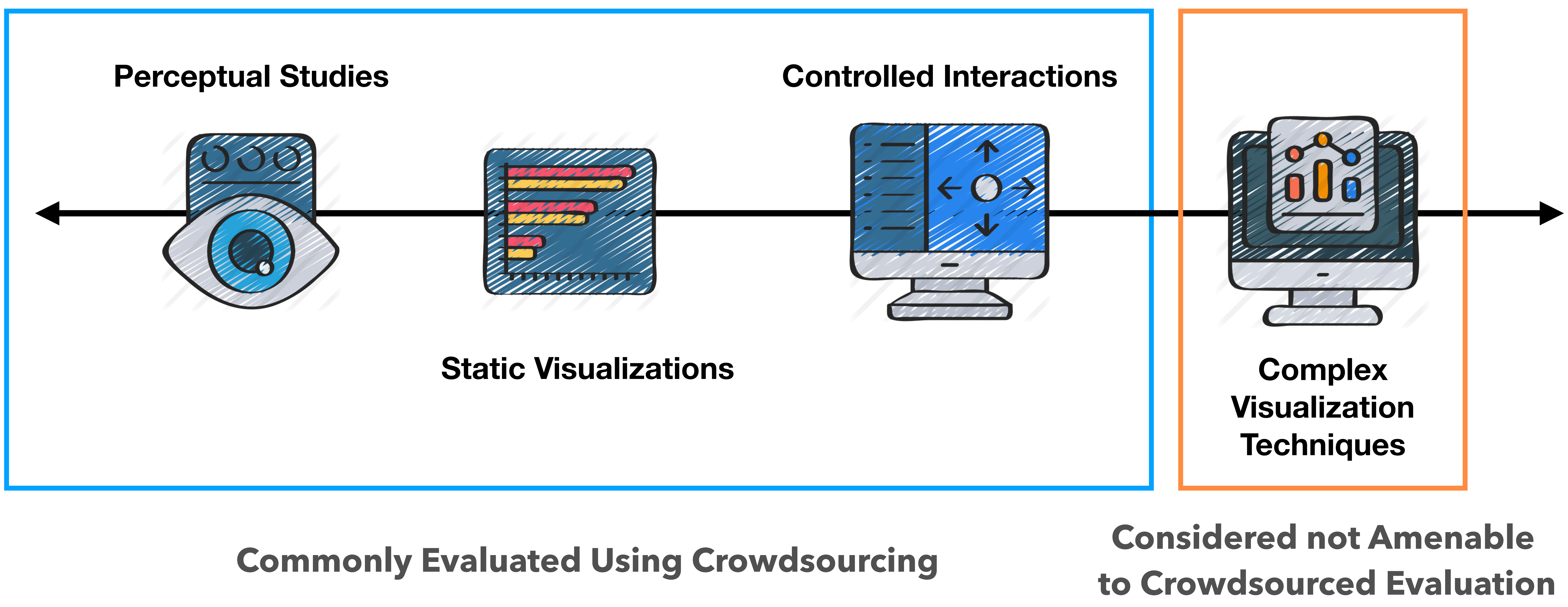
Evaluating Complex Systems



Empirically Evaluating Complex Interactive Visualization Techniques

Carolina Nobre, Dylan Wootton, Lane Harrison

[CHI 2020]


Perceptual Studies
Controlled Interactions
Static Visualizations
Complex Visualization Techniques
Commonly Evaluated Using Crowdsourcing
Considered not Amenable to Crowdsourced Evaluation

Can we use empirical studies to evaluate complex interactive visualizations?

EUROVIS 2019
R. S. Laramee, S. Oeltze, and M. Sedlmair
(Guest Editors)

Volume 38 (2019), Number 3
STAR – State of The Art Report

The State of the Art in Visualizing Multivariate Networks

C. Nobre[1], M. Meyer[1], M. Streit[2], and A. Lex[1]

[1]University of Utah, Utah, USA
[2]Johannes Kepler University Linz, Austria

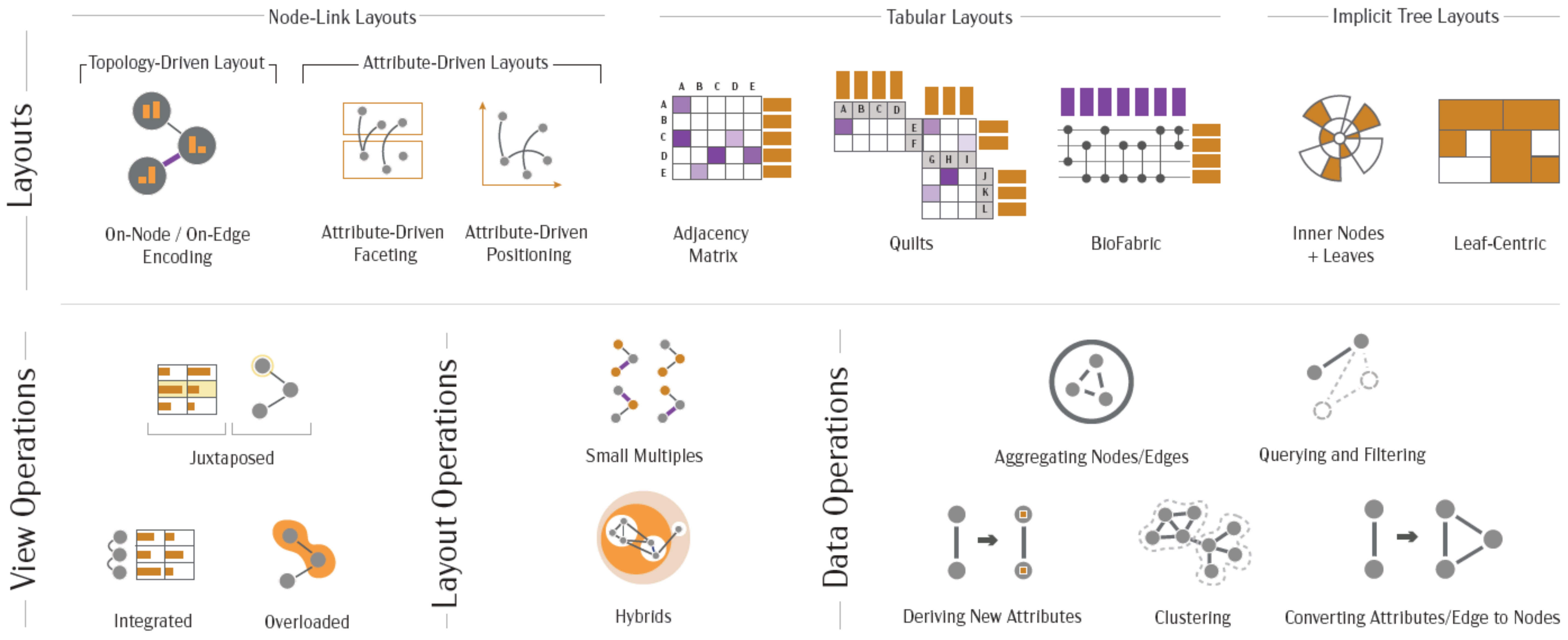


Figure 1: *A typology of operations and layouts used in multivariate network visualization.* ***Layouts*** *describe the fundamental choices for encoding multivariate networks.* ***View Operations*** *capture how topology and attribute focused visualizations can be combined.* ***Layout Operations*** *are applied to basic layouts to create specific visualization techniques.* ***Data Operations*** *are used to transform a network or derive attributes before visualizations. The colors reflect node attributes (orange), edge attributes (purple), and topology (grey).*

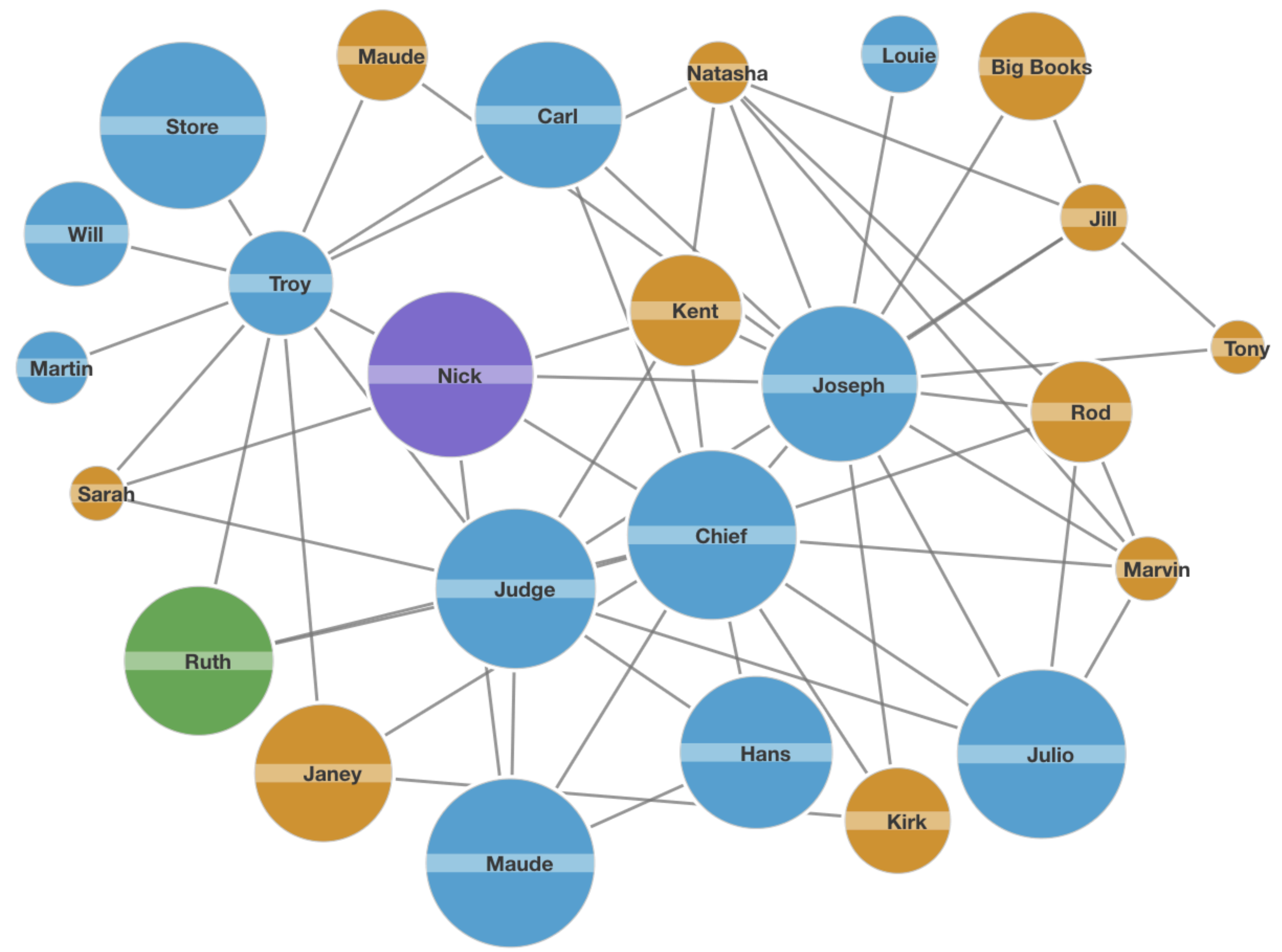
Abstract
Multivariate networks are made up of nodes and their relationships (links), but also data about those nodes and links as attributes. Most real-world networks are associated with several attributes, and many analysis tasks depend on analyzing both, relationsh[illegible] attributes. Visualization of multivariate networks, however, is challenging, especially when both the topology of the netw[illegible] and attributes need to be considered concurrently. In this state-of-the-art report, we analyze current practices and classify techniques along four axes: layouts, view operations, layout operations, and data operations. We also provide an analysis of tasks specific to multivariate networks and give recommendations for which technique to use in which scenario. Finally, we survey application areas and evaluation methodologies.

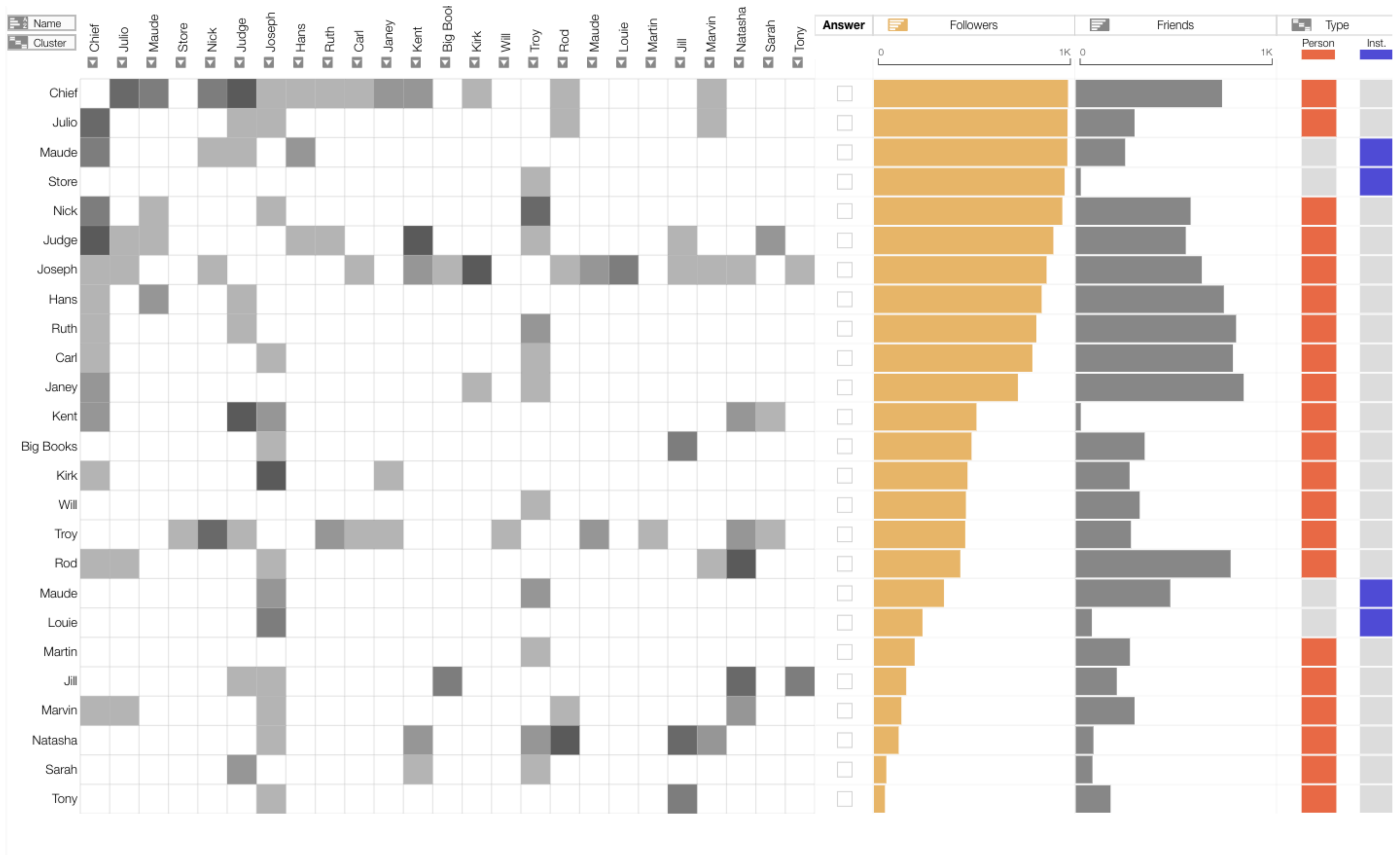
Which is better for which task?

CHALLENGE

CONFOUNDERS

HOW CAN WE MAKE SURE THAT WHAT WE TEST IS WHAT WE CARE ABOUT?





SOLUTION

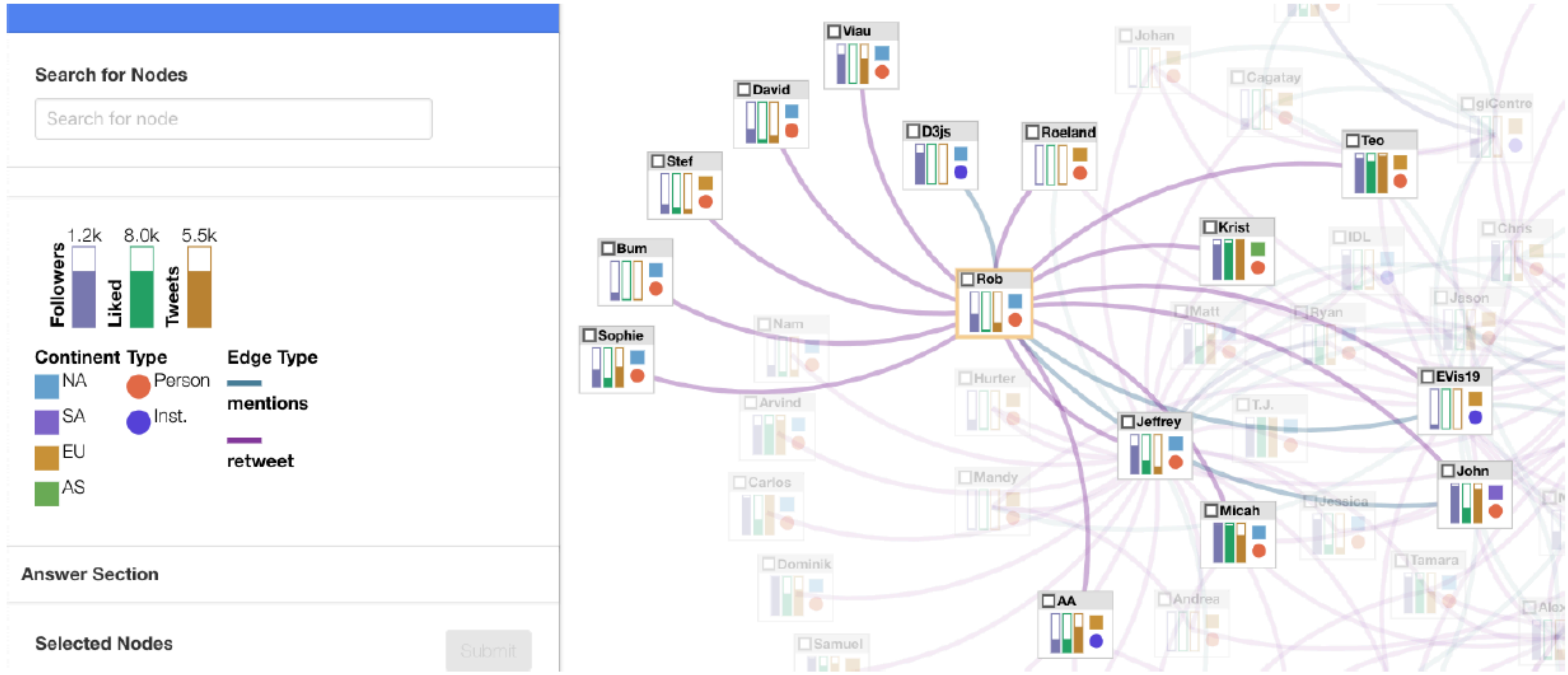
CONFOUNDERS

DESIGN BASED ON EXISTING GUIDELINES AND KNOWLEDGE

VALIDATED & REFINE DESIGN BASED ON EXPERT HEURISTIC EVALUATION

Please rate relative to conceivable design alternatives but assuming a node-link diagram as given.

Nested Bars/Glyphs



26. **Embedded bar charts are well suited to encode multiple numerical attributes.**
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly Disagree	◯	◯	◯	◯	◯	◯	◯	Strongly Agree

27. **Embedded colored glyphs are well suited to encode multiple categorical attributes.**
Mark only one oval.

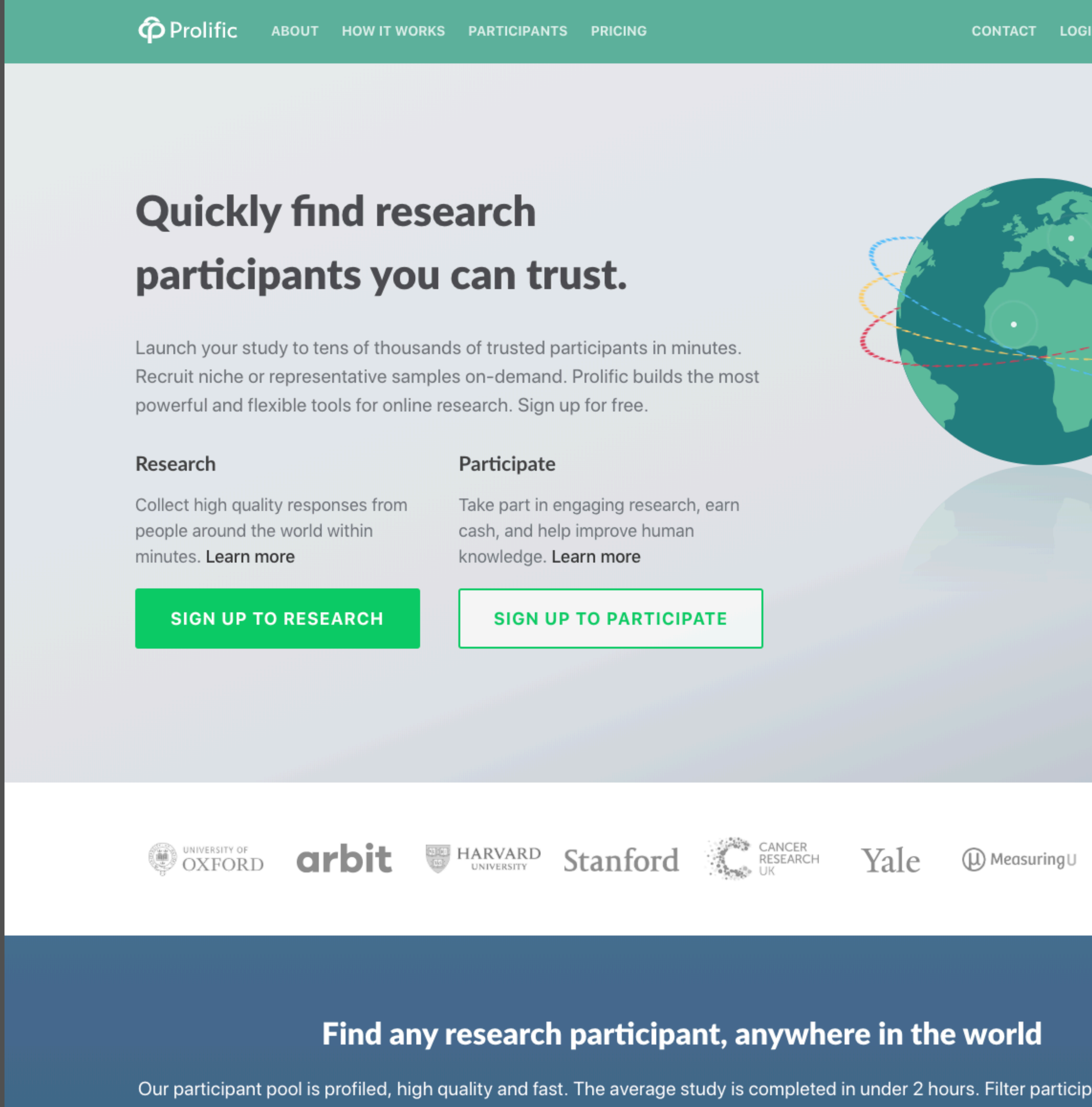
	1	2	3	4	5	6	7	
Strongly Disagree	◯	◯	◯	◯	◯	◯	◯	Strongly Agree

CHALLENGE

SCALE

NEED STATISTICAL POWER

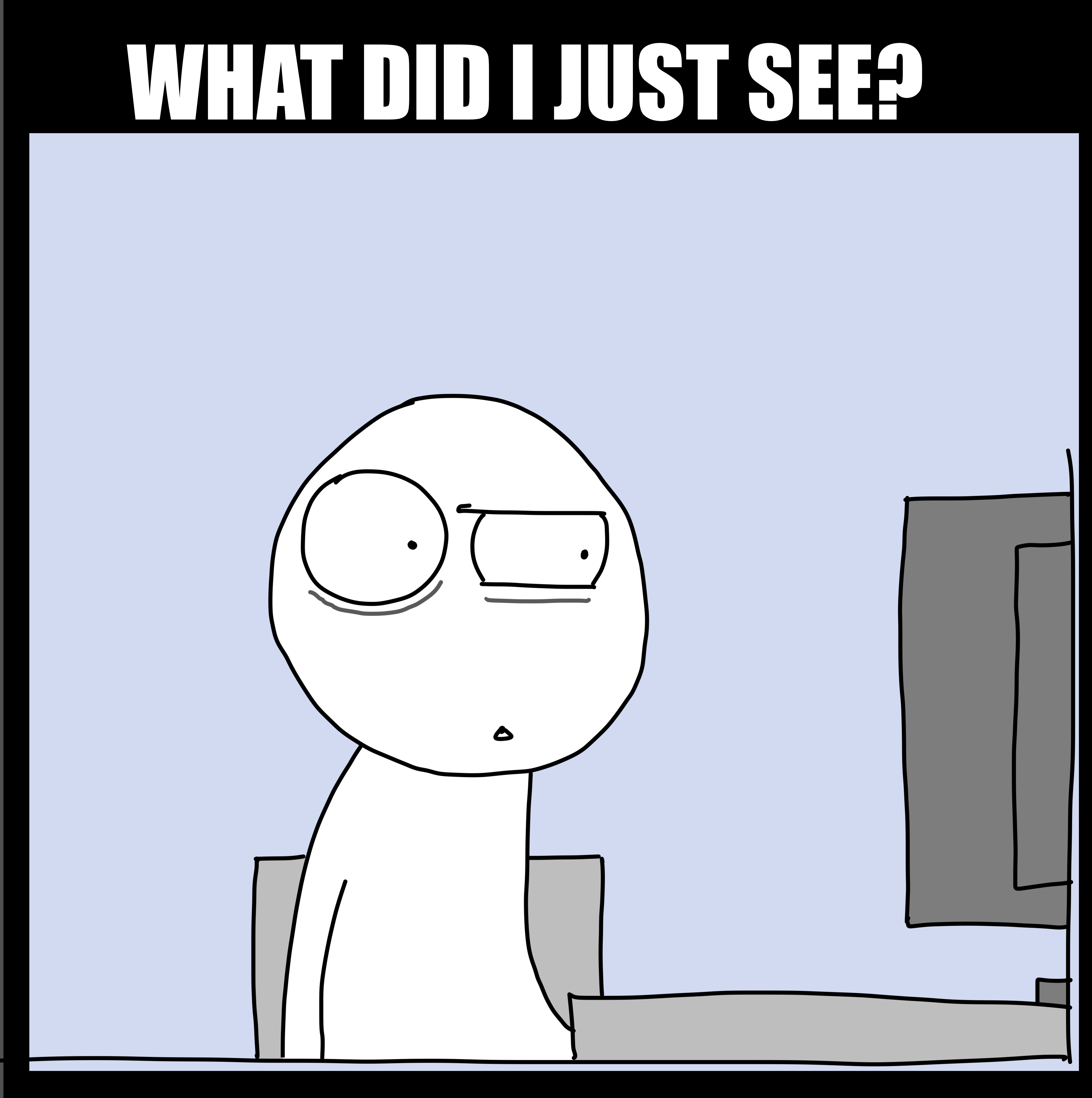
HOW CAN WE DO THIS IN A CROWDSOURCED SETTING?



CHALLENGE

NOVICE USERS

NOVICE USERS DON'T KNOW ABOUT ADVANCED VISUALIZATIONS

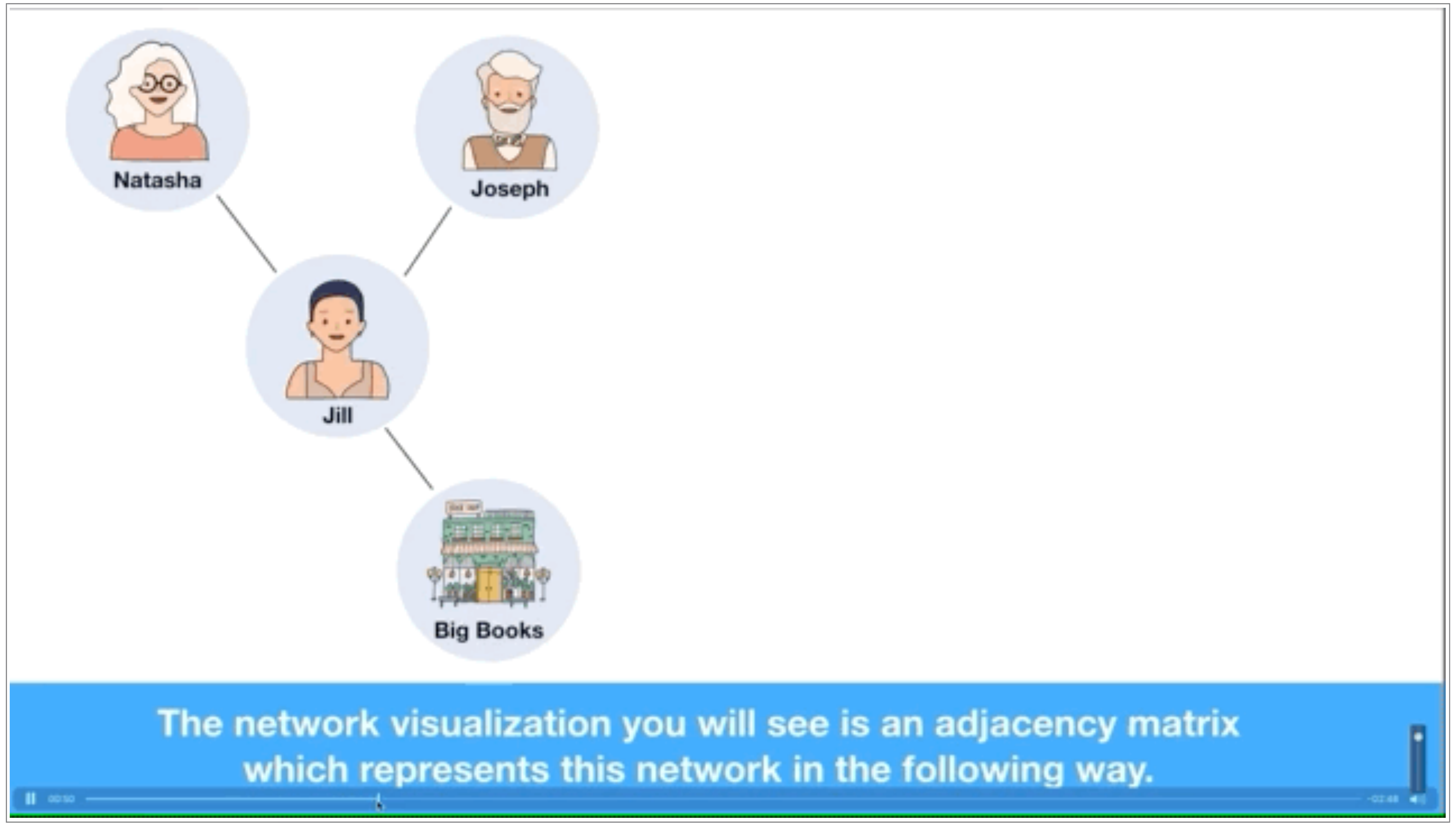


SOLUTION

NOVICE USERS

TRAINING CAN GIVE USERS THE EXPERTISE NECESSARY TO COMPLETE THE TASKS.

Passive Training



SOLUTION

NOVICE USERS

TRAINING CAN GIVE USERS THE EXPERTISE NECESSARY TO COMPLETE THE TASKS.

Active Training

CHALLENGE

INCENTIVES

HOW CAN WE GET USERS
TO TRY HARD

AND

TO PARTICIPATE IN AN EXPERIMENT
THAT TAKES ~1H

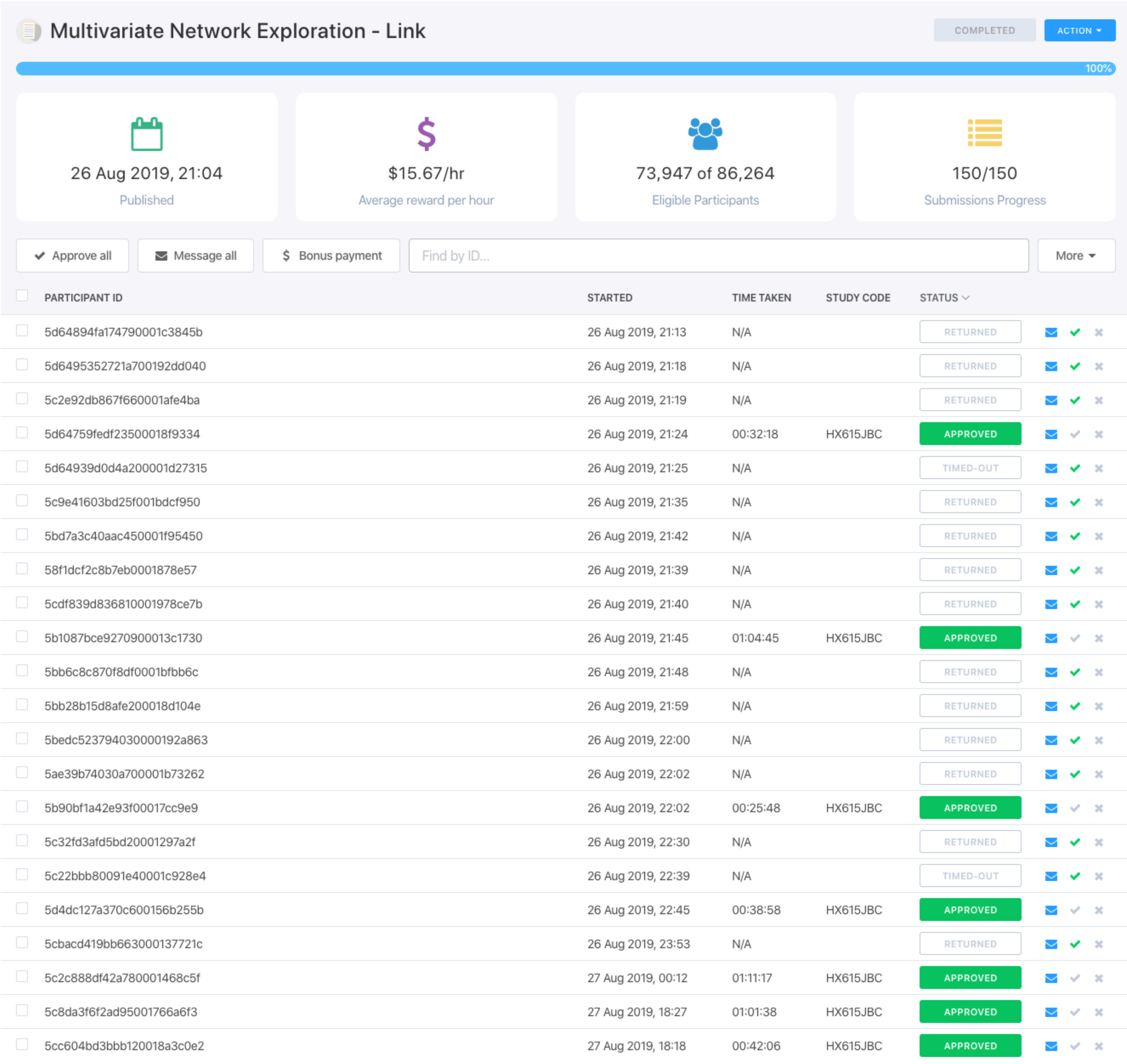
[Alfrey Davilla]

SOLUTION

INCENTIVES

AN INTERESTING PROBLEM

MONEY



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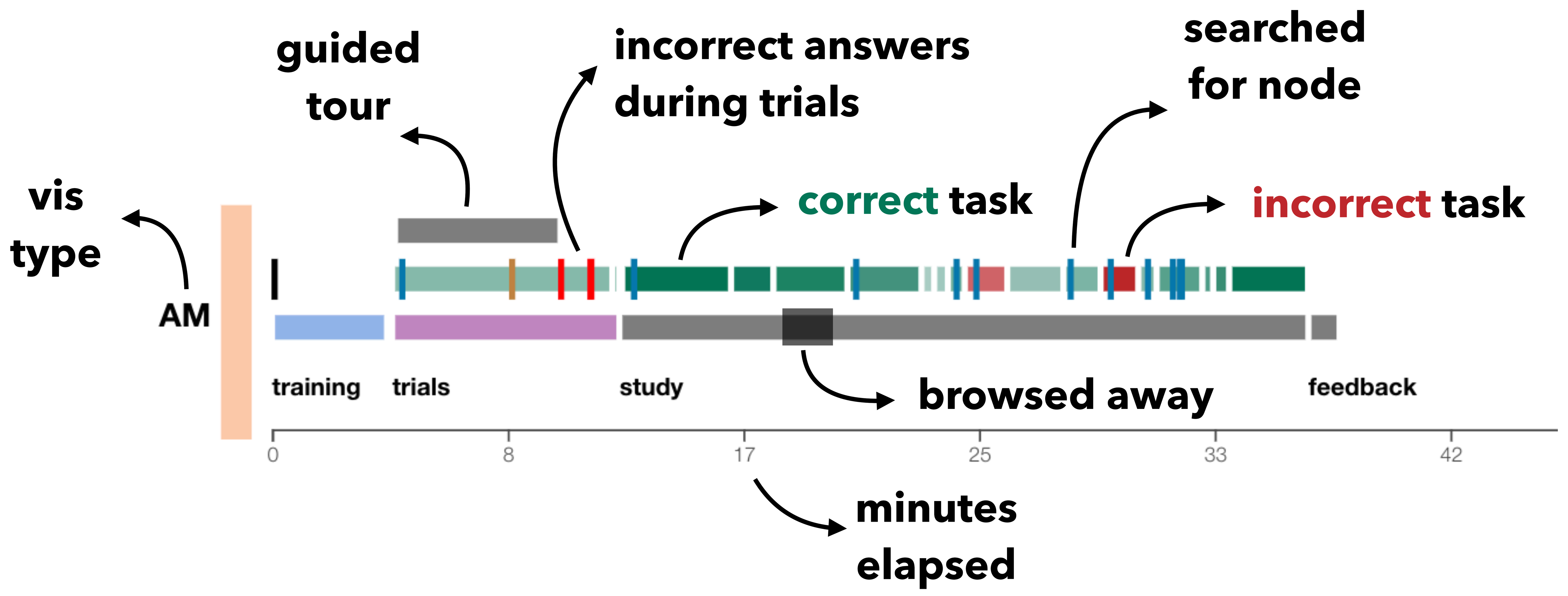
~ $ 4,500 in 2h

VALIDATION

HOW CAN WE MAKE SURE THIS ALL WORKS?

DETAILED PROVENANCE TRACKING

MULTIPLE PILOTS



TRRACK

A library for reproducible tracking

Example Applications

Trrack Provenance Visualization

Tracks "differential state"

Tracks 2 levels:

- **Application State**
- **Study Metadata (responses, etc.)**

https://vdl.sci.utah.edu/trrack/

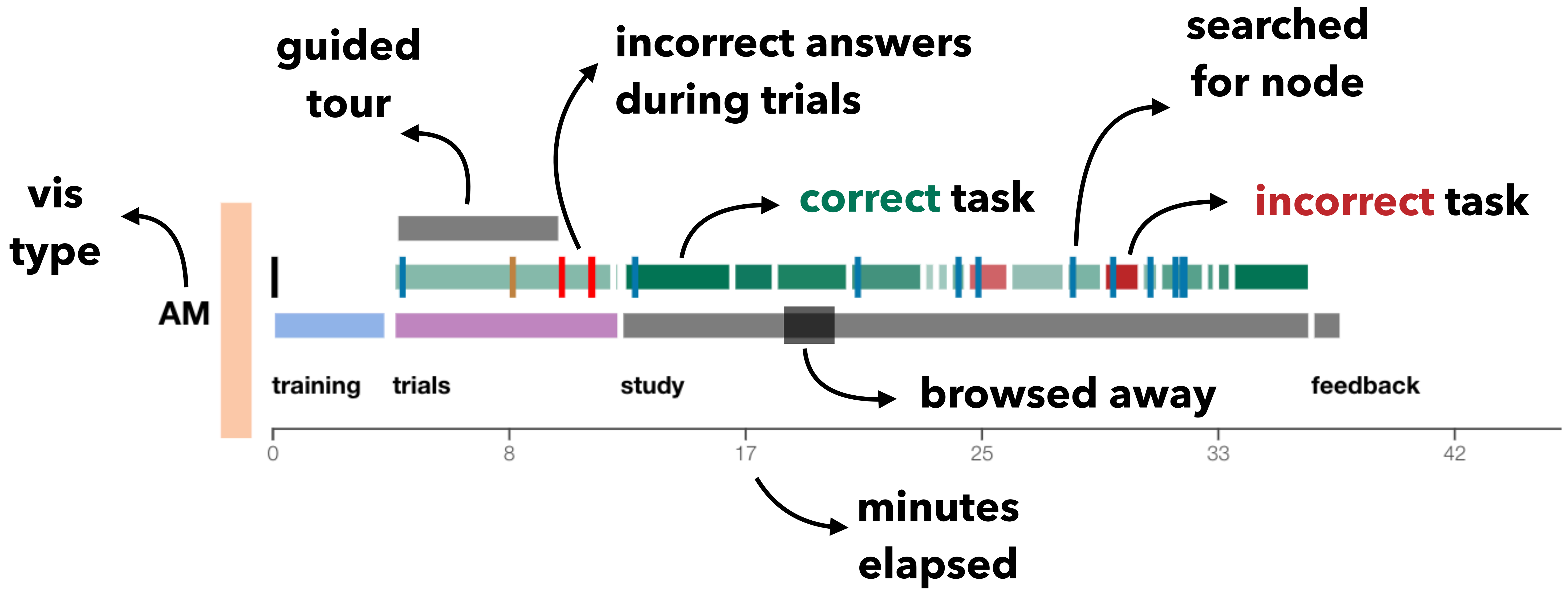
[VIS Short 2020]

PROVENANCE TRACKING

Allows a full re-hyrdrate of every analysis session

- Great for debugging pilots – what went wrong for this person?
- Great for detailed analysis

Provenance data vis to spot problems e.g. with tasks

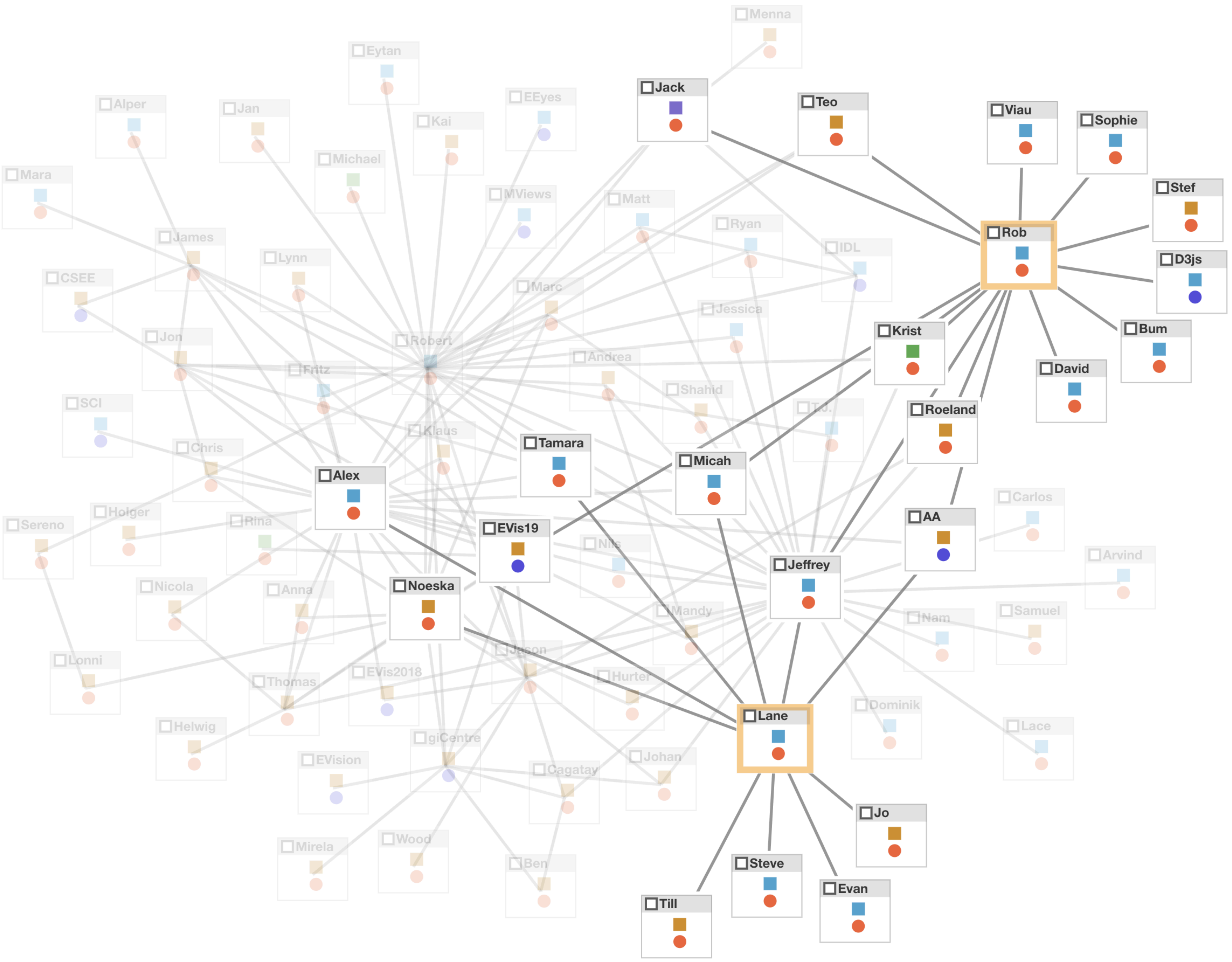


SELECTED RESULTS

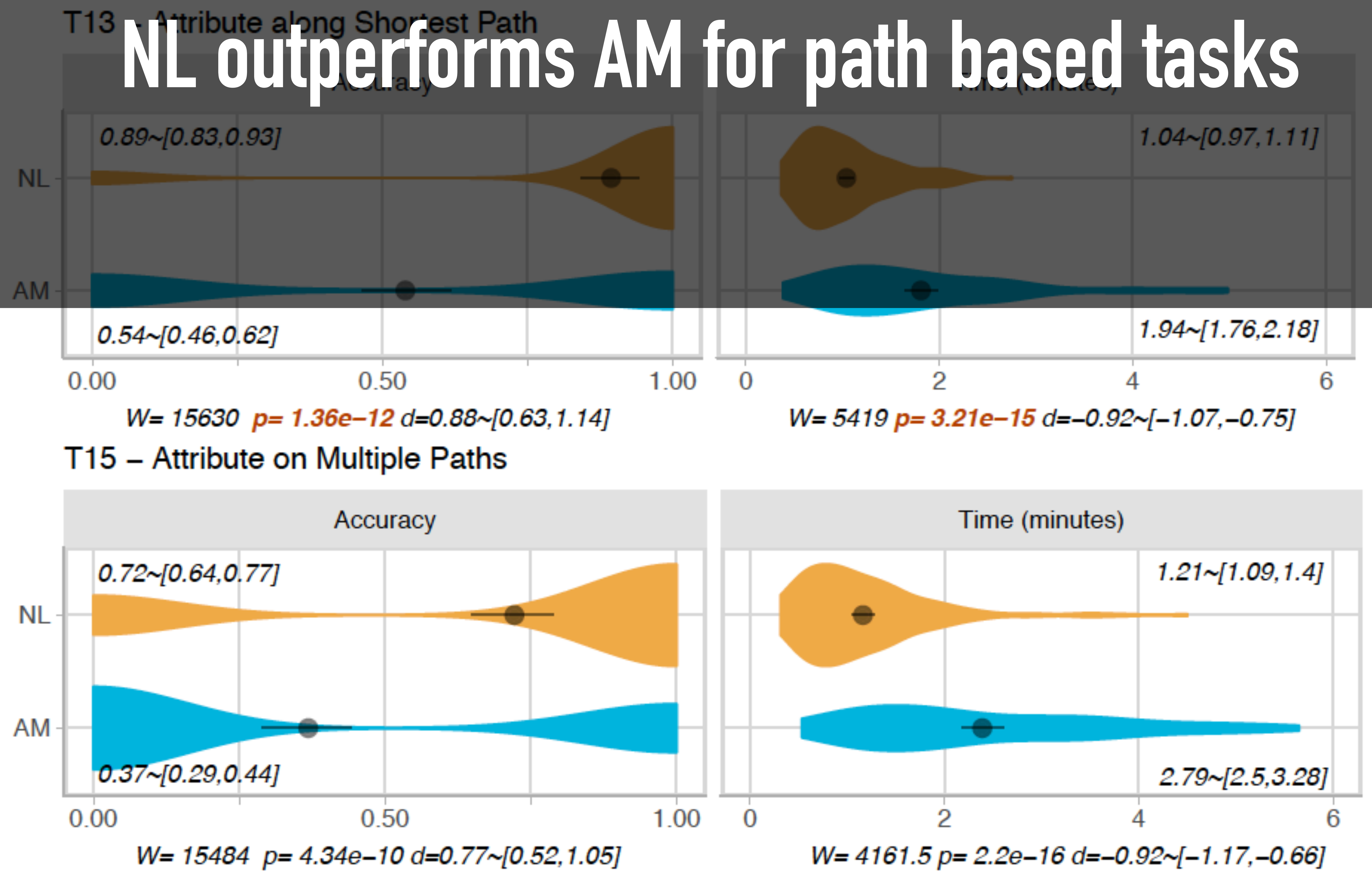

Menna
Eytan
Jack
Teo
Alper
Jan
Kai
EEyes
Viau
Sophie
Mara
Michael
MViews
Matt
Stef
James
Ryan
IDL
Rob
CSEE
Lynn
Marc
D3js
Jessica
Jon
Robert
Krist
Bum
Fritz
Andrea
David
Shahid
SCI
T.J.
Roeland
Klaus
Chris
Tamara
Micah
Alex
Carlos
Sereno
Holger
Rina
EVis19
AA
Nils
Jeffrey
Arvind
Nicola
Anna
Noeska
Mandy
Nam
Samuel
Lonni
Thomas
EVis2018
Jason
Hurter
Dominik
Helwig
Lane
Lace
giCentre
EVision
Cagatay
Johan
Jo
Mirela
Wood
Ben
Steve
Evan
Till
Name
Cluster
Likes
Followers
Tweets
Acct. Age
Type
Continent
0
8K
0
1K
0
6K
175
4K
Person
Inst.
NA
SA
EU
AS

PATHS

Is NL or AM better for Path Tasks?



NL outperforms AM for path based tasks



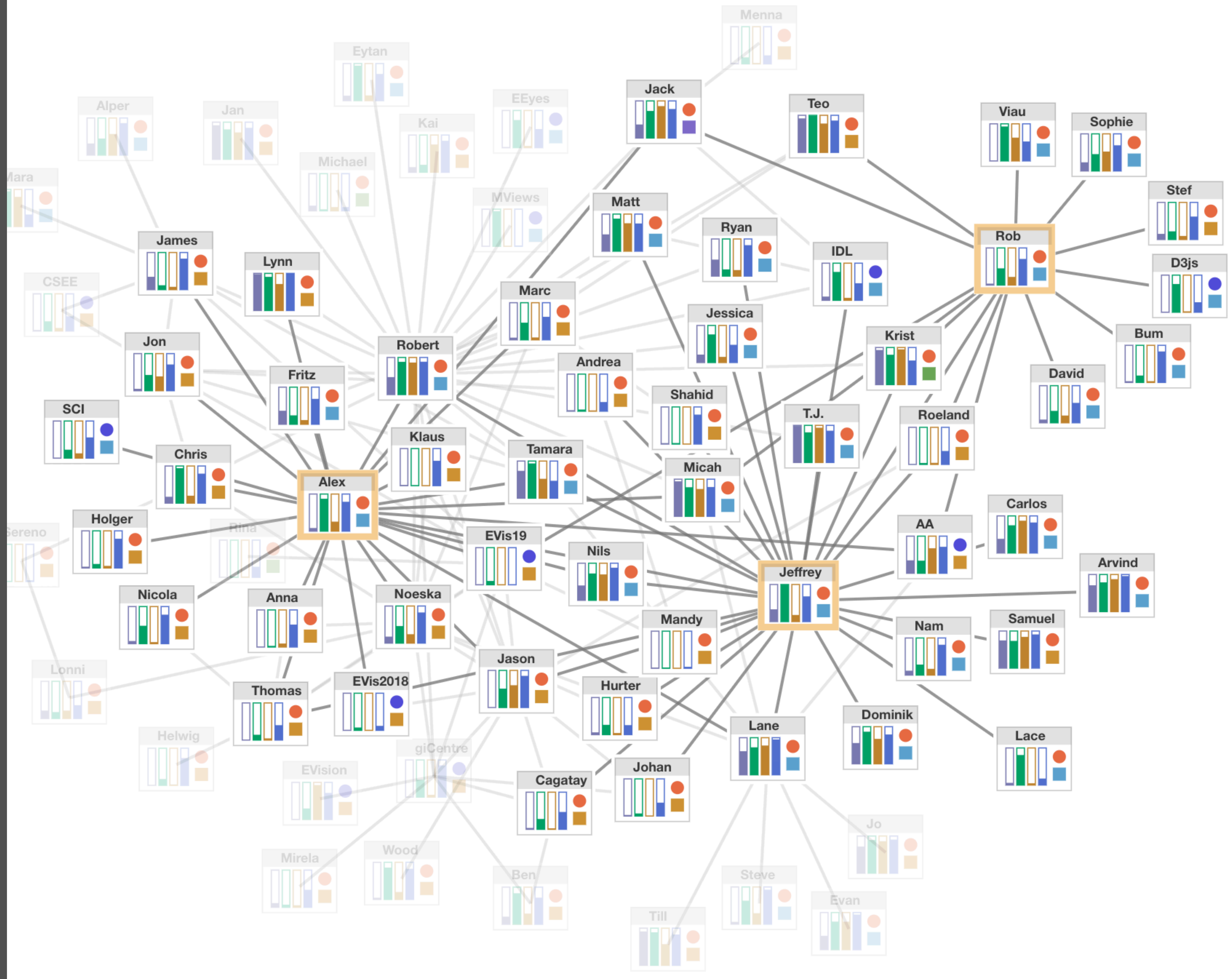
What types of insight do NL and AM representations support?

ATTRIBUTE OVERVIEW

"INSTITUTIONS HAVE MUCH FEWER TWEETS IN GENERAL THAN PERSON ACCOUNTS"

TOPOLOGY–ATTRIBUTE

"IT DOES SEEM A BIT ODD THAT JEFFREY ALEX AND ROB HAVE SUCH LARGE NETWORKS WITH THEIR LOWER THEN AVERAGE TWEETING."



RECAP

CAN WE DO QUANTITATIVE EVALUATION WITH COMPLEX SYSTEMS?

Yes We Can!

- Picking the right techniques
- Evidence-based design
- Design validation
- Careful training
- Good compensation
- Interesting Tasks

Pushing the boundary of what can be evaluated using crowdsourcing

CAVEATS / THOUGHTS

Should this be the new gold standard to evaluate systems?

NO!

Needs established techniques

Needs specifically designed and instrumented systems

Our instrumentation can be used broadly

ADVANCED ANALYSIS OF STUDY DATA

[CHI 21]

INSTRUMENTED STUDIES

What else can we do with this rich data?

Do different analysis strategies result in different results?

Participant A   Participant B

How do **analysis strategies** impact **user performance** when using interactive visualizations?


Pilot Iterations
Study Design
Instrumentation
User Study
Data Analysis
Analysis Outcomes

Pilot Iterations
Study Design
Instrumentation
User Study
Data Analysis
reVISit
2.5
7.1
3.5
TIME
ORDER
CONFIDENCE
Quantitative Analysis
Sequence Aggregation
Event Sequence Mining
most important nodes in the graph.
Interesting Pattern
Qualitative Analysis
Event Playback in Study
Analysis Outcomes


Data Analysis
reVISit
2.5
7.1
3.5
TIME
ORDER
CONFIDENCE
Quantitative Analysis
Sequence Aggregation
Event Sequence Mining
Interesting Pattern
most important nodes in the graph.
Qualitative Analysis
Event Playback in Study
Ana

FUTURE WORK: BETTER SCAFFOLDING FOR STUDIES

reVISit: Scalable Empirical Evaluation of Interactive Visualizations

Community Input

Collaborators
Core Community
Community Workshops
Broader Community

User Services and Resources

Documentation / Examples
Replications
Community Engagement

Inform Software Development

Synergistic Activities

Core Infrastructure: Software Components

New Component — Prototype — Robust

Aim 1: Study Infrastructure and Multilevel Instrumentation

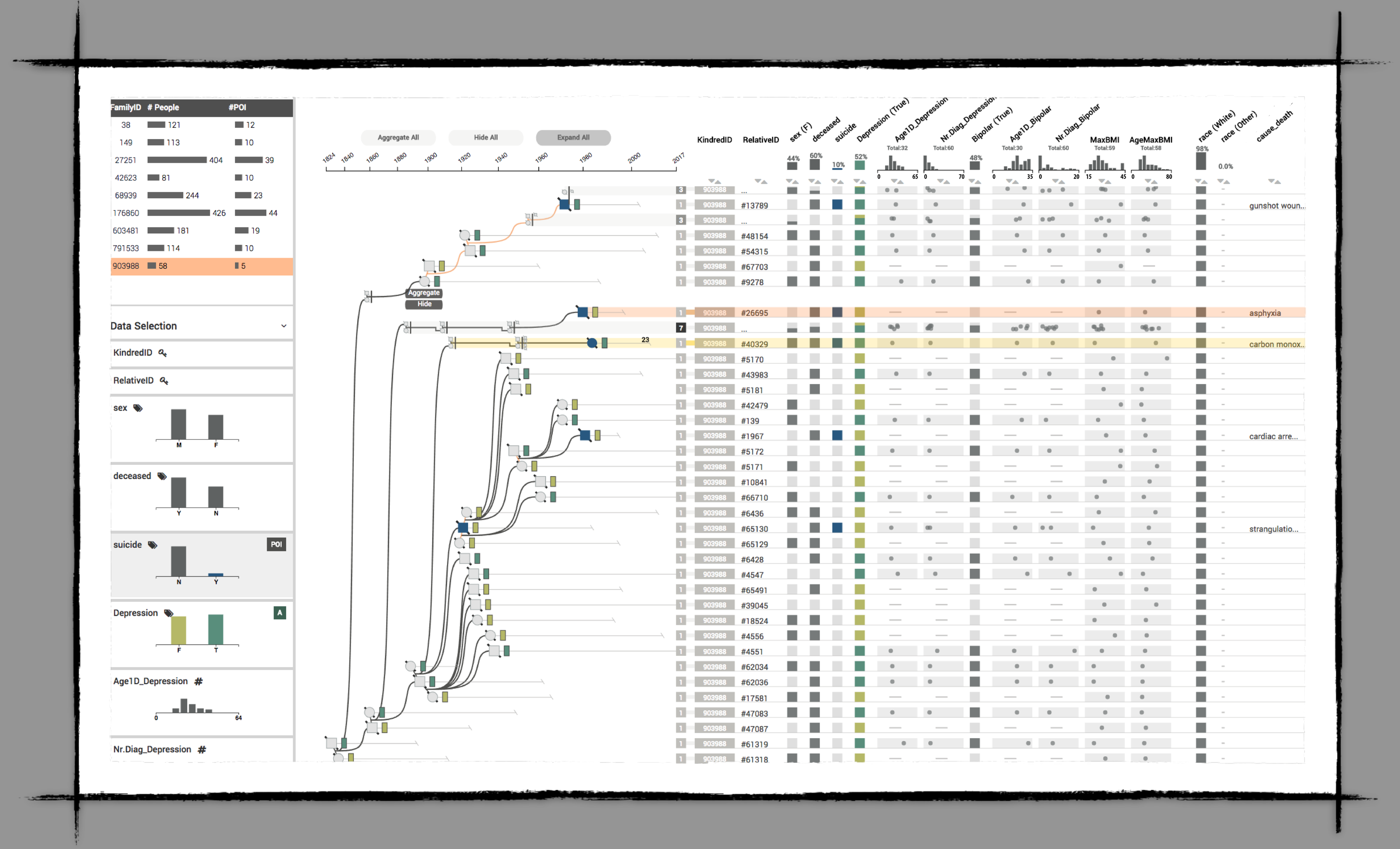
Study Scaffolding
Integration with Crowdsourcing Platforms
Component Registry
Capturing Insights / Rationale
Provenance Tracking
Designing Trainings

Aim 2: Data Transformation and Visualization Methods

Data Transformation
Event Sequence Visualization
Trials Visualization
Study Results Visualization
Study Replay Interface
Qualitative Coding Tools

DOMAIN DRIVEN TECHNIQUES

Clinical Genealogies



LINEAGE:

VISUALIZING CLINICAL DATA IN GENEALOGY GRAPHS

Carolina Nobre, Nils Gehlenborg, Hilary Coon, Alexander Lex


THE WORLD HEALTH
ORGANIZATION ESTIMATES
ONE PERSON DIES OF
SUICIDE EVERY 40 SECONDS

SUICIDE IS THE SECOND LEADING CAUSE OF DEATH

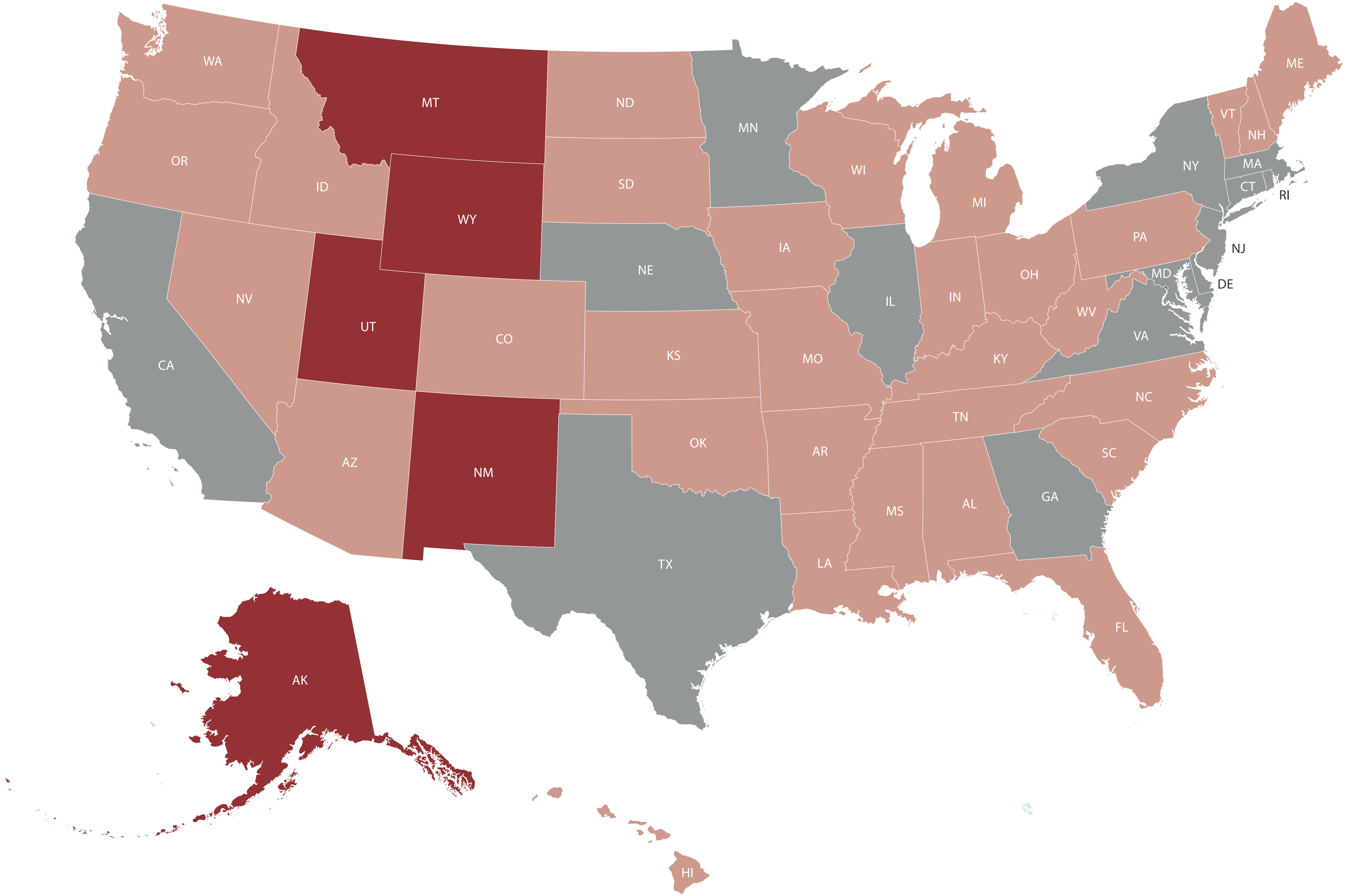
IN YOUTHS BETWEEN 15 AND 29 YEARS OLD

AVERAGE SUICIDE RATE BY STATE
(National average 13.26 per 100,000)

Top 5 states with the highest suicide rates

States with suicide rates above the national average

States with suicide rates below the national average



AVERAGE SUICIDE RATE BY STATE
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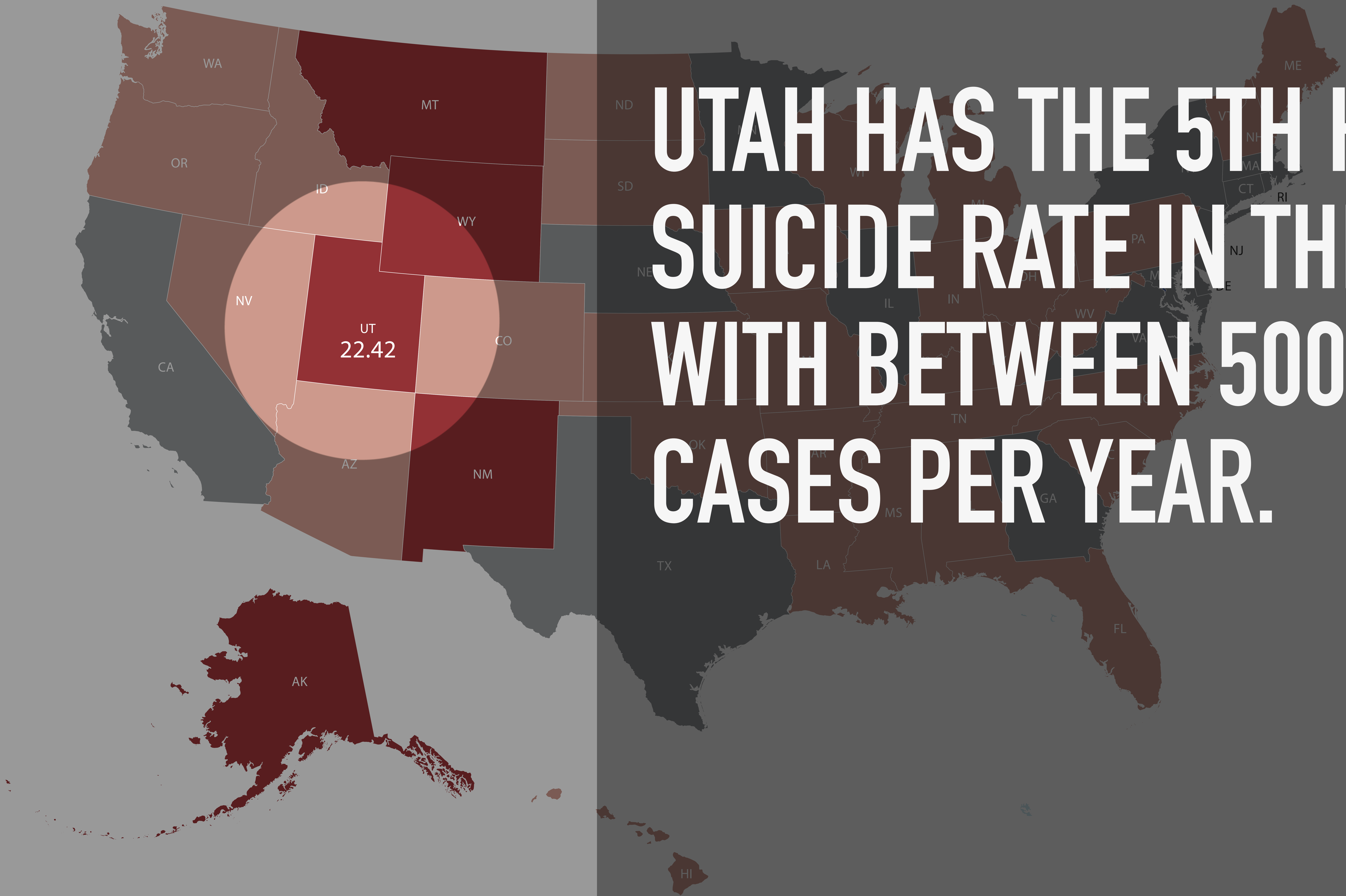


UTAH HAS THE 5TH HIGHEST SUICIDE RATE IN THE COUNTRY, WITH BETWEEN 500–600 CASES PER YEAR.

American Journal of Epidemiology
Vol. 181, No. 5
DOI: 10.1093/aje/kwu341
Advance Access publication: February 10, 2015

Original Contribution

Acute Air Pollution Exposure and Risk of Suicide Completion

er, Hilary Coon, Douglas Gray, Phillip Wilson,
nshaw

artment of Psychiatry, School of Medicine, University of Utah, 650 Komas Drive, Suite 206,
@hsc.utah.edu).

for publication August 11, 2014.

OPEN

Citation: Transl Psychiatry (2013) **3**, e325; doi:10.1038/tp.2013.100

www.nature.com/tp

ORIGINAL ARTICLE

Genetic risk factors in two Utah pedigrees at high risk for suicide

H Coon[1], T Darlington[1], R Pimentel[2], KR Smith[2,3], CD Huff[4], H Hu[4], L Jerominski[1], J Hansen[1], M Klein[5], WB Callor[6], J Byrd[6], A Bakian[1], SE Crowell[1,7], WM McMahon[1], V Rajamanickam[8], NJ Camp[8], E McGlade[1,9], D Yurgelun-Todd[1,9], T Grey[6] and D Gray[1,9]

We have used unique population-based data re
over twice that expected from demographically
two high-risk pedigrees. In the first of these (pe
death was 30.95. In the second (pedigree 5), 7/5
decedents in pedigree 12 and nine in pedigree
analyzed using the Variant Annotation, Analysis,
functional impact of the DNA variation, aggrega
prioritized variants that were: (1) shared across
(3) ⩽ 5% in genotyping data from 398 other Ut
from 1358 controls and/or in dbSNP. Results in
FAM38A and *HRCT1* for pedigree 5). Other gene

The Role of Social Isolation in Suicide

Deborah L. Trout M.A.

First published: Spring 1980 | https://doi-org.ezproxy.lib.utah.edu/10.1111/j.1943-278X.1980.tb00693.x

The author wishes to thank Dr. Charles Neuringer for his assistance with the preparation of this manuscript.

MOTIVATION & DATA

Understand **Complex Conditions**

Discover **Genetic Risk Factors**

Dataset:

118k people, 19k suicide cases, ~2k with genomic data, 550 families

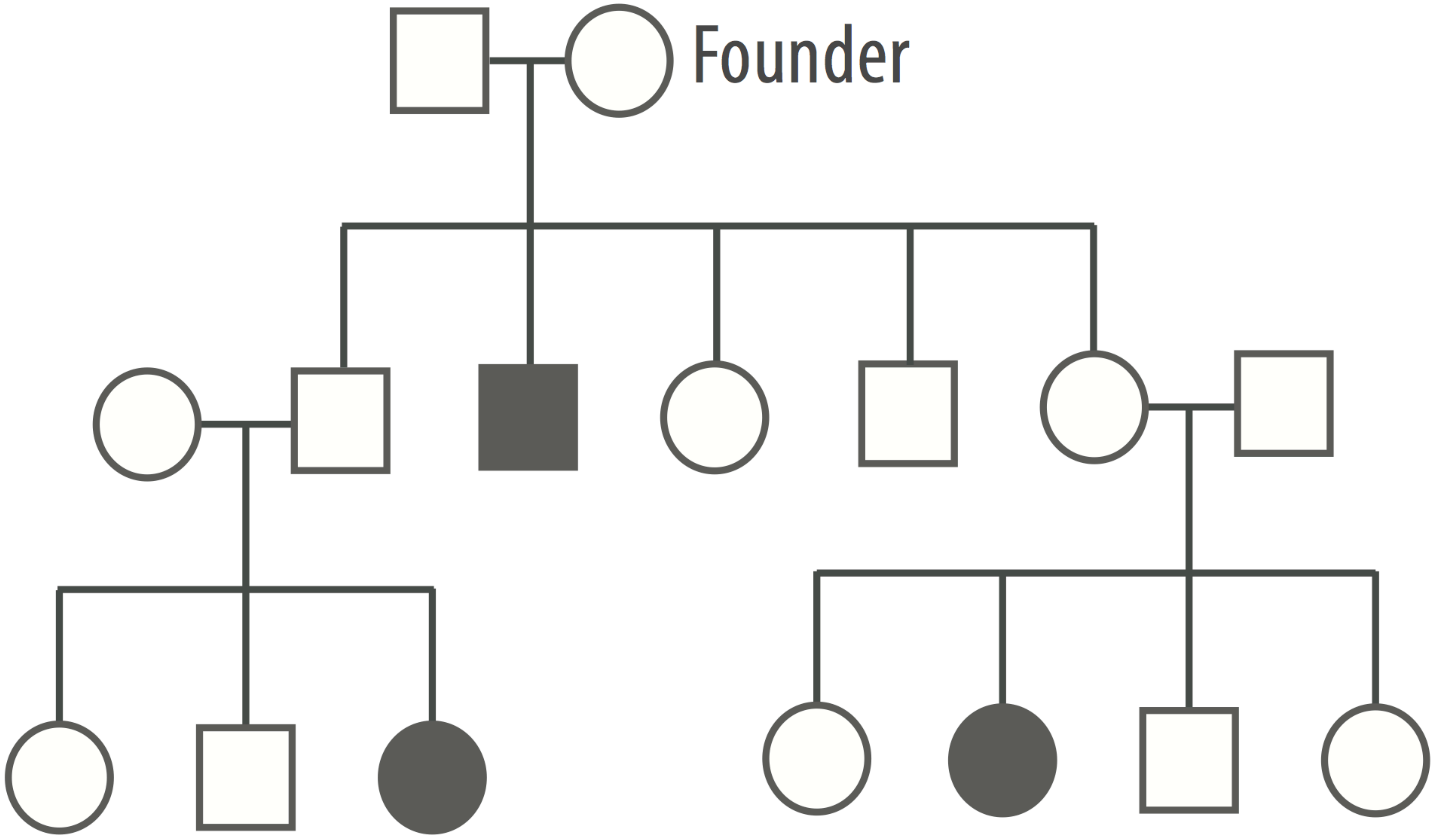
Based on **Utah Population Database**

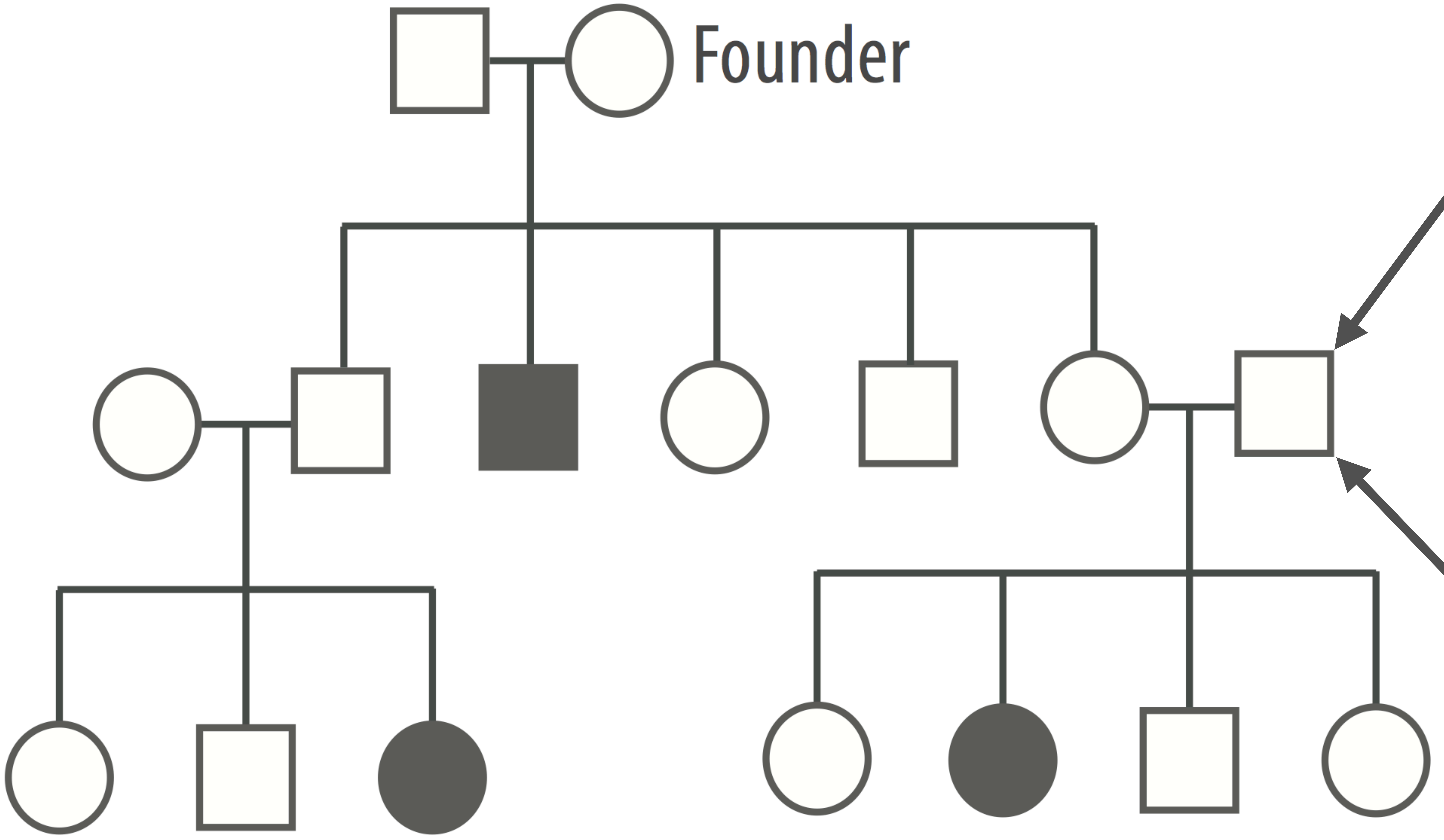
SPECIFIC GOALS

Find familial cases that also have an "interesting" phenotype
e.g., predominantly female, associated with rare psychiatric disease, etc.

Prioritize those cases for analysis of shared genomic sequences

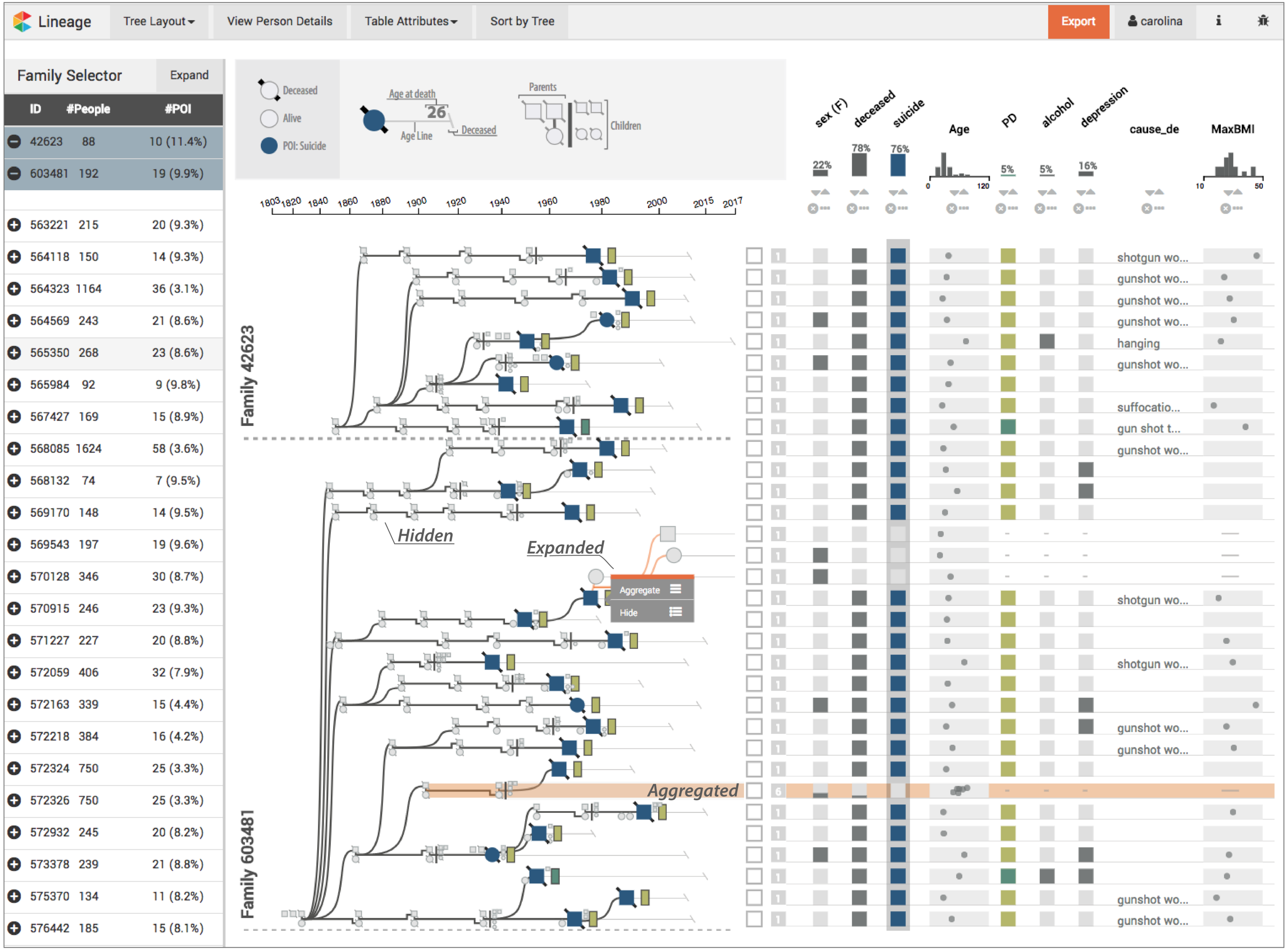
Proofread the Data!


Founder

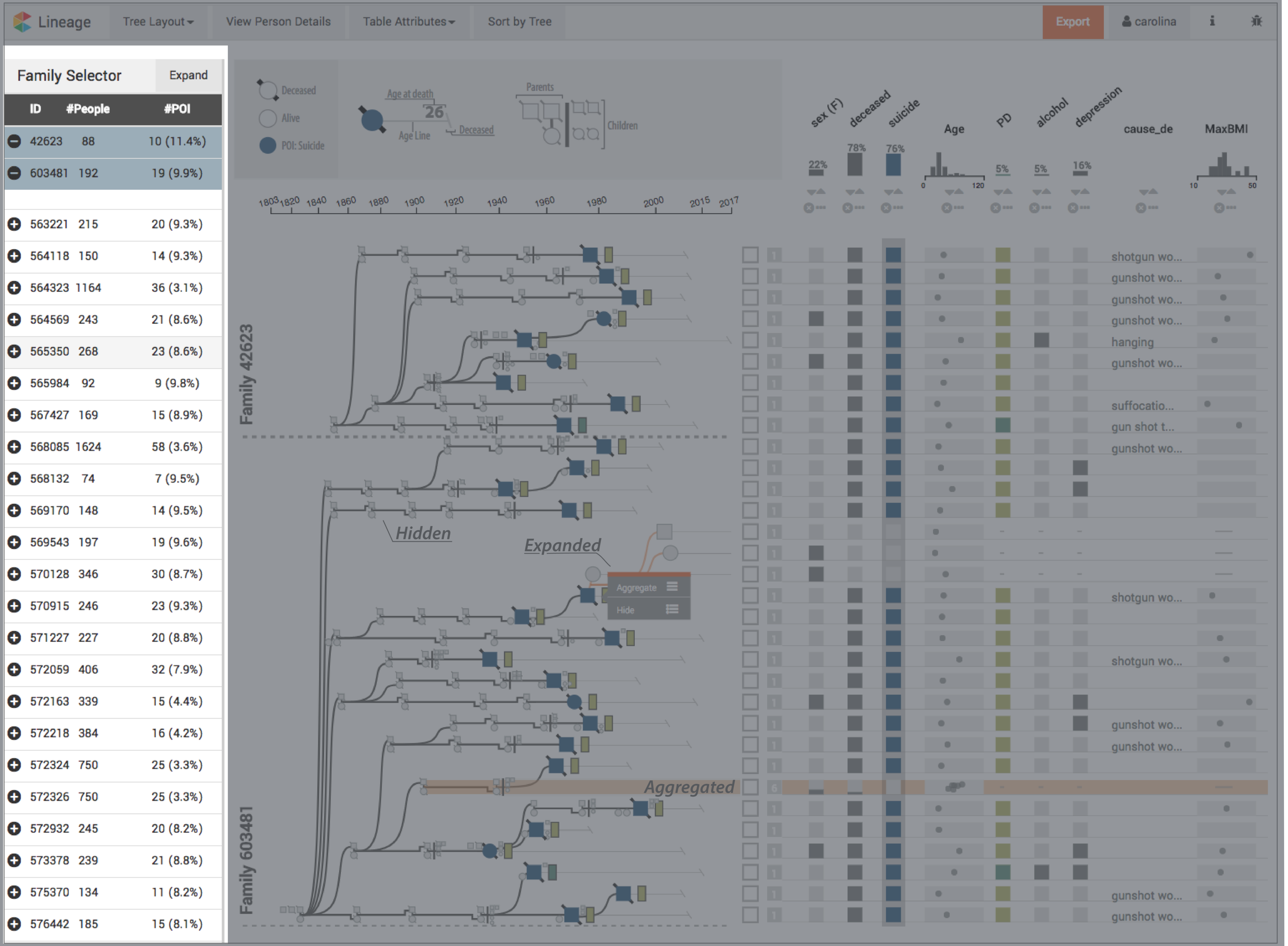


Age
Sex
Race
Bipolar
Depression
Asthma
Obesity
Schizophrenia
Cause of Death
Weapon Used
...

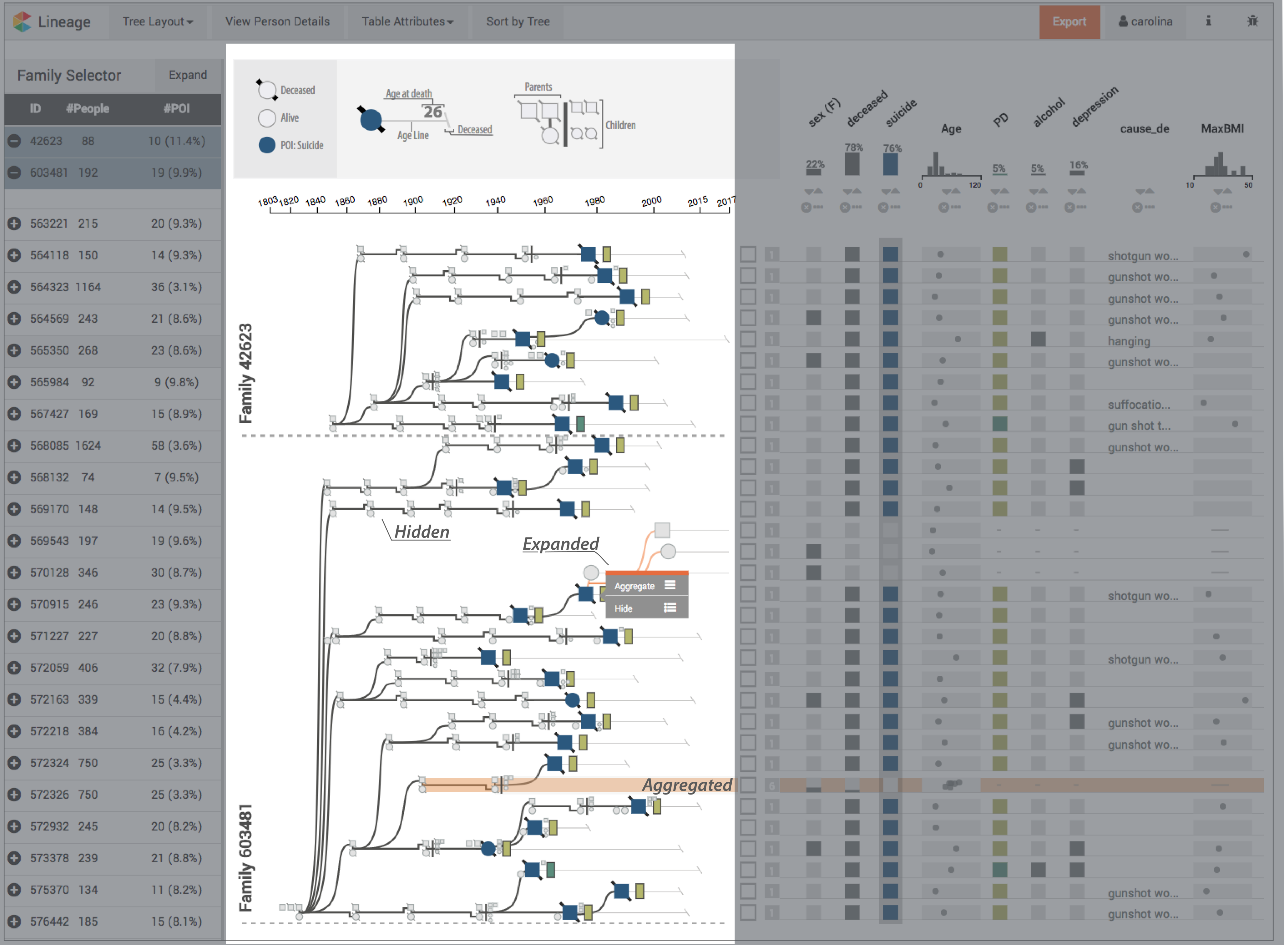
GENEALOGY WITH ~400 MEMBERS RENDERED WITH PROGENY



Lineage
Tree Layout
View Person Details
Table Attributes
Sort by Tree
Export
carolina
Family Selector
Expand
ID #People #POI
42623 88 10 (11.4%)
603481 192 19 (9.9%)
563221 215 20 (9.3%)
564118 150 14 (9.3%)
564323 1164 36 (3.1%)
564569 243 21 (8.6%)
565350 268 23 (8.6%)
565984 92 9 (9.8%)
567427 169 15 (8.9%)
568085 1624 58 (3.6%)
568132 74 7 (9.5%)
569170 148 14 (9.5%)
569543 197 19 (9.6%)
570128 346 30 (8.7%)
570915 246 23 (9.3%)
571227 227 20 (8.8%)
572059 406 32 (7.9%)
572163 339 15 (4.4%)
572218 384 16 (4.2%)
572324 750 25 (3.3%)
572326 750 25 (3.3%)
572932 245 20 (8.2%)
573378 239 21 (8.8%)
575370 134 11 (8.2%)
576442 185 15 (8.1%)
Deceased
Alive
POI: Suicide
Age at death
26
Age Line
Deceased
Parents
Children
1803 1820 1840 1860 1880 1900 1920 1940 1960 1980 2000 2015 2017
Family 42623
Family 603481
Hidden
Expanded
Aggregate
Hide
Aggregated
sex (F)
deceased
suicide
Age
PD
alcohol
depression
cause_de
MaxBMI
22%
78%
76%
5%
5%
16%
0
120
10
50
shotgun wo...
gunshot wo...
gunshot wo...
gunshot wo...
hanging
gunshot wo...
suffocatio...
gun shot t...
gunshot wo...
shotgun wo...
shotgun wo...
gunshot wo...
gunshot wo...
gunshot wo...
gunshot wo...

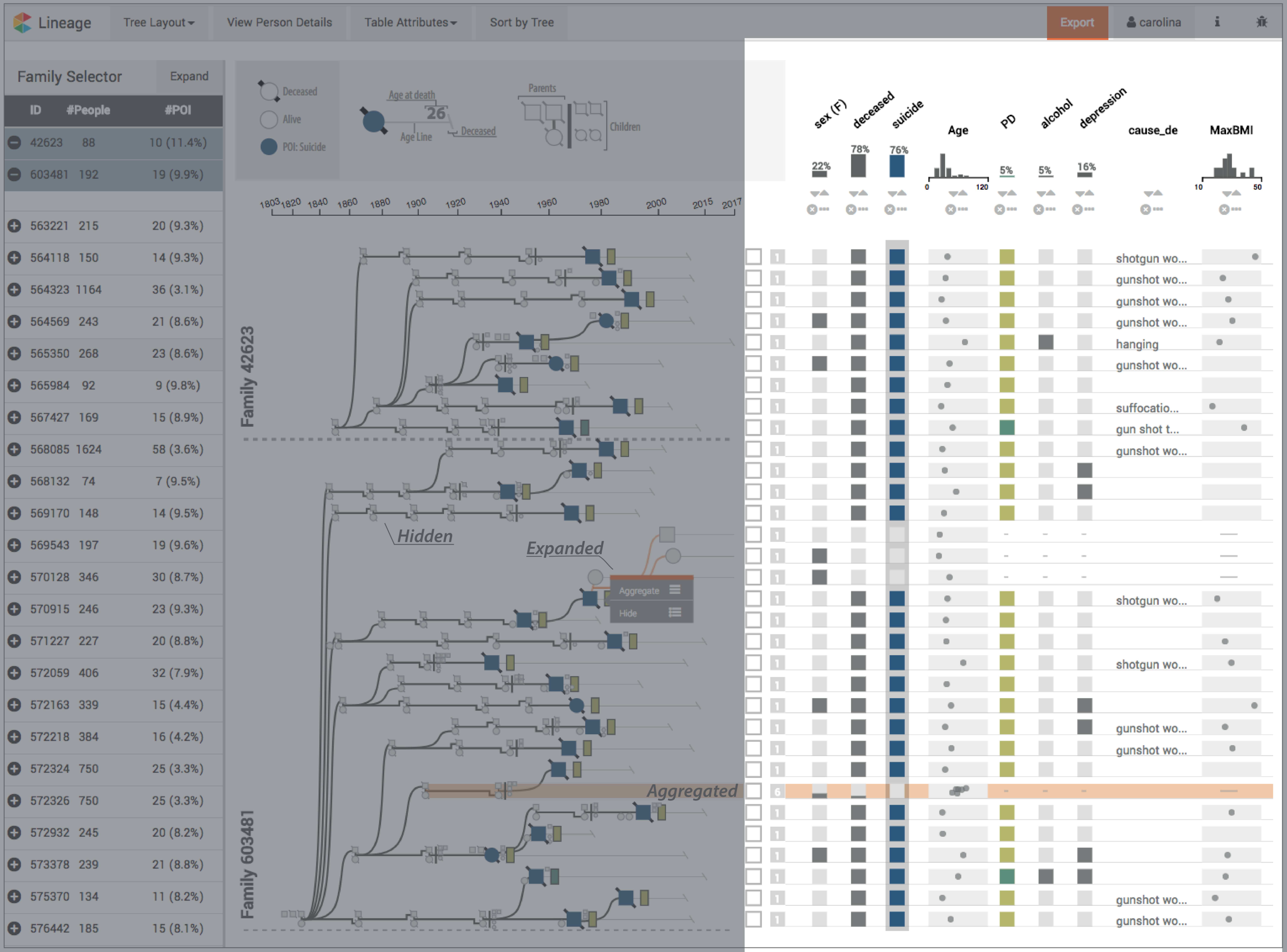


Family Selector



Family Selector

Pedigree Visualization

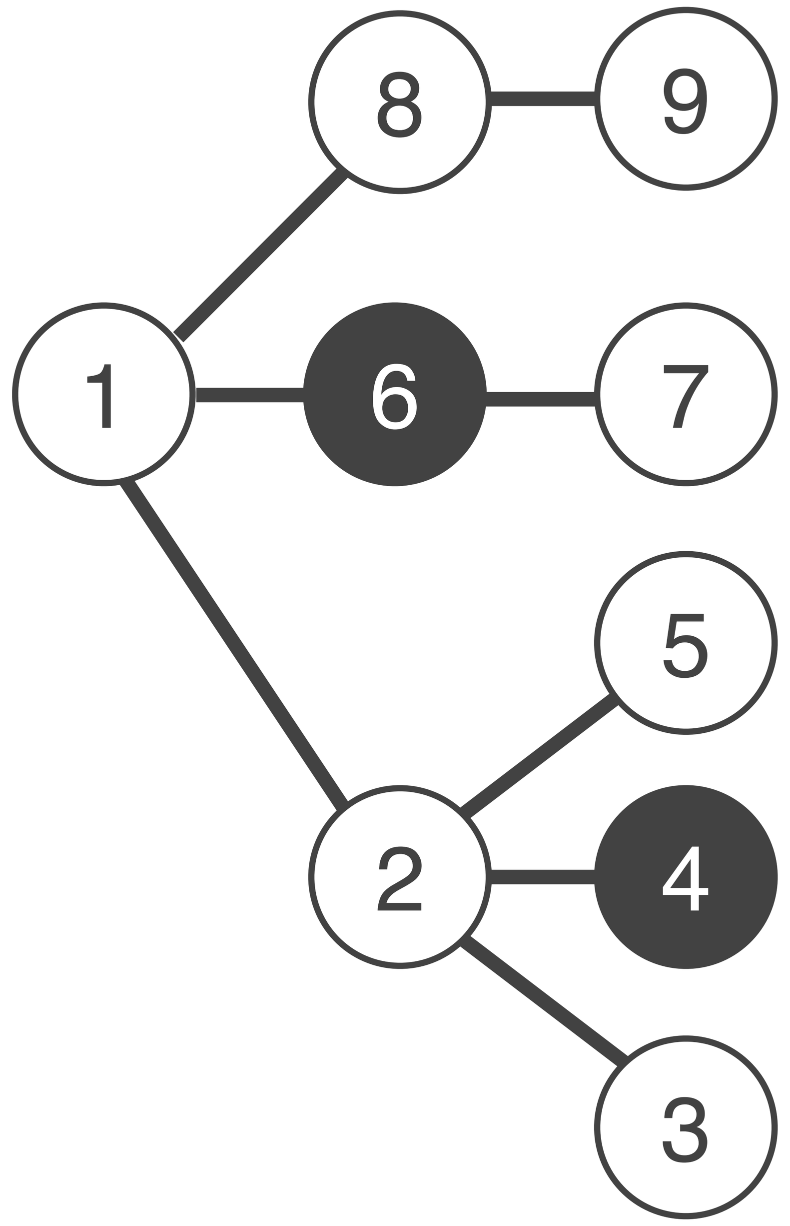


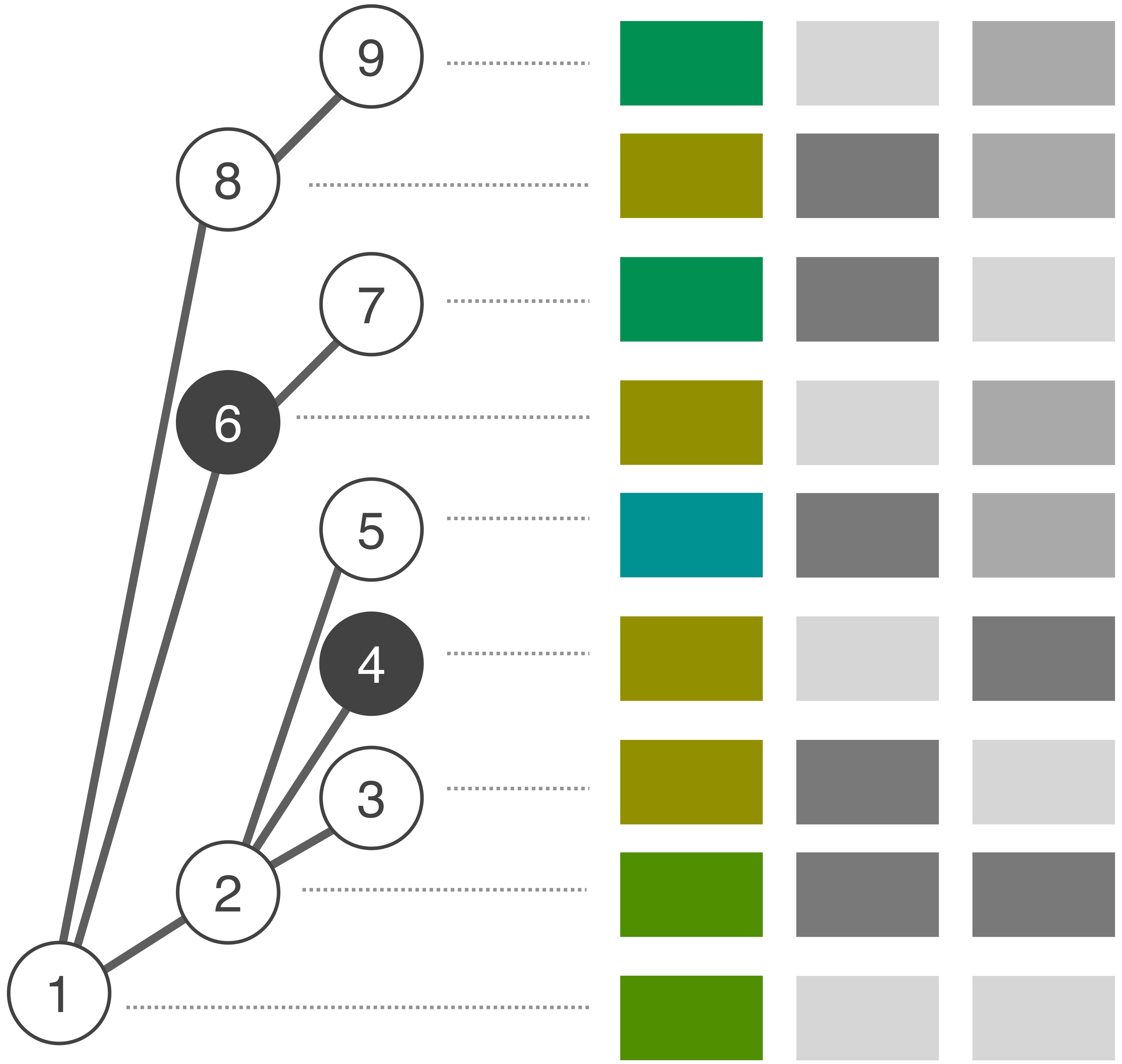
Family Selector

Pedigree Visualization

Attribute Table

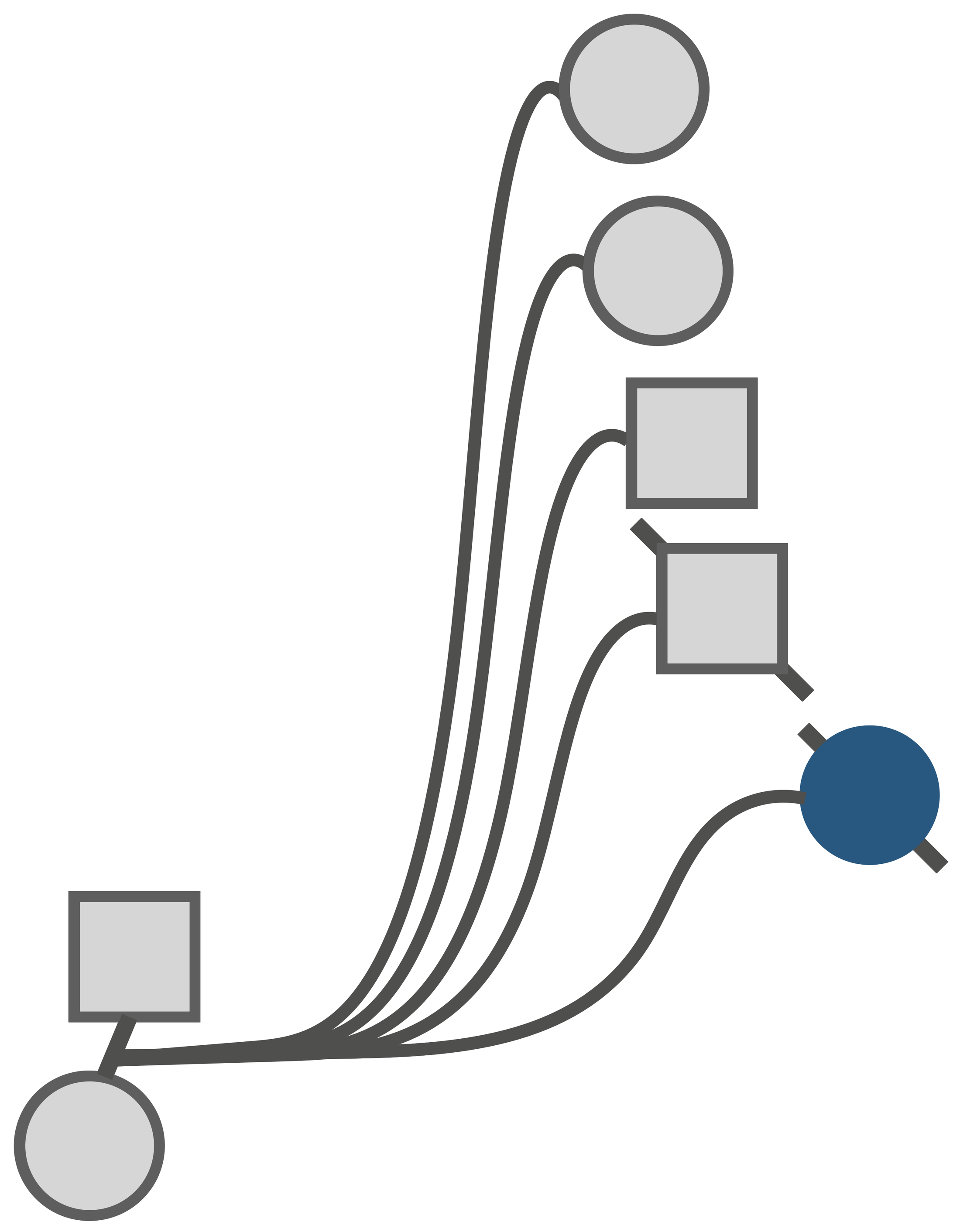
LINEARIZING

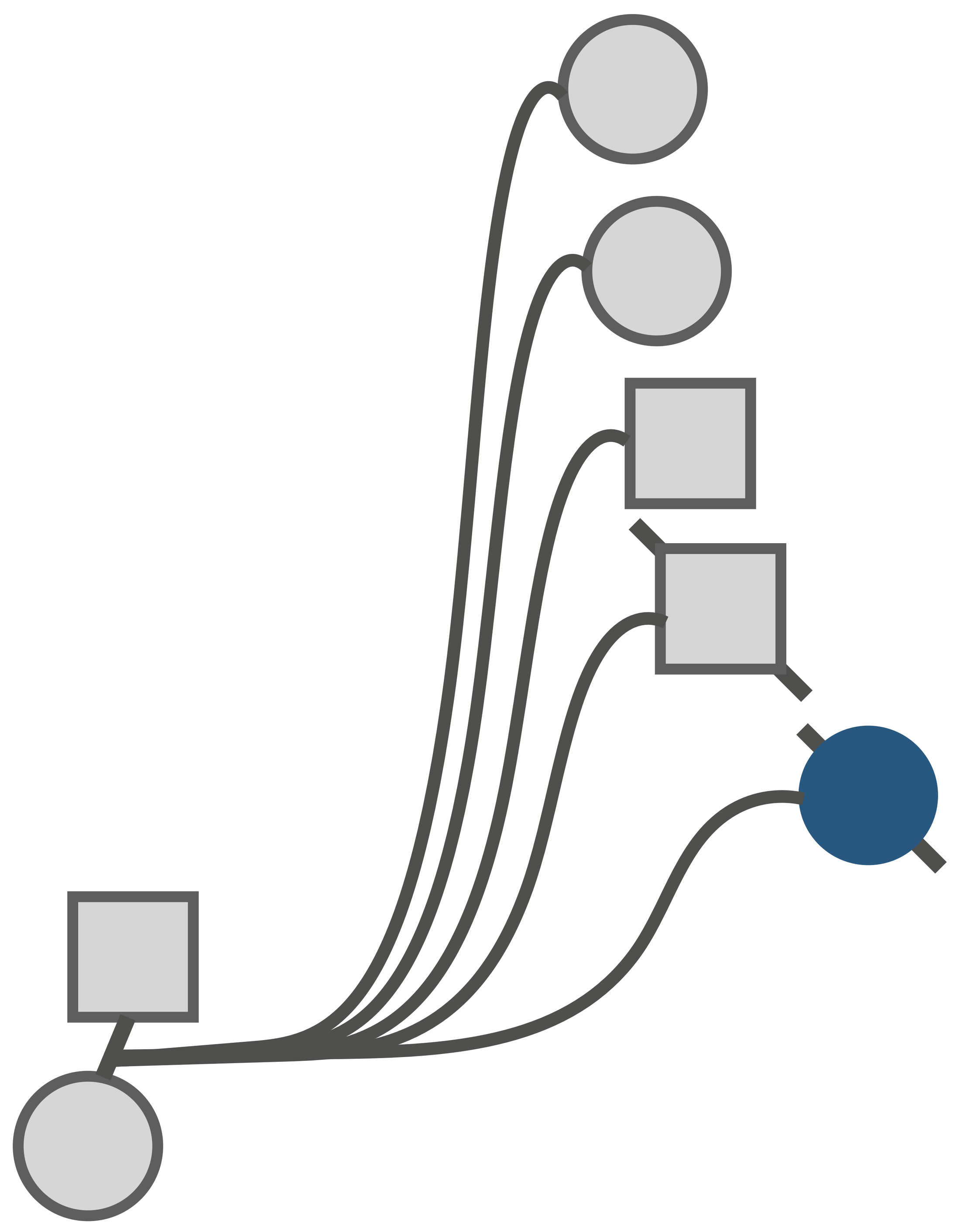




Can't show many people

Lots of missing data






KindredID
RelativeID
sex (F)
deceased
suicide
Bipolar (True)
MaxBMI
Depression (True)
Age1D_Depression
cause_death
Total:59
Total:32
45%
59%
9%
47%
50%
15
45
0
65
1
903988
#13789
gunshot woun...


Lineage
Tree Layout
View Person Details
Table Attributes
Sort by Tree
Family Selector
Expand
ID #People #POI
38 129 12 (9.3%)
38 129 12 (9.3%)
149 122 10 (8.2%)
212 368 35 (9.5%)
234 145 13 (9%)
331 389 19 (4.9%)
490 277 25 (9%)
709 285 28 (9.8%)
1253 245 23 (9.4%)
1474 237 18 (7.6%)
1627 171 17 (9.9%)
1787 768 29 (3.8%)
1843 218 18 (8.3%)
1881 196 19 (9.7%)
2053 322 31 (9.6%)
2082 209 21 (10%)
2117 190 17 (8.9%)
2194 164 13 (7.9%)
2208 162 13 (8%)
2563 157 15 (9.6%)
2749 230 19 (8.3%)
2902 224 17 (7.6%)
3222 191 20 (10.5%)
3841 313 15 (4.8%)
3933 198 8 (4%)
Deceased
Alive
POI/Suicide
Age at death
26
Age Line
Deceased
Parents
Children
1806 1820 1840 1860 1880 1900 1920 1940 1960 1980 2000 2016 2017
Family 38
KindredI
Relative
sex (F)
deceased
suicide
Age
LabID
bipolar spectrum illness
anxiety-non-trauma
alcohol
PD
psychosis
depression
cause_de
17%
100%
100%
0
120
0.0%
0.0%
8%
17%
0.0%
17%
#18561684 #89343 gunshot wo...
#18561686 #93380 gunshot wo...
#15638474 gunshot wo...
#15512738 asphyxia
#16324365
#15188353
#28016042 carbon mon...
#21982847 asphyxia
#1307826 #96031 gunshot wo...
#26200382 mixed drug...
#16881308
#15312962 #48318 gunshot wo...

USAGE & FUTURE WORK

Currently used by team of Psychiatry researchers on a daily basis

Widespread interest from other labs working with UPDB data

Integration of other data types
Geospatial, Environmental, Genomic

Alexander Lex

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http://alexander-lex.net

Thanks to: **Carolina Nobre**, **Dylan Wootton, Kiran Gadhave, Zach Cutler**, Marc Streit, Jochen Görtler, Oliver Deussen, Miriah Meyer, Jeff Phillips, Samuel Gratzl, Holger Stitz, Nils Gehlenborg, Hendrik Strobelt, Romain Vuillemot, Hanspeter Pfister, and many others!

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visualization design lab

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