

Visualization for Data Science

Multiview I



What?

Datasets

Attributes

What?

Why?

How?

→ Data Types

- Items
- Attributes
- Links
- Positions
- Grids

→ Attribute Types

- Categorical



→ Data and Dataset Types

Tables	Networks & Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items (nodes)	Grids	Items	Clusters, Sets, Lists
Attributes	Links	Positions	Positions	Items

→ Ordered

- Ordinal

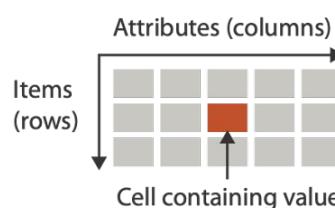


→ Quantitative

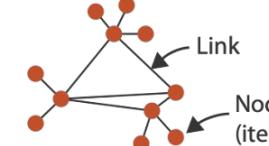


→ Dataset Types

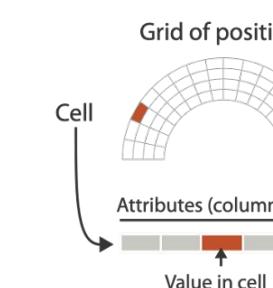
→ Tables



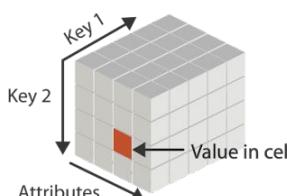
→ Networks



→ Fields (Continuous)



→ Multidimensional Table



→ Trees



→ Geometry (Spatial)



→ Dataset Availability

→ Static



→ Dynamic



→ Ordering Direction

→ Sequential



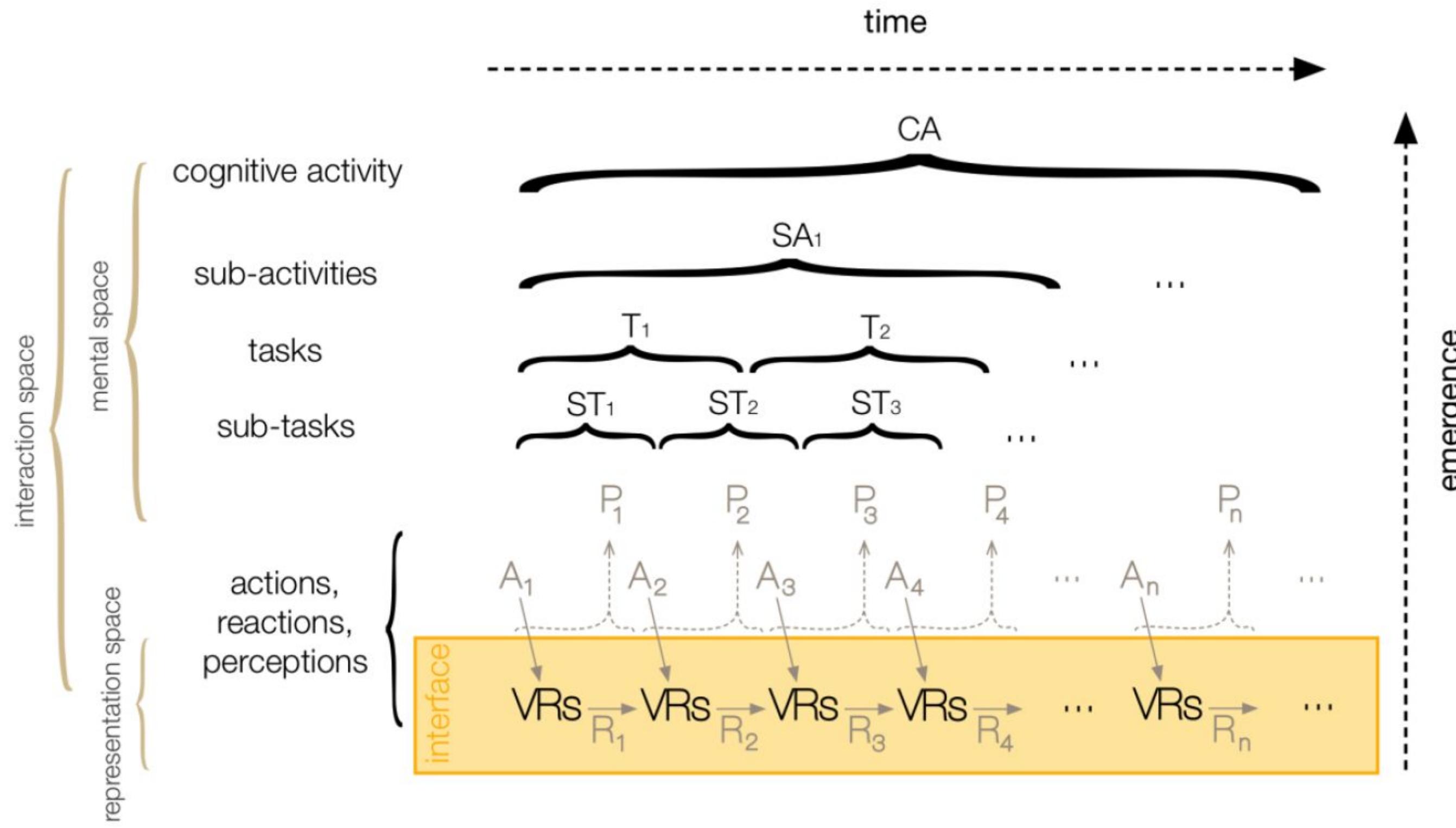
→ Diverging



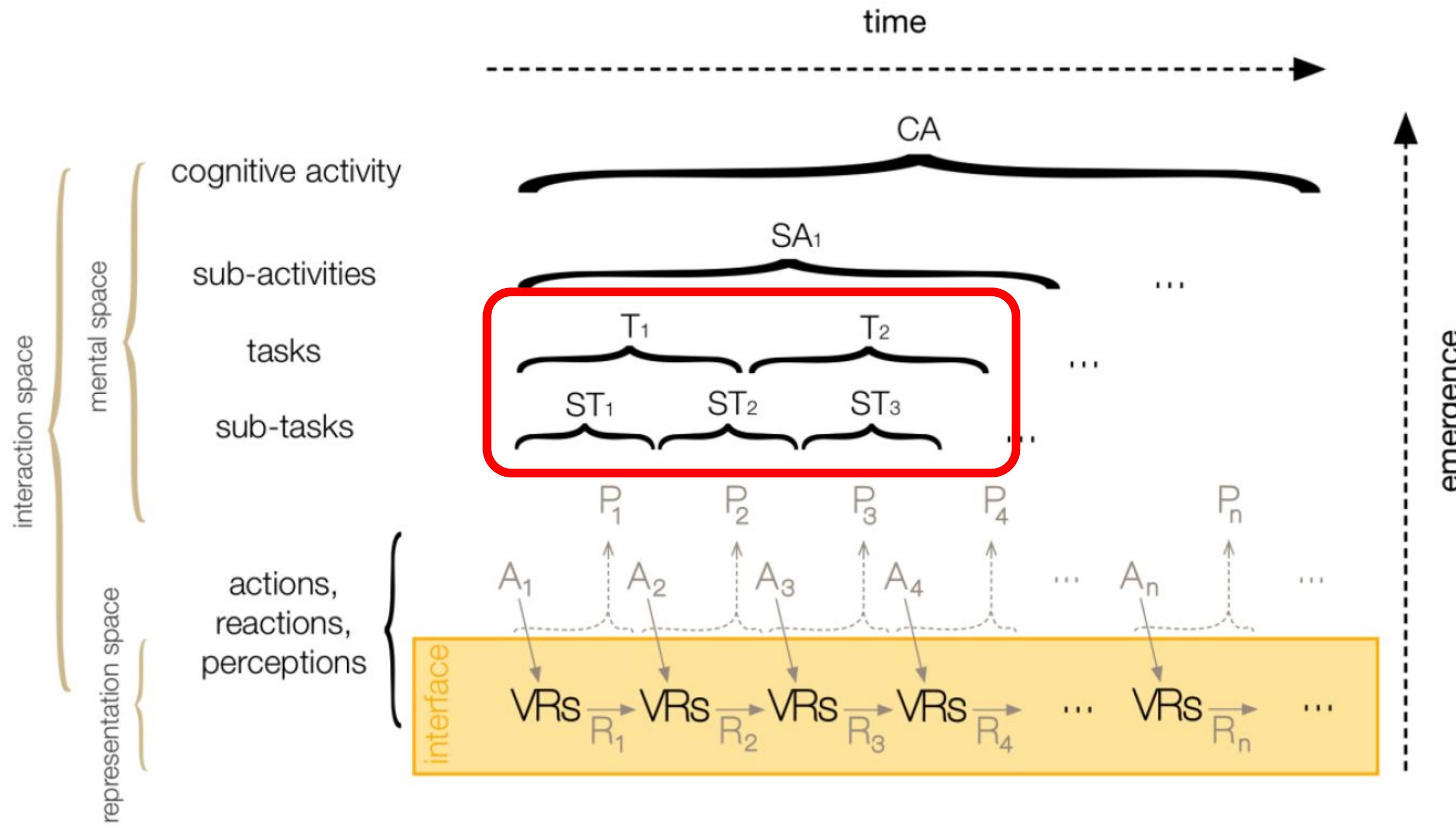
→ Cyclic



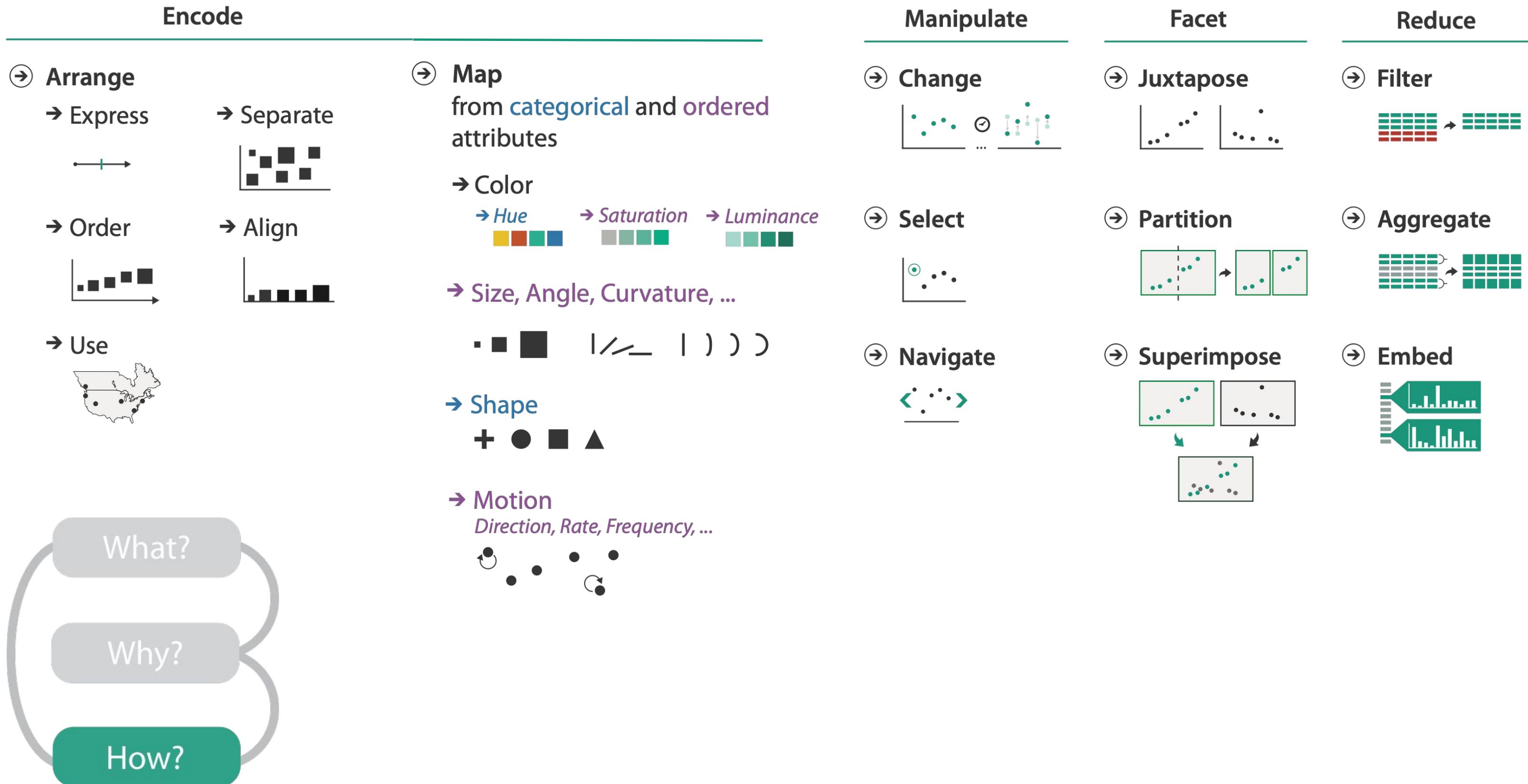
The Hierarchical Structure of a Complex Cognitive Activity



The Hierarchical Structure of a Complex Cognitive Activity



How?

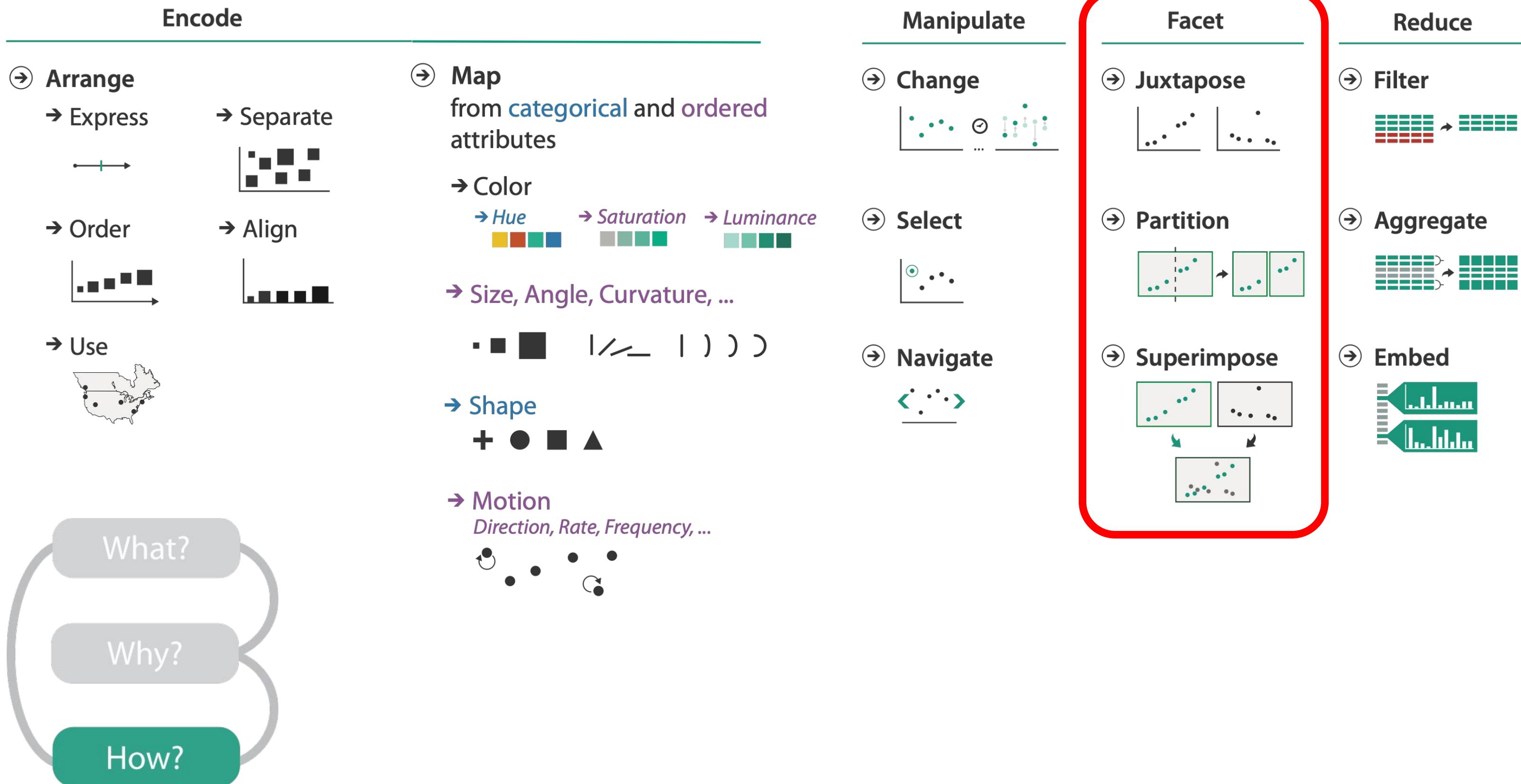


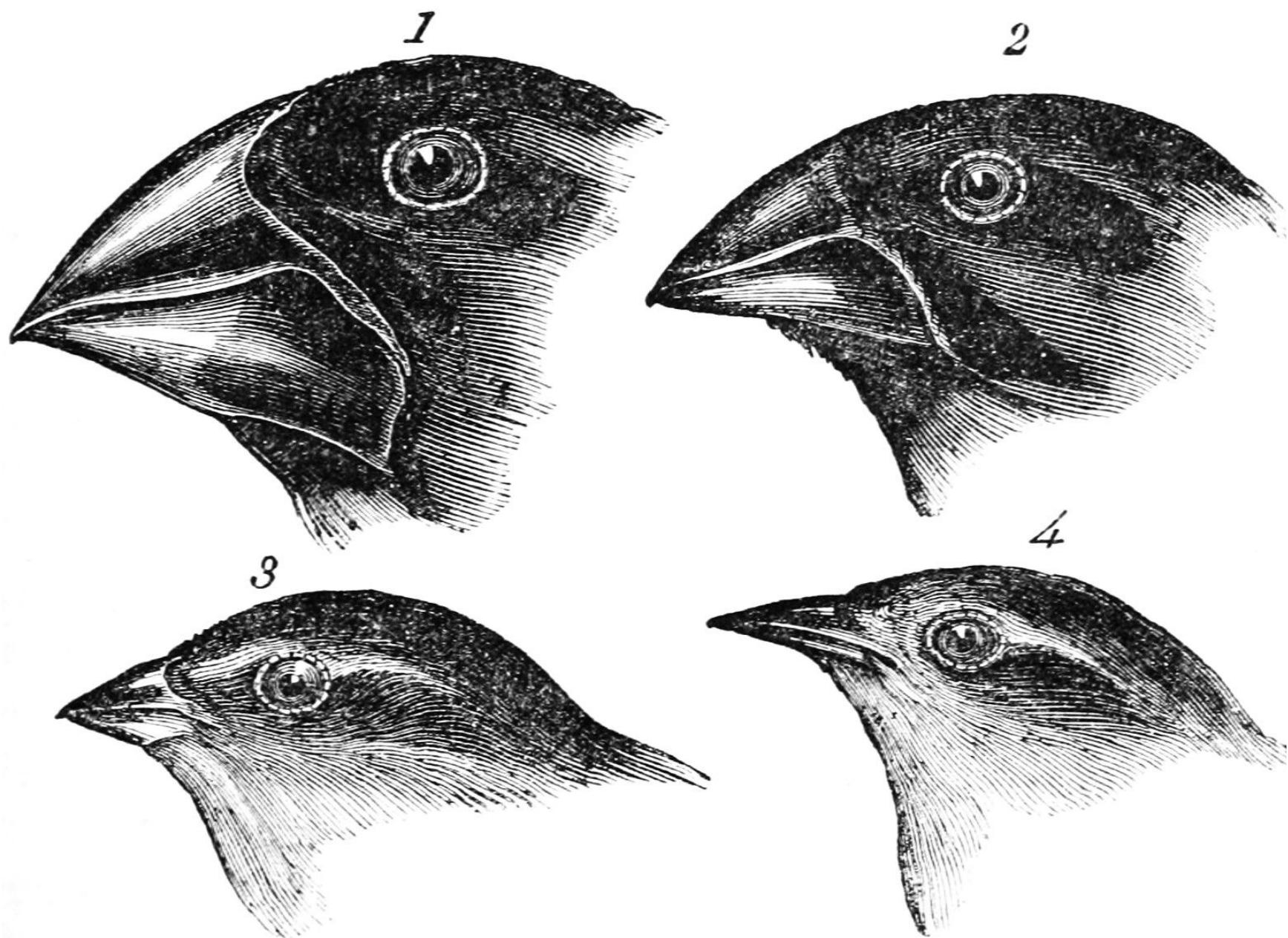
Approaches to Supporting the Discourse with Large Datasets

- **Manipulate** – user interacts with the visual encoding
- **Facet** – splits the visual encoding into multiple views
- **Reduce**
 - embed additional visual encodings into smaller glyphs
 - reduce amount of attributes visualized, dimensionality reduction (e.g. maps reduces from 3D to 2D)



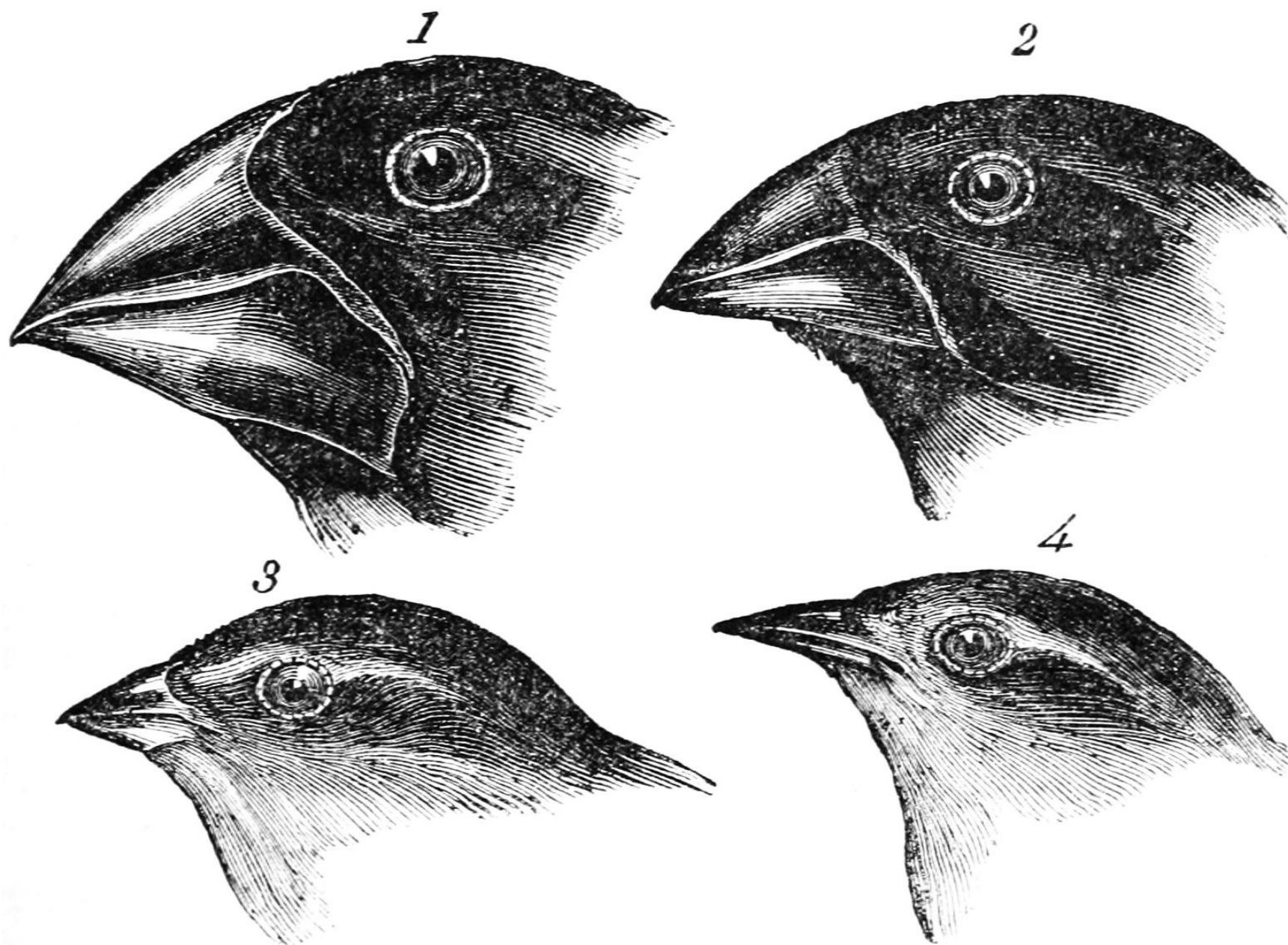
How?





1. *Geospiza magnirostris.*
3. *Geospiza parvula.*

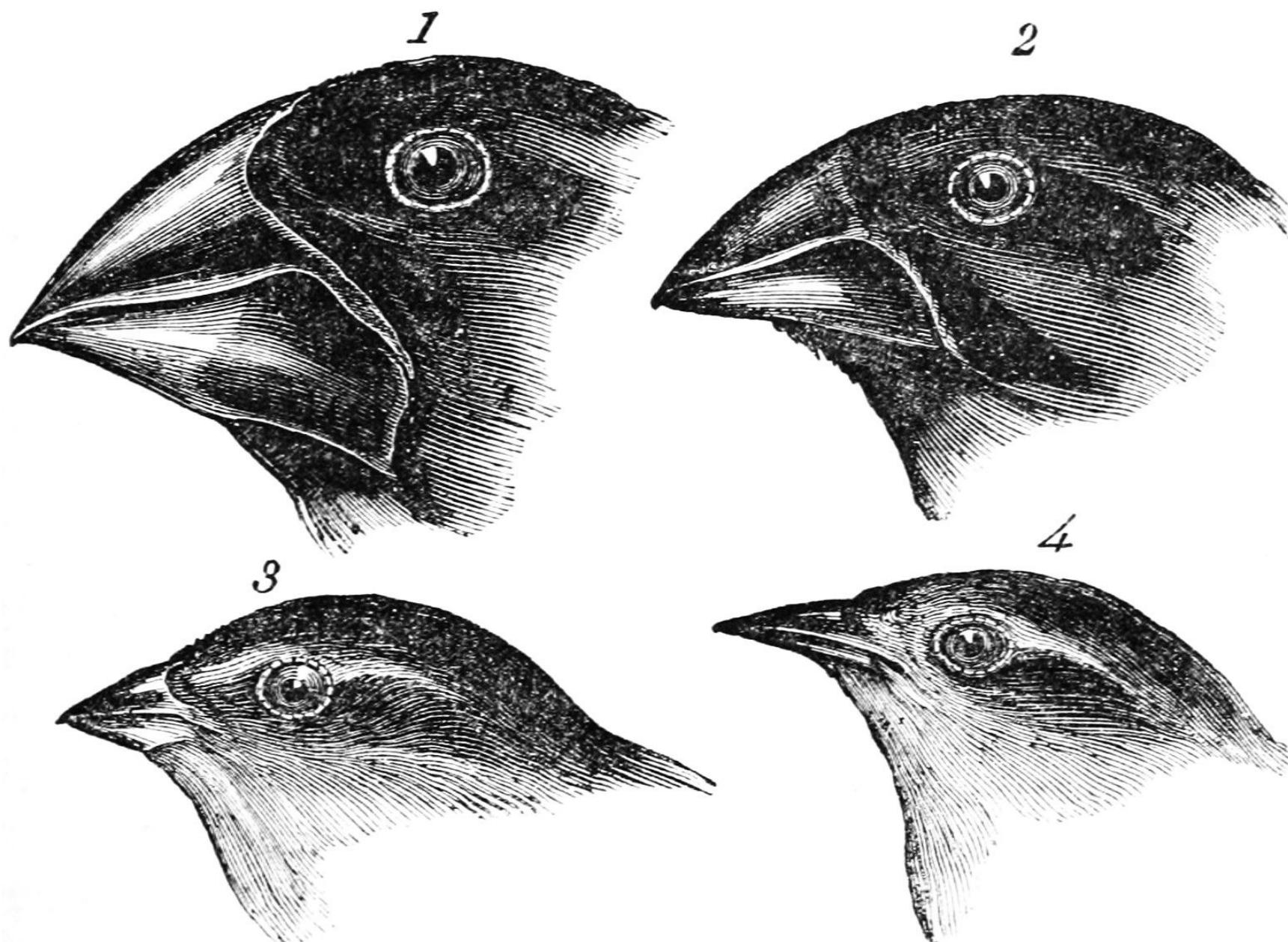
2. *Geospiza fortis.*
4. *Certhidea olivacea.*



1. *Geospiza magnirostris.*
3. *Geospiza parvula.*

2. *Geospiza fortis.*
4. *Certhidea olivacea.*

This illustration is 180 years old!



1. *Geospiza magnirostris.*
3. *Geospiza parvula.*

2. *Geospiza fortis.*
4. *Certhidea olivacea.*

Darwin, Charles (1845). Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. Beagle round the world, under the Command of Capt. Fitz Roy, R.N. 2d edition.



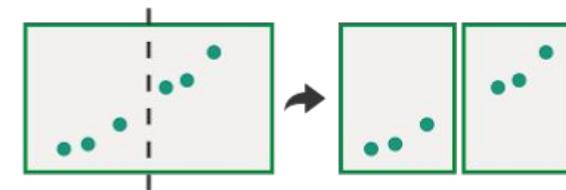
Kiwi Rex, Darwin's finches (February 21, 2019) [CC BY-SA 4.0]
https://commons.wikimedia.org/wiki/File:Darwin%27s_finches.png

To Facet

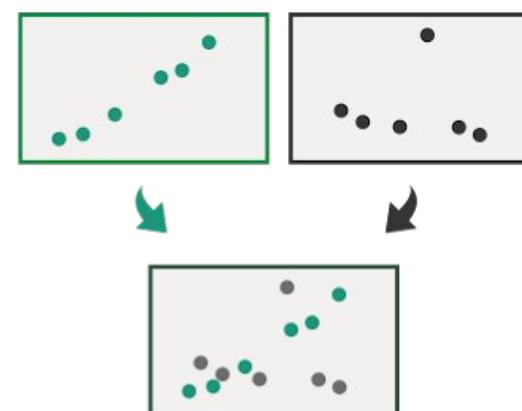
→ **Juxtapose**



→ **Partition**



→ **Superimpose**



Juxtapose and coordinate views (Design Space)

→ Share Encoding: Same/Different

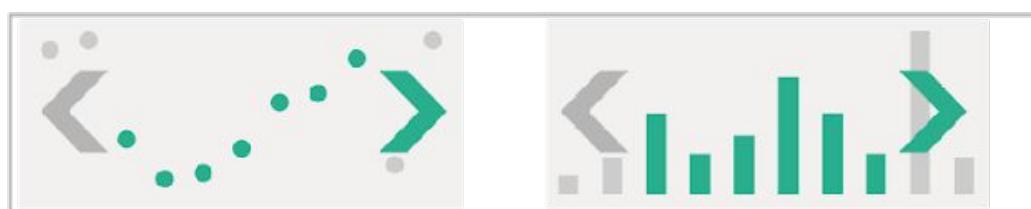
→ *Linked Highlighting*



→ Share Data: All/Subset/None



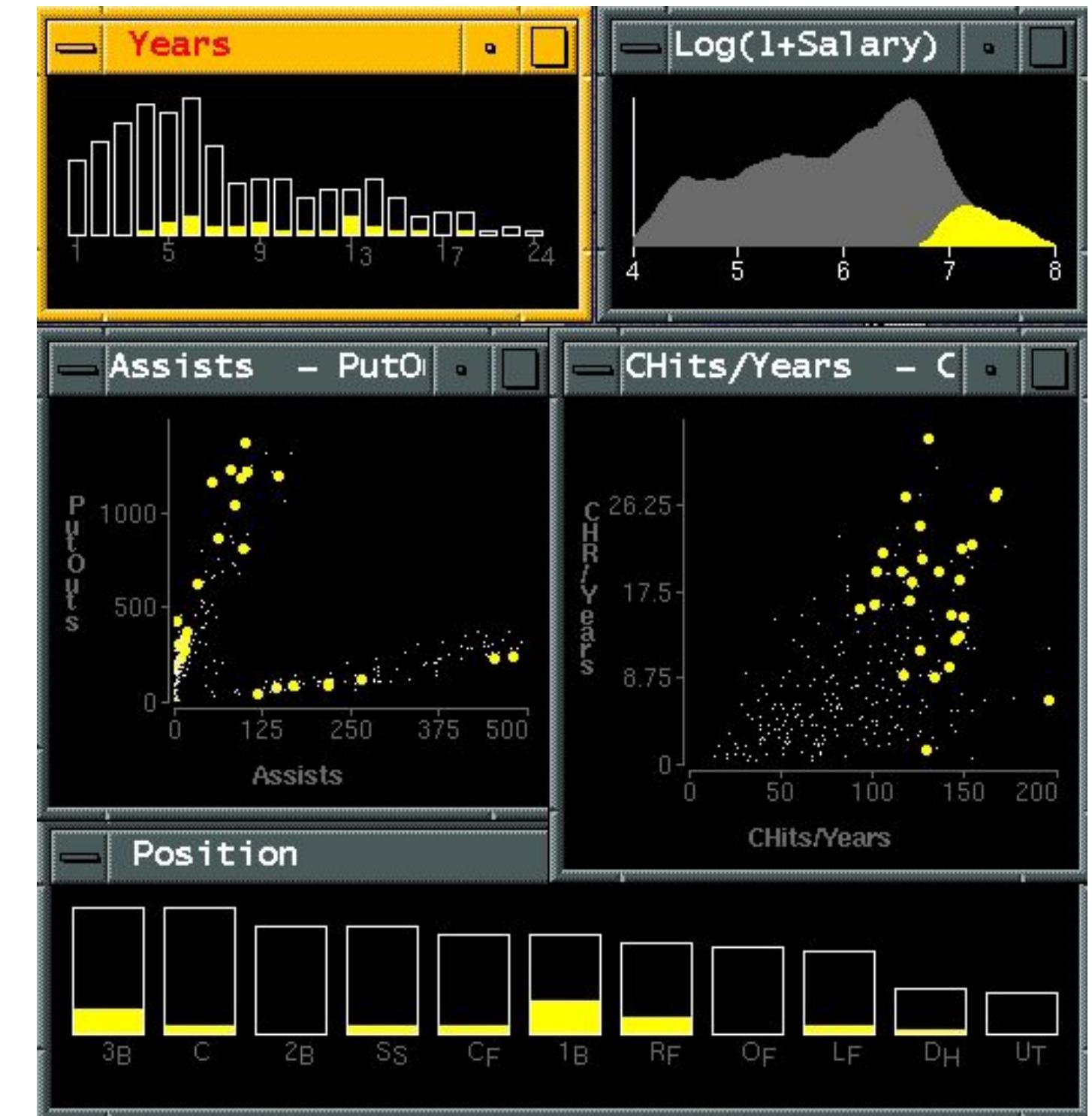
→ Share Navigation



Idiom: **Linked highlighting**

System: **EDV**

- see how regions contiguous in one view are distributed within another
 - powerful and pervasive interaction idiom
- encoding: different
 - *multiform*
- data: all shared
 - all **items** shared
 - different **attributes** across the views
- aka: brushing and linking

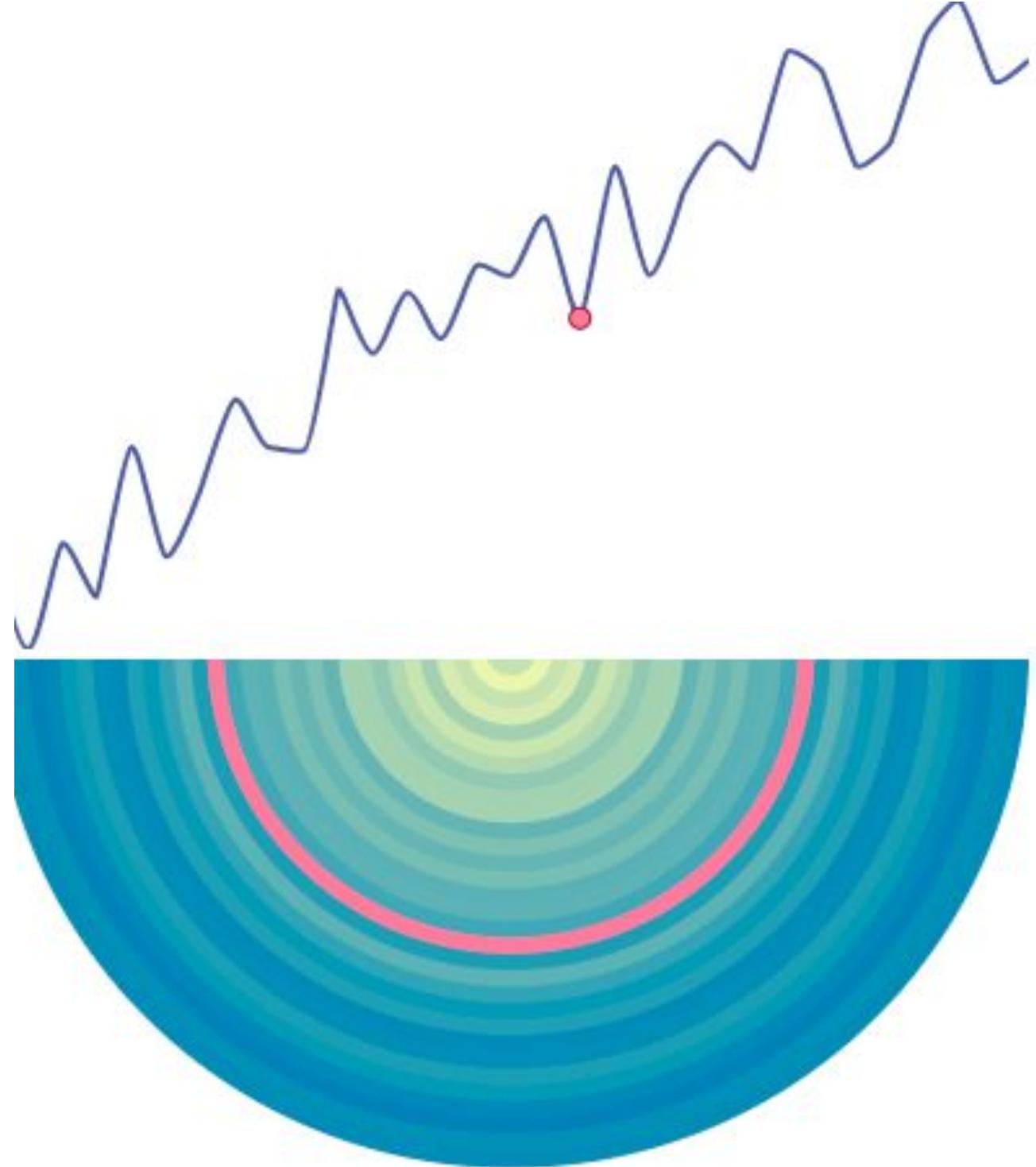


[*Visual Exploration of Large Structured Datasets*. Wills.

Proc. New Techniques and Trends in Statistics (NTTS), pp. 237–246. IOS Press, 1995.]

Linked views: Directionality

- unidirectional vs bidirectional linking
 - bidirectional almost always better!



<http://pbeshai.github.io/linked-highlighting-react-vega-redux/>

Idiom: Overview+detail views

System: Google Maps

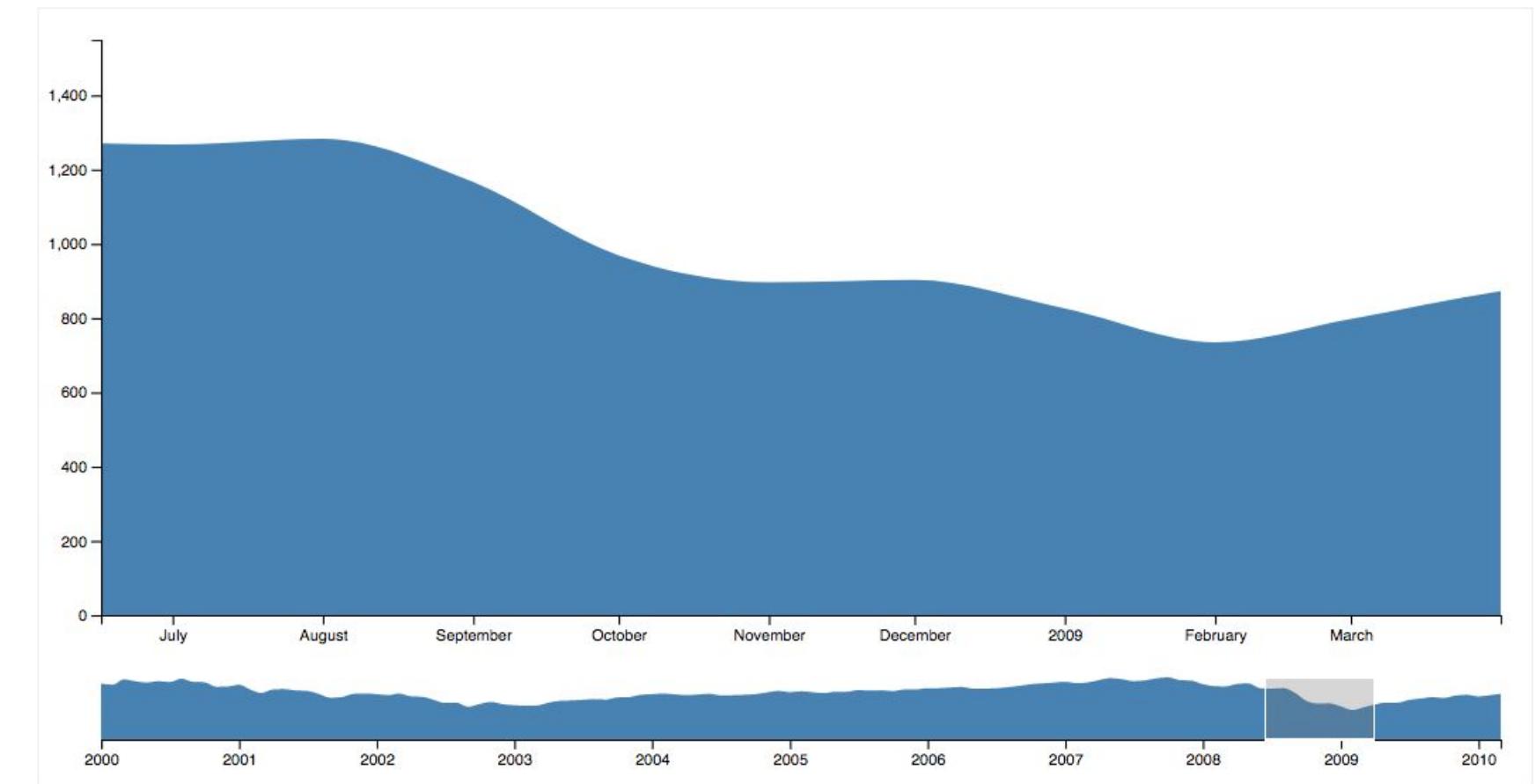
- encoding: same or different
 - ex: same (birds-eye map)
- data: subset shared
 - viewpoint differences:
subset of data items
- navigation: shared
 - bidirectional linking
- other differences
 - (window size)



[*A Review of Overview+Detail, Zooming, and Focus+Context Interfaces.*
Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31]

Idiom: Overview-detail navigation

- encoding: same or different
- data: subset shared
- navigation: shared
 - unidirectional linking
 - select in small overview,
change extent in large detail view



<https://observablehq.com/@uwdata/interaction>

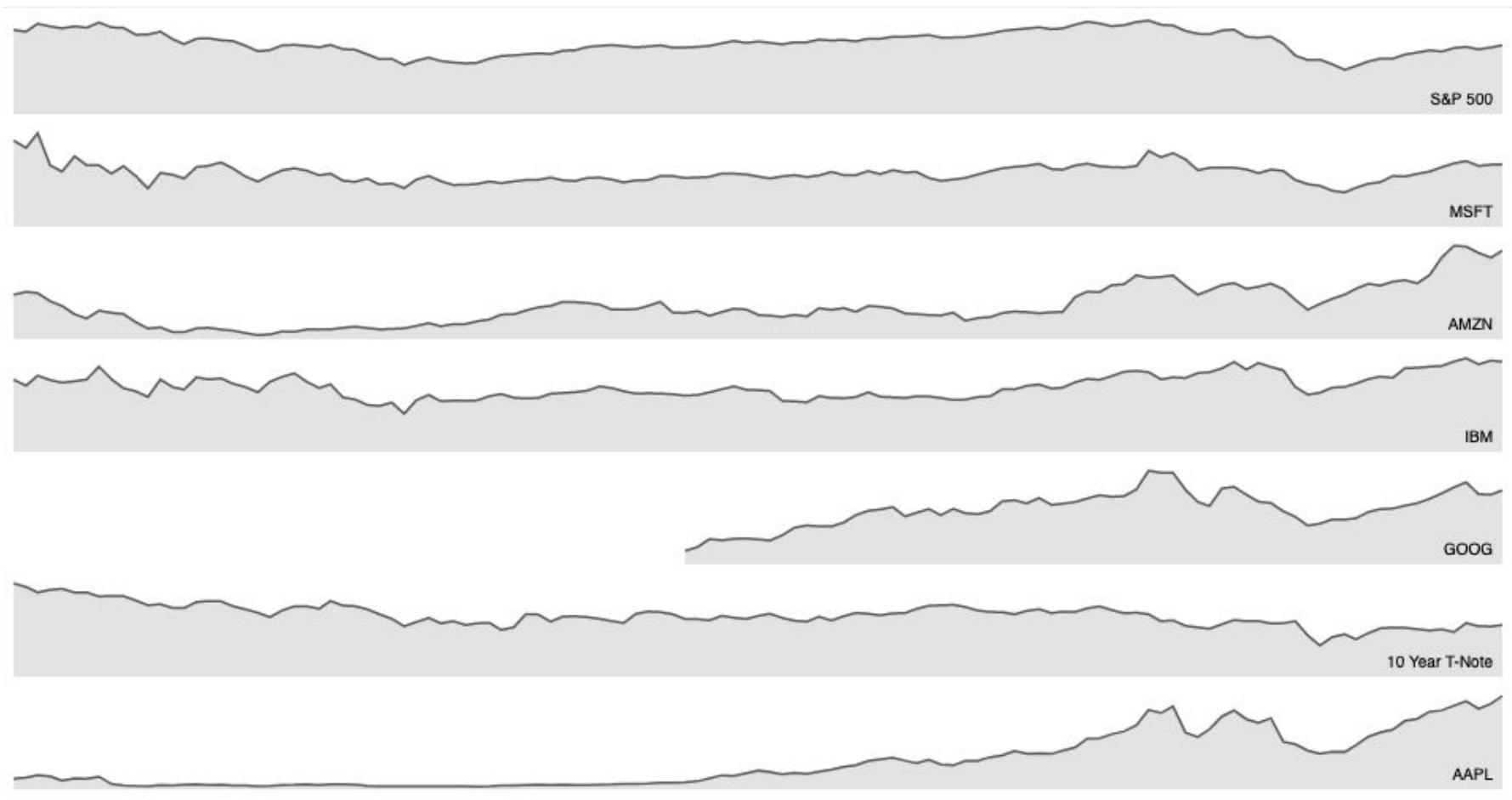
Idiom: Tooltips

- popup information for selection
 - hover or click
 - specific case of detail view:
provide useful additional detail on demand
 - beware: does not support overview!
 - always consider if there's a way to visually encode directly to provide overview
 - “If you make a rollover or tooltip, assume nobody will see it. If it's important, make it explicit.”
 - Gregor Aisch, NYTimes



Idiom: Small multiples

- encoding: same
 - ex: line charts
- data: none shared
 - different slices of dataset
 - items or attributes
 - ex: stock prices for different companies



[<https://bl.ocks.org/mbostock/1157787>]

Interactive small multiples

- linked highlighting:
analogous item/attribute
across views
 - same year highlighted across all
charts if hover within any chart

The Rise and Decline of Ask MetaFilter

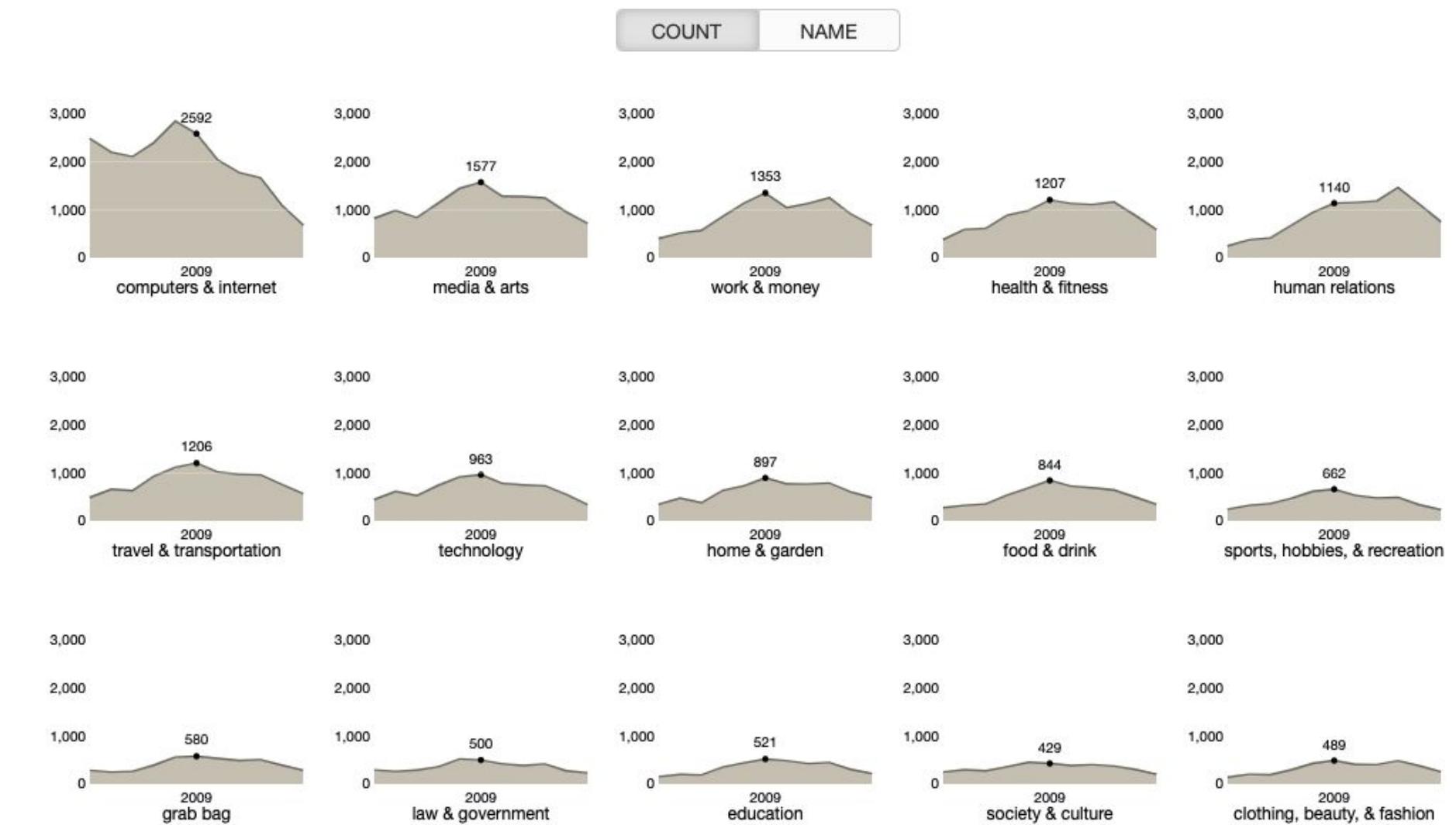
Metafilter's revenue has been on the decline, but has its content dried up as well?

Here we look at new posts on Ask Metafilter by category.

Categories like **computers & internet** have been dropping in use for a long time, most likely due to competition like Stack Overflow.

Other smaller categories have had consistent use patterns until more recently.

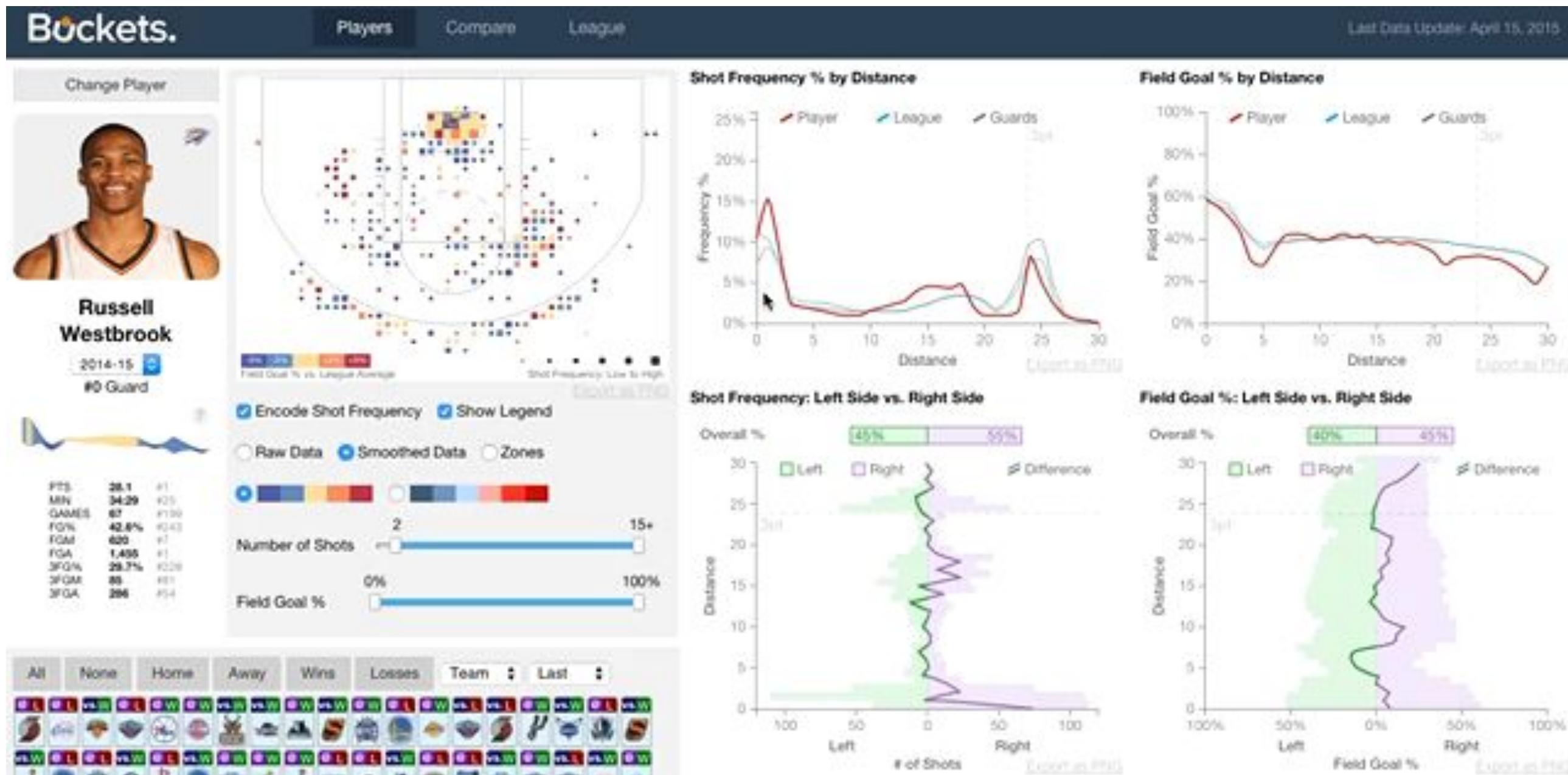
Disclaimer: 2014 is included, even though the year is not over yet.



[http://projects.flowingdata.com/tut/linked_small_multiples_demo/]

Example: Combining many interaction idioms

System: Buckets

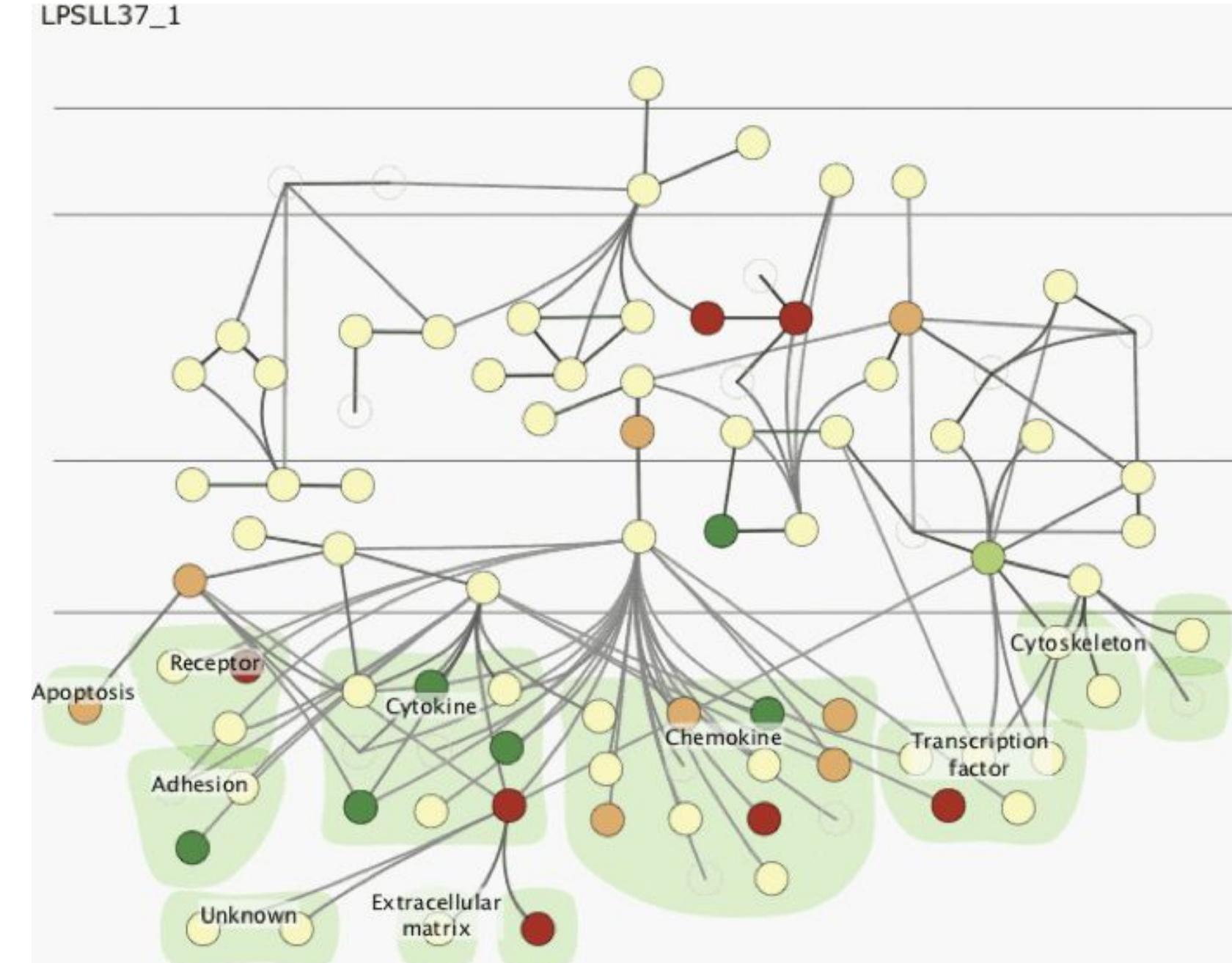


- multiform
- multidirectional linked highlighting of small multiples
- tooltips

<http://buckets.peterbeshai.com/>

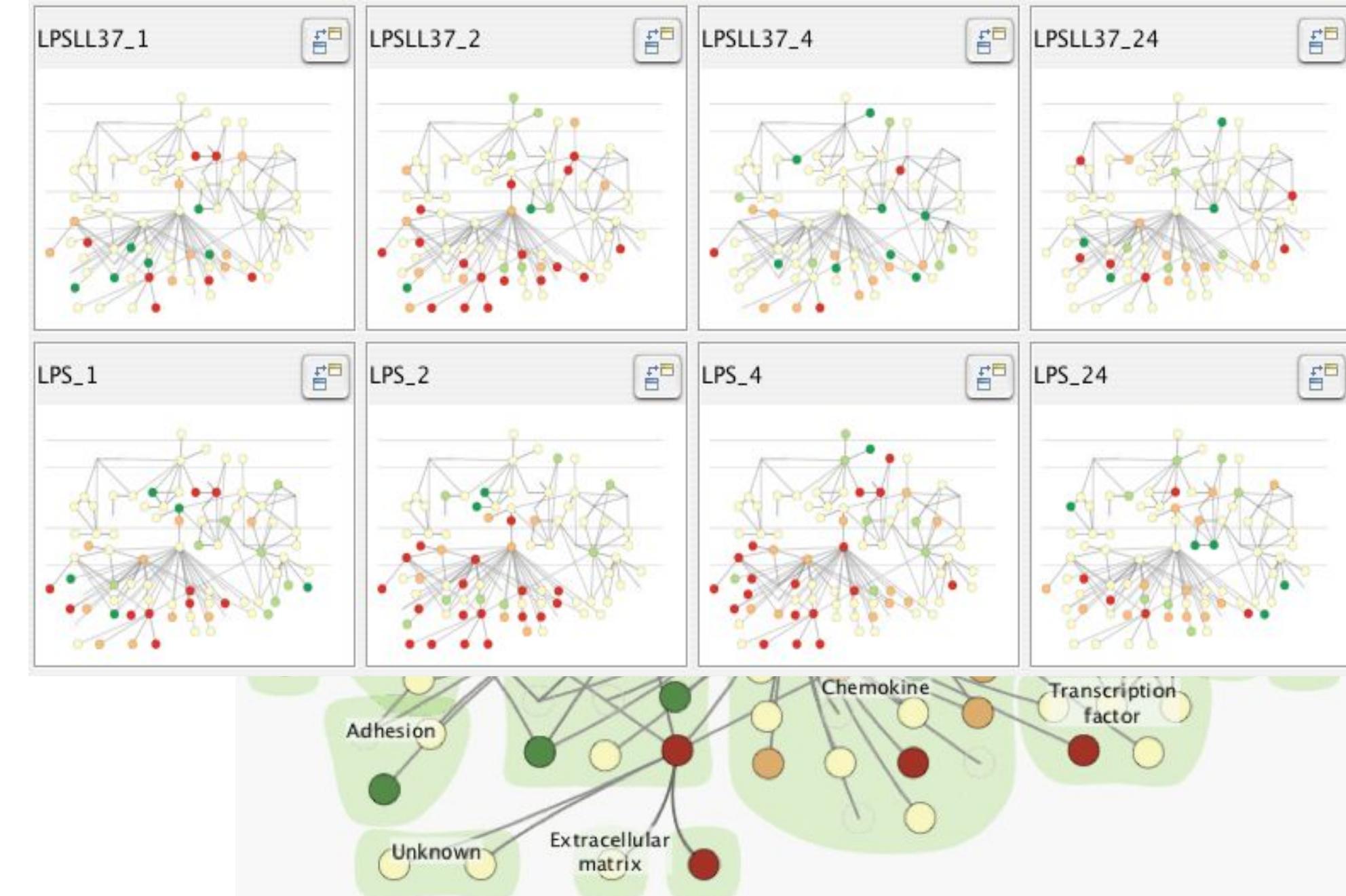
Juxtapose vs animate

- animate: hard to follow if many scattered changes or many frames
 - vs easy special case: animated transitions

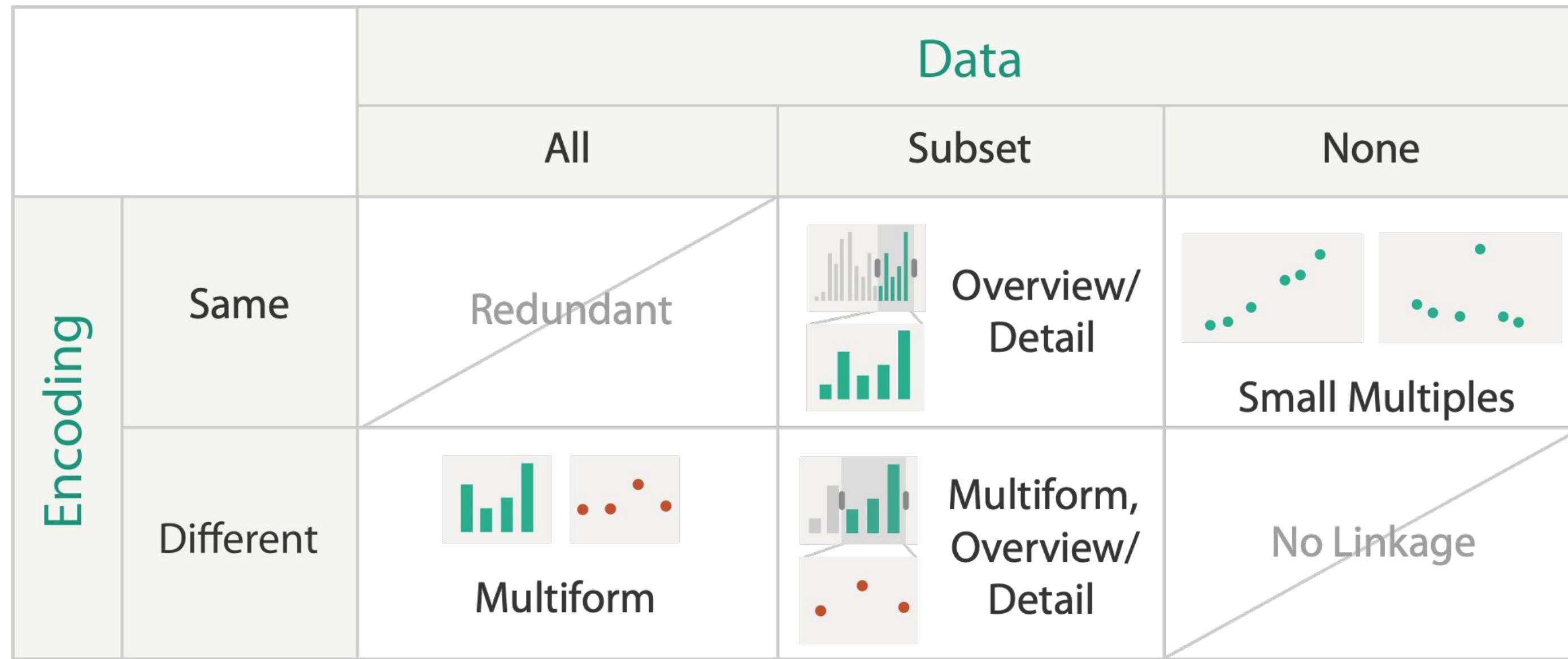


Juxtapose vs animate

- animate: hard to follow if many scattered changes or many frames
 - vs easy special case: animated transitions
- juxtapose: easier to compare across small multiples
 - different conditions (color), same gene (layout)

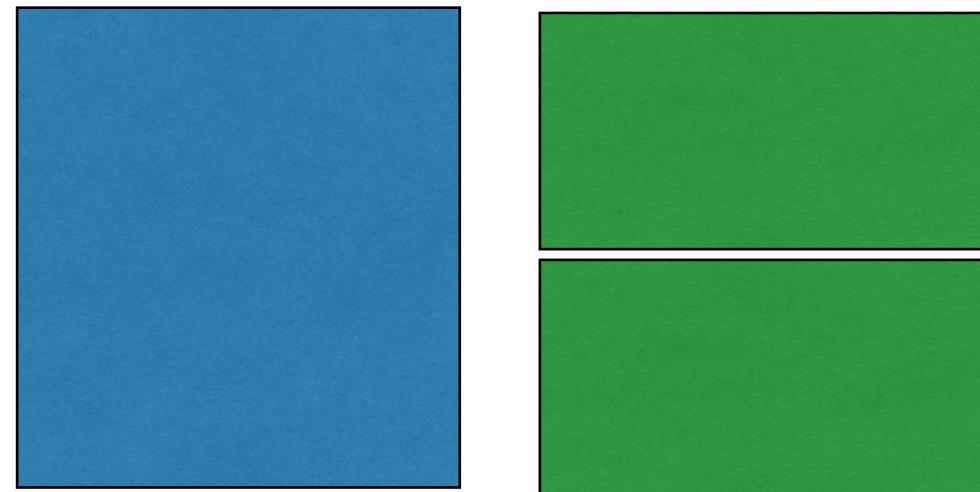


View coordination: Design choices



Juxtapose views: tradeoffs

- juxtapose costs
 - display area
 - 2 views side by side: each has only half the area of one view
- juxtapose benefits
 - cognitive load: eyes vs memory
 - lower cognitive load: move eyes between 2 views
 - higher cognitive load: compare single changing view to memory of previous state

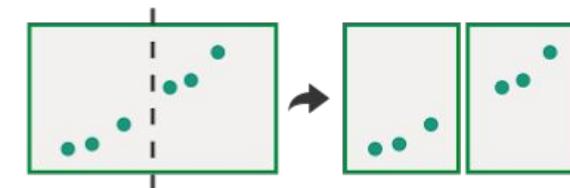


To Facet

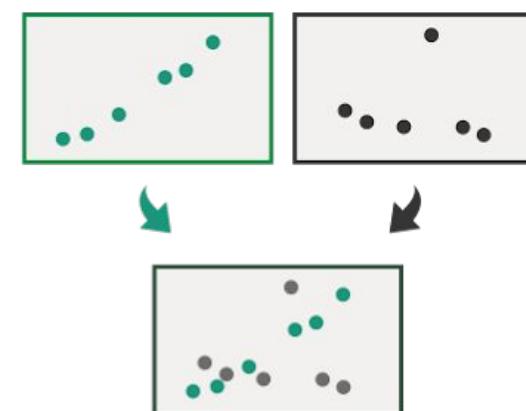
→ **Juxtapose**



→ **Partition**



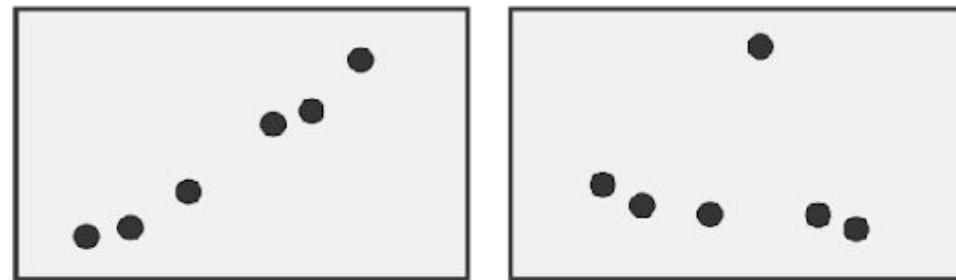
→ **Superimpose**



Partition into views

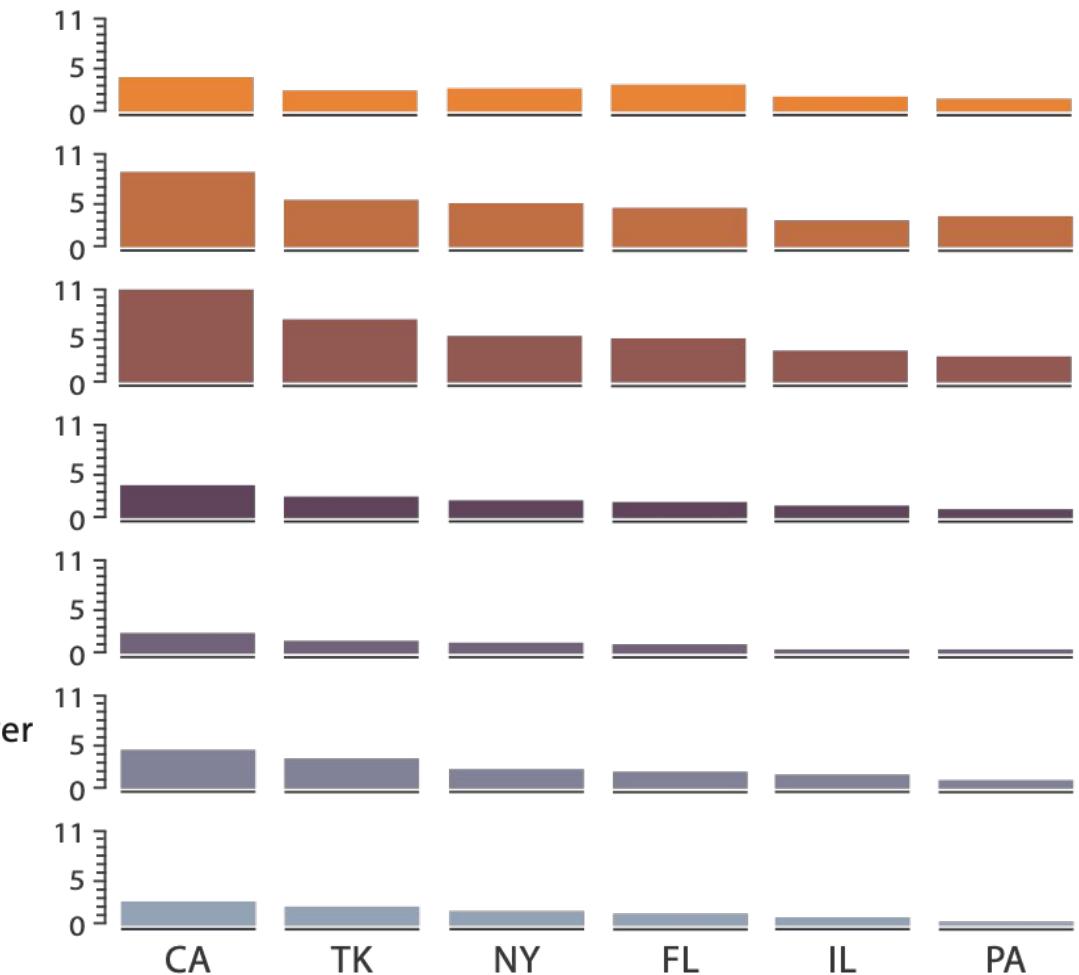
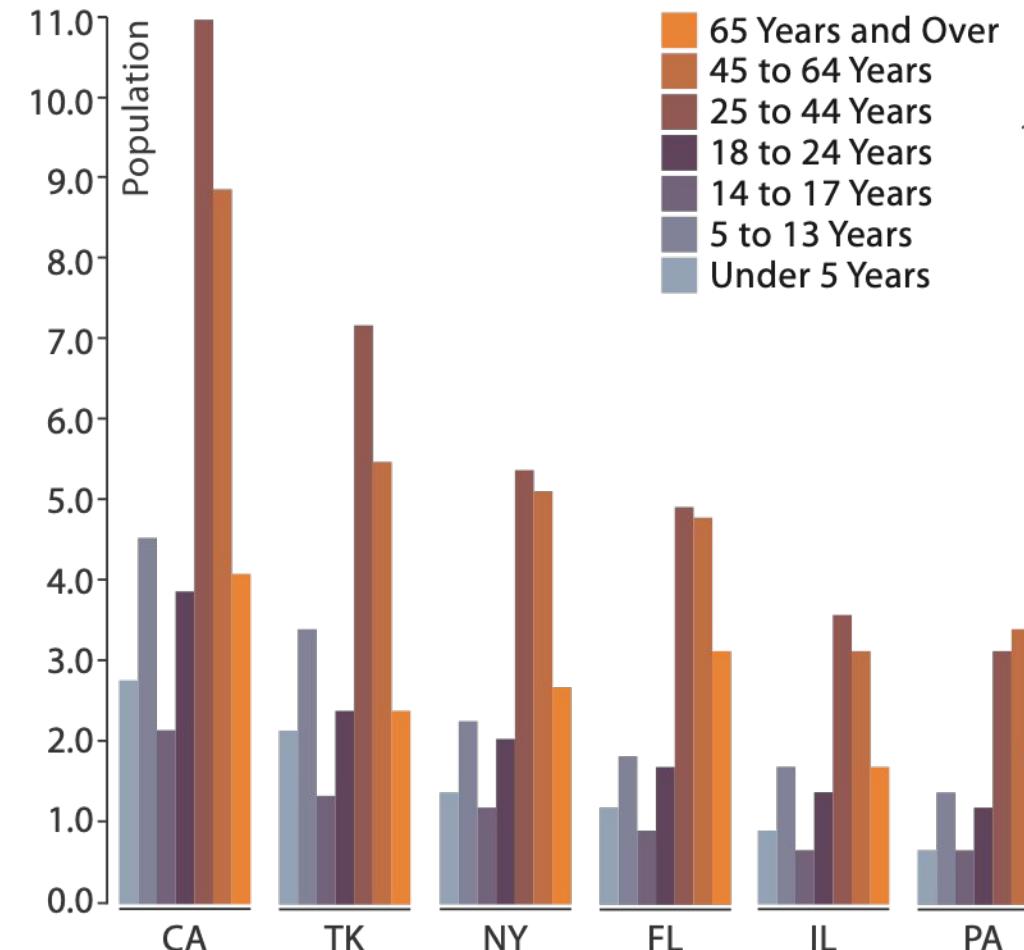
- how to divide data between views
 - split into regions by attributes
 - encodes association between items using spatial proximity
 - order of splits has major implications for what patterns are visible

→ Partition into Side-by-Side Views



Partitioning: Grouped vs small-multiple bars

- bar chart with grouped bars
 - split by state into regions
 - complex glyph within each region showing all ages
 - compare: ***easy within state, hard across ages***
- small-multiple bar charts
 - split by age into regions
 - one chart per region
 - compare: ***easy within age, harder across states***

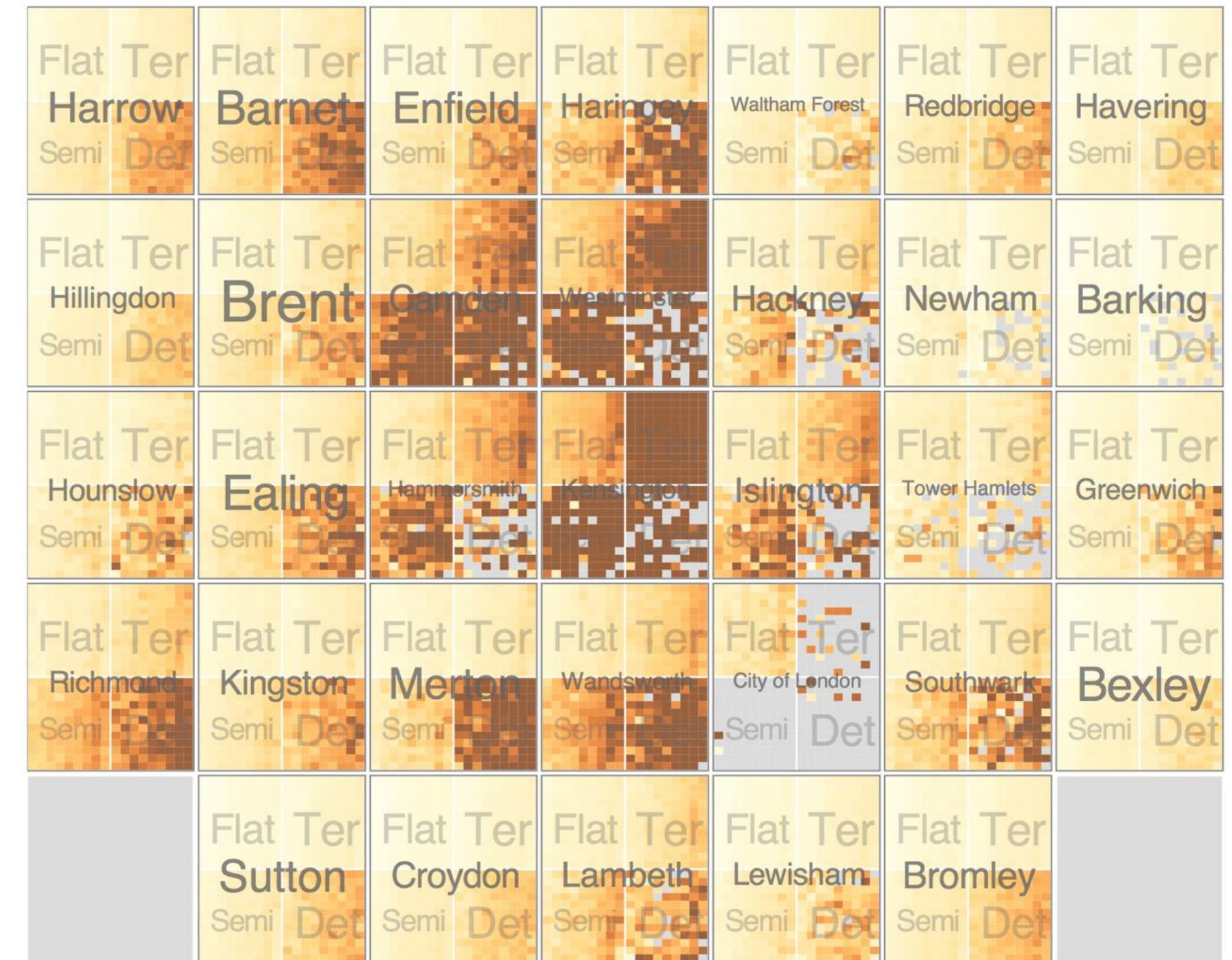


[<https://observablehq.com/@d3/grouped-bar-chart>]

Partitioning: Recursive subdivision

System: **HIVE**

- first split by borough
- then by type
 - flat, terrace, semi-detached, detached
- then time
 - years as rows
 - months as columns
- color by price
- neighborhood patterns
 - where it's expensive
 - where you pay much more for detached type



Partitioning: Recursive subdivision

System: **HIVE**

- **switch partition splits!**
 - first by dwelling type
 - flat, terrace, semi-detached, detached
 - then by borough
 - years as rows
 - months as columns
 - color by price variation
 - *now we can reveal price range variability within a borough if the user is in the hunt for a great deal!*



[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood]

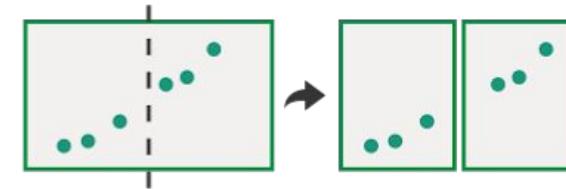
IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

To Facet

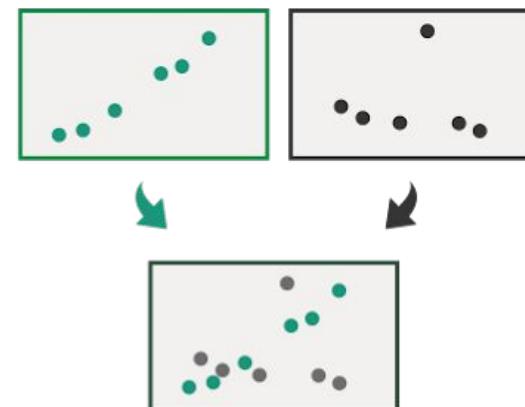
→ Juxtapose



→ Partition



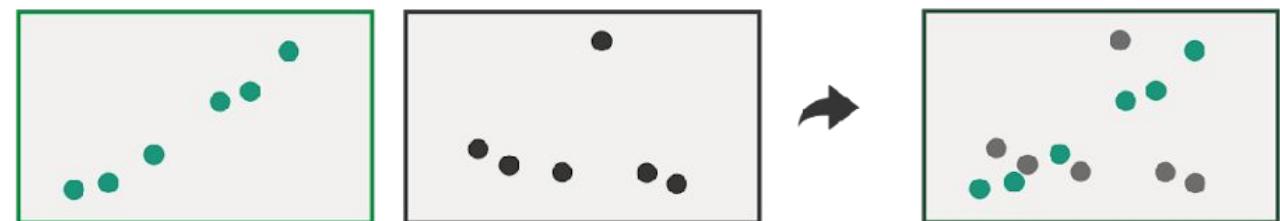
→ Superimpose



Superimpose layers

- layer: set of objects spread out over region
 - each set is visually distinguishable group
 - extent: whole view
- design choices
 - how many layers, how to distinguish?
 - encode with different, nonoverlapping channels
 - two layers achievable, three with careful design
 - small static set, or dynamic from many possible?

→ Superimpose Layers



Static visual layering

- foreground layer: roads
 - hue, size distinguishing main from minor
 - high luminance contrast from background
- background layer: regions
 - desaturated colors for water, parks, land areas
- user can selectively focus attention

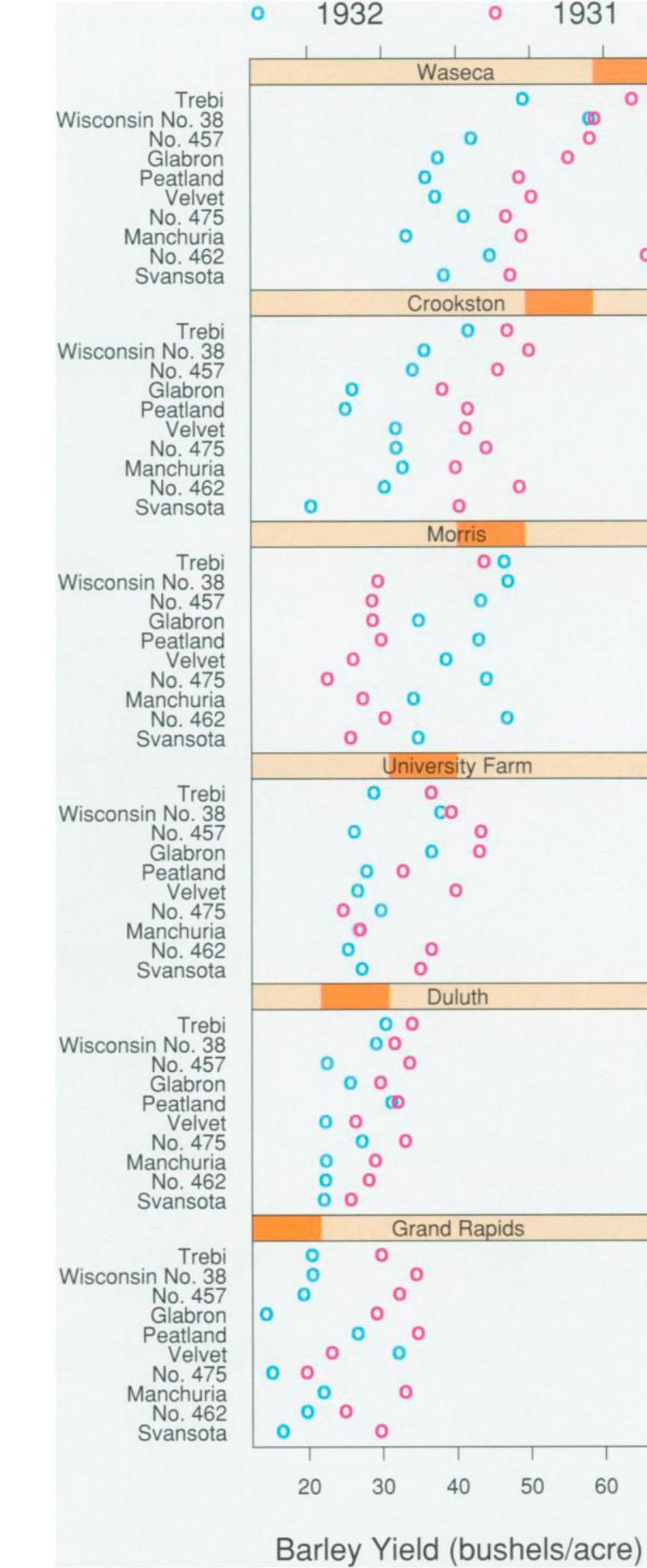


[Get it right in black and white. Stone. 2010.

<http://www.stonesc.com/wordpress/2010/03/get-it-right-in-black-and-white/>

Idiom: Trellis plots

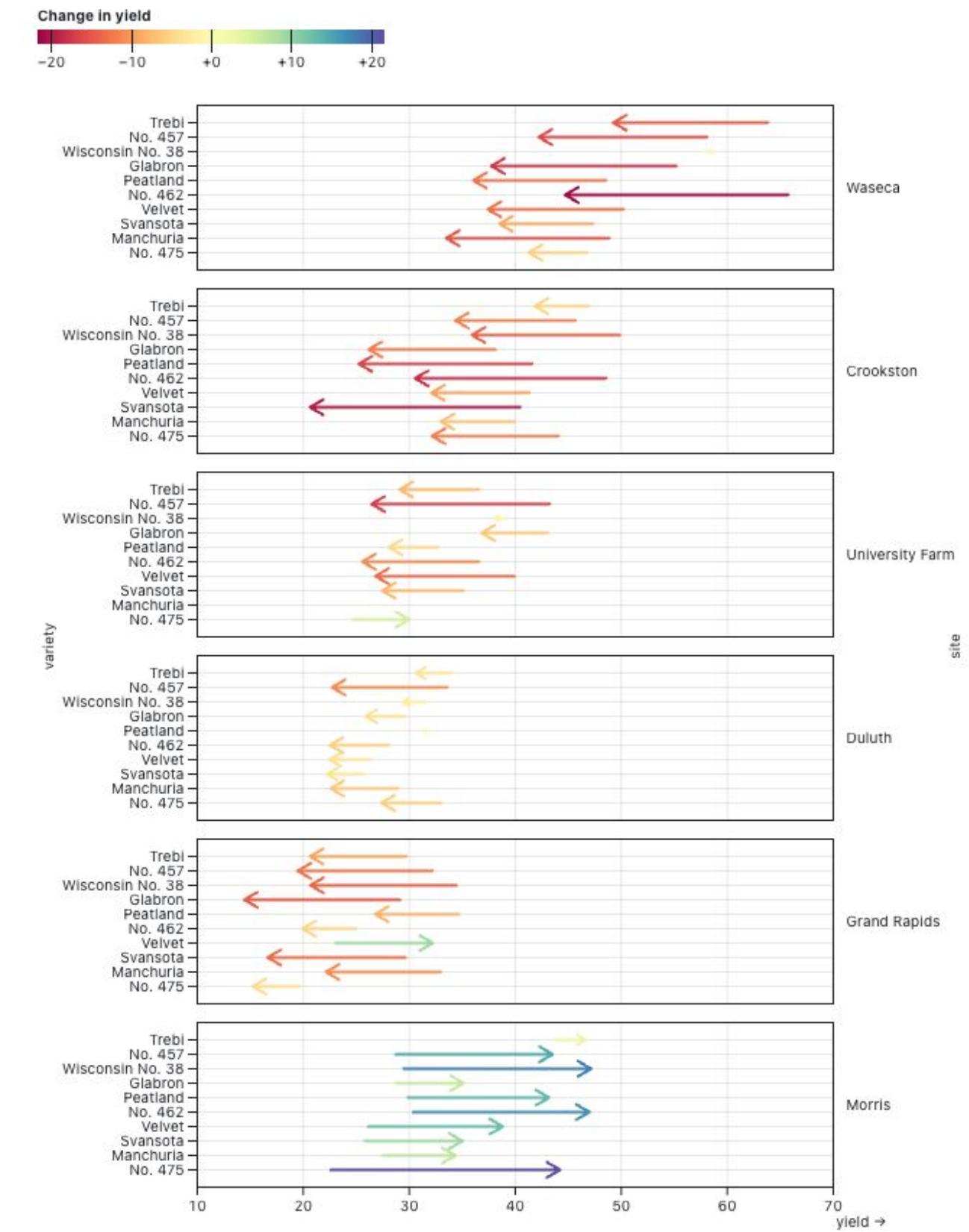
- superimpose within same frame
 - color code by year
- partitioning
 - split by site, rows are barley varieties
- main-effects ordering
 - derive value of median for group
 - order rows within view by variety median
 - order views themselves by site median



[*The Visual Design and Control of Trellis Display*. Becker, Cleveland, & Shyu.
Journal of Computational and Graphical Statistics 5(2):123-155 1996.]

Idiom: Trellis plots

- superimpose within same frame
 - color code by year
- partitioning
 - split by site, rows are barley varieties
- main-effects ordering
 - derive value of median for group
 - order rows within view by variety median
 - order views themselves by site median

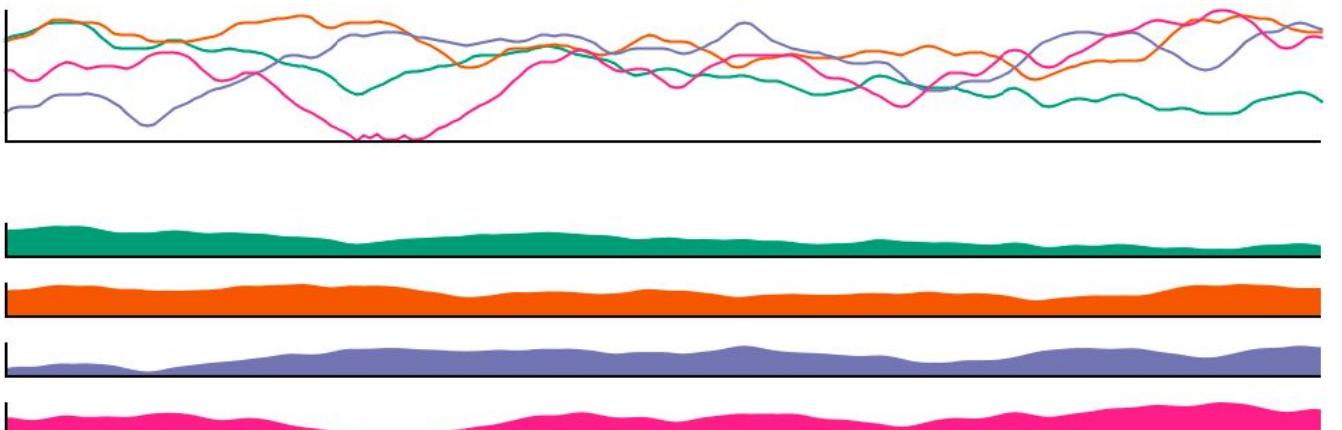


[The Visual Design and Control of Trellis Display. Becker, Cleveland, & Shyu.
Journal of Computational and Graphical Statistics 5(2):123-155 1996.]

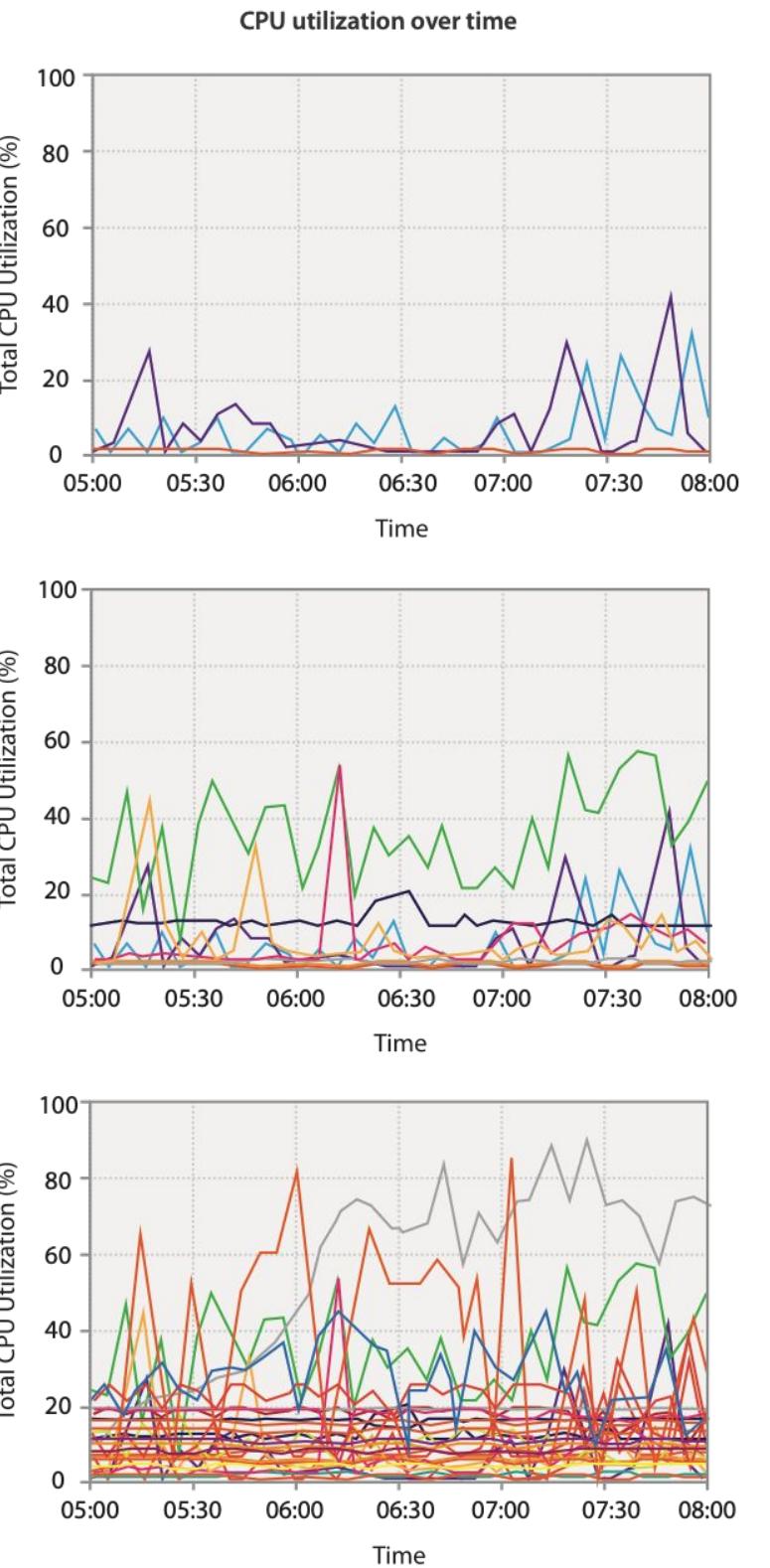
[<https://observablehq.com/@observablehq/plot-barley-trellis-arrows>]

Superimposing limits (static)

- few layers, more lines
 - up to a few dozen lines
 - but not hundreds
- superimpose vs juxtapose: empirical study
 - same size: all multiples, vs single superimposed
 - superimposed: local tasks
 - juxtaposed: global tasks, esp. for many charts



[*Graphical Perception of Multiple Time Series.*
Javed, McDonnel, and Elmqvist. IEEE
Transactions on Visualization and Computer
Graphics (Proc. IEEE InfoVis 2010) 16:6
(2010), 927–934.]



Considerations with Multiviews—Evolving Science

The mental facets involved in managing information entail:

- the duration and energy needed to familiarize oneself with the system
- the demand on the user's short-term memory
- the exertion needed for contrasting elements
- the effort involved in switching between contexts



Rules of Thumb – Evolving Science

Rule of Diversity: Implement multiple views when faced with varied attributes, models, user profiles, abstraction levels, or genres.

Rule of Complementarity: Implement multiple views when they highlight relationships or differences. Within a single view, users may have to mentally segregate and retain parts they want to juxtapose. Keeping track of and shifting between these parts can strain cognition.

Rule of Decomposition: Break down data across views to form digestible segments and shed light on interactions among various dimensions. Using multiple views allows users to approach information in a "divide and conquer" manner, supporting memory by lessening the volume of data they must process simultaneously.



DSCI 320

Project
Github Repo

 firasm	Add altairdata to the repo gitignore	cae1f19 · 7 months ago	 4 Commits
 analysis	Initial commit	8 months ago	
 code	Initial commit	8 months ago	
 data	Initial commit	8 months ago	
 images	Initial commit	8 months ago	
 report	Initial commit	8 months ago	
 ungraded	Initial commit	8 months ago	
 .gitignore	Add altairdata to the repo gitignore	7 months ago	
 .pre-commit-config.yaml	Initial commit	8 months ago	
 CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago	
 LICENSE	Initial commit	8 months ago	
 README.md	Update README.md	8 months ago	
 project_vision.md	Initial commit	8 months ago	

 README  Code of conduct 

Group {Name} - {Short Title of your project}

• Your title can change over time.

Describe your dataset in about 150-200 words

(Add a description of your dataset here, including the source)

Describe your topic/interest in about 150-200 words

(Add a description of what you're interested in exploring here)

Team Members

• Person 1: one sentence about you!
• Person 2: one sentence about you!
• Person 3: one sentence about you!
• Person 4: one sentence about you!

Images

(You should use this area to add a screenshot of an interesting view, and eventually, of your dashboard)



Package requirements

• altair
• pre-commit

References

(Add your stuff here)

 **firasm** Add altairdata to the repo gitignore

cae1f19 · 7 months ago 4 Commits

 analysis	Initial commit	8 months ago
 code	Initial commit	8 months ago
 data	Initial commit	8 months ago
 images	Initial commit	8 months ago
 report	Initial commit	8 months ago
 ungraded	Initial commit	8 months ago
 .gitignore	Add altairdata to the repo gitignore	7 months ago
 .pre-commit-config.yaml	Initial commit	8 months ago
 CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago
 LICENSE	Initial commit	8 months ago
 README.md	Update README.md	8 months ago
 project_vision.md	Initial commit	8 months ago

 README  Code of conduct 

Group {Name} - {Short Title of your project}

- Your title can change over time.

Describe your dataset in about 150-200 words

{Add a description of your dataset here, including the source}

Describe your topic/interest in about 150-200 words

{Add a description of what you're interested in exploring here}

Team Members

- Person 1: one sentence about you!
- Person 2: one sentence about you!
- Person 3: one sentence about you!
- Person 4: one sentence about you!

Images

{You should use this area to add a screenshot of an interesting view, and eventually, of your dashboard}

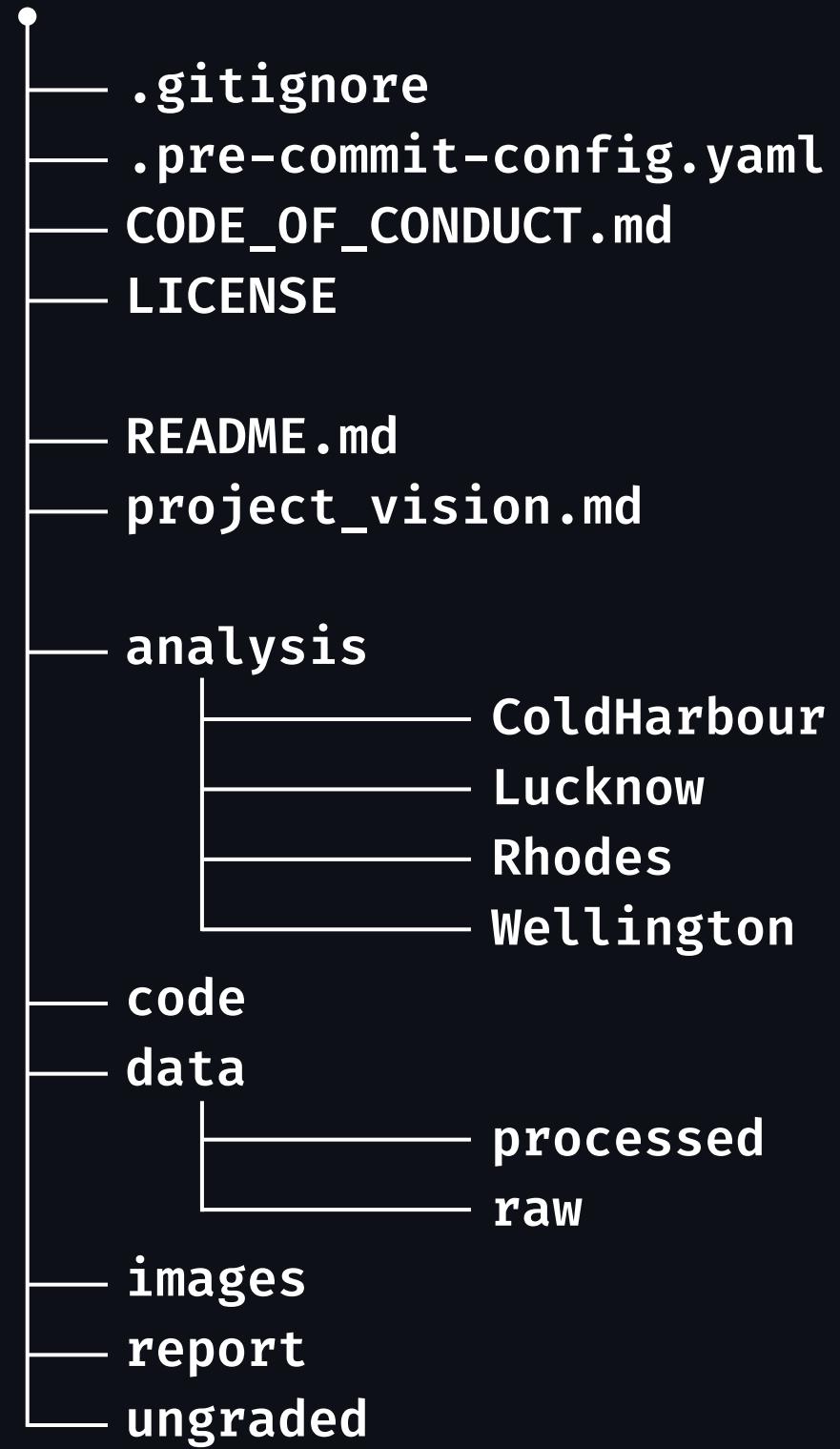


Package requirements

- altair
- pre-commit

References

{Add your stuff here}



 firasm	Add altairdata to the repo gitignore	cae1f19 · 7 months ago	4 Commits
 analysis	Initial commit	8 months ago	
 code	Initial commit	8 months ago	
 data	Initial commit	8 months ago	
 images	Initial commit	8 months ago	
 report	Initial commit	8 months ago	
 ungraded	Initial commit	8 months ago	
 .gitignore	Add altairdata to the repo gitignore	7 months ago	
 .pre-commit-config.yaml	Initial commit	8 months ago	
 CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago	
 LICENSE	Initial commit	8 months ago	
 README.md	Update README.md	8 months ago	
 project_vision.md	Initial commit	8 months ago	

README Code of conduct MIT license

Group {Name} - {Short Title of your project}

- Your title can change over time.

Describe your dataset in about 150-200 words

{Add a description of your dataset here, including the source}

Describe your topic/interest in about 150-200 words

{Add a description of what you're interested in exploring here}

Team Members

- Person 1: one sentence about you!
- Person 2: one sentence about you!
- Person 3: one sentence about you!
- Person 4: one sentence about you!

Images

{You should use this area to add a screenshot of an interesting view, and eventually, of your dashboard}

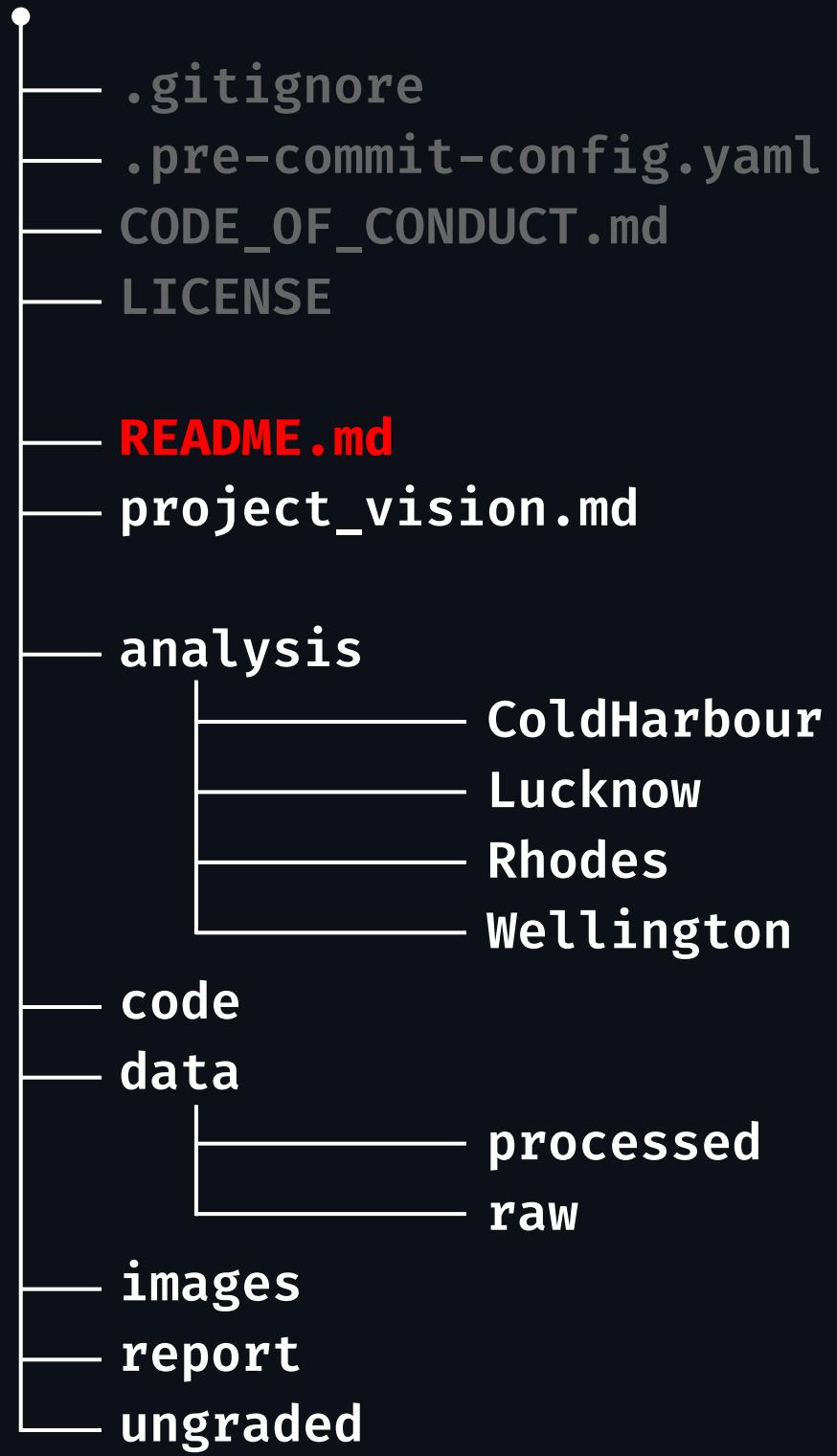


Package requirements

- altair
- pre-commit

References

{Add your stuff here}



 firasm Add altairdata to the repo gitignore	cae1f19 · 7 months ago	4 Commits
└ analysis	Initial commit	8 months ago
└ code	Initial commit	8 months ago
└ data	Initial commit	8 months ago
└ images	Initial commit	8 months ago
└ report	Initial commit	8 months ago
└ ungraded	Initial commit	8 months ago
└ .gitignore	Add altairdata to the repo gitignore	7 months ago
└ .pre-commit-config.yaml	Initial commit	8 months ago
└ CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago
└ LICENSE	Initial commit	8 months ago
└ README.md	Update README.md	8 months ago
└ project_vision.md	Initial commit	8 months ago

```
.gitignore
.pre-commit-config.yaml
CODE_OF_CONDUCT.md
LICENSE
README.md
project_vision.md
analysis
ColdHarbour
Lucknow
Rhodes
Wellington
code
data
processed
raw
images
report
ungraded
```

 firasm Add altairdata to the repo gitignore	cae1f19 · 7 months ago	4 Commits
 analysis	Initial commit	8 months ago
 code	Initial commit	8 months ago
 data	Initial commit	8 months ago
 images	Initial commit	8 months ago
 report	Initial commit	8 months ago
 ungraded	Initial commit	8 months ago
 .gitignore	Add altairdata to the repo gitignore	7 months ago
 .pre-commit-config.yaml	Initial commit	8 months ago
 CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago
 LICENSE	Initial commit	8 months ago
 README.md	Update README.md	8 months ago
 project_vision.md	Initial commit	8 months ago

```
.gitignore
.pre-commit-config.yaml
CODE_OF_CONDUCT.md
LICENSE
README.md
project_vision.md

analysis
ColdHarbour
Lucknow
Rhodes
Wellington
code
data
processed
raw
images
report
ungraded
```

 firasm Add altairdata to the repo gitignore	cae1f19 · 7 months ago	4 Commits
📁 analysis	Initial commit	8 months ago
📁 code	Initial commit	8 months ago
📁 data	Initial commit	8 months ago
📁 images	Initial commit	8 months ago
📁 report	Initial commit	8 months ago
📁 ungraded	Initial commit	8 months ago
📄 .gitignore	Add altairdata to the repo gitignore	7 months ago
📄 .pre-commit-config.yaml	Initial commit	8 months ago
📄 CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago
📄 LICENSE	Initial commit	8 months ago
📄 README.md	Update README.md	8 months ago
📄 project_vision.md	Initial commit	8 months ago

```
.gitignore
.pre-commit-config.yaml
CODE_OF_CONDUCT.md
LICENSE
README.md
project_vision.md

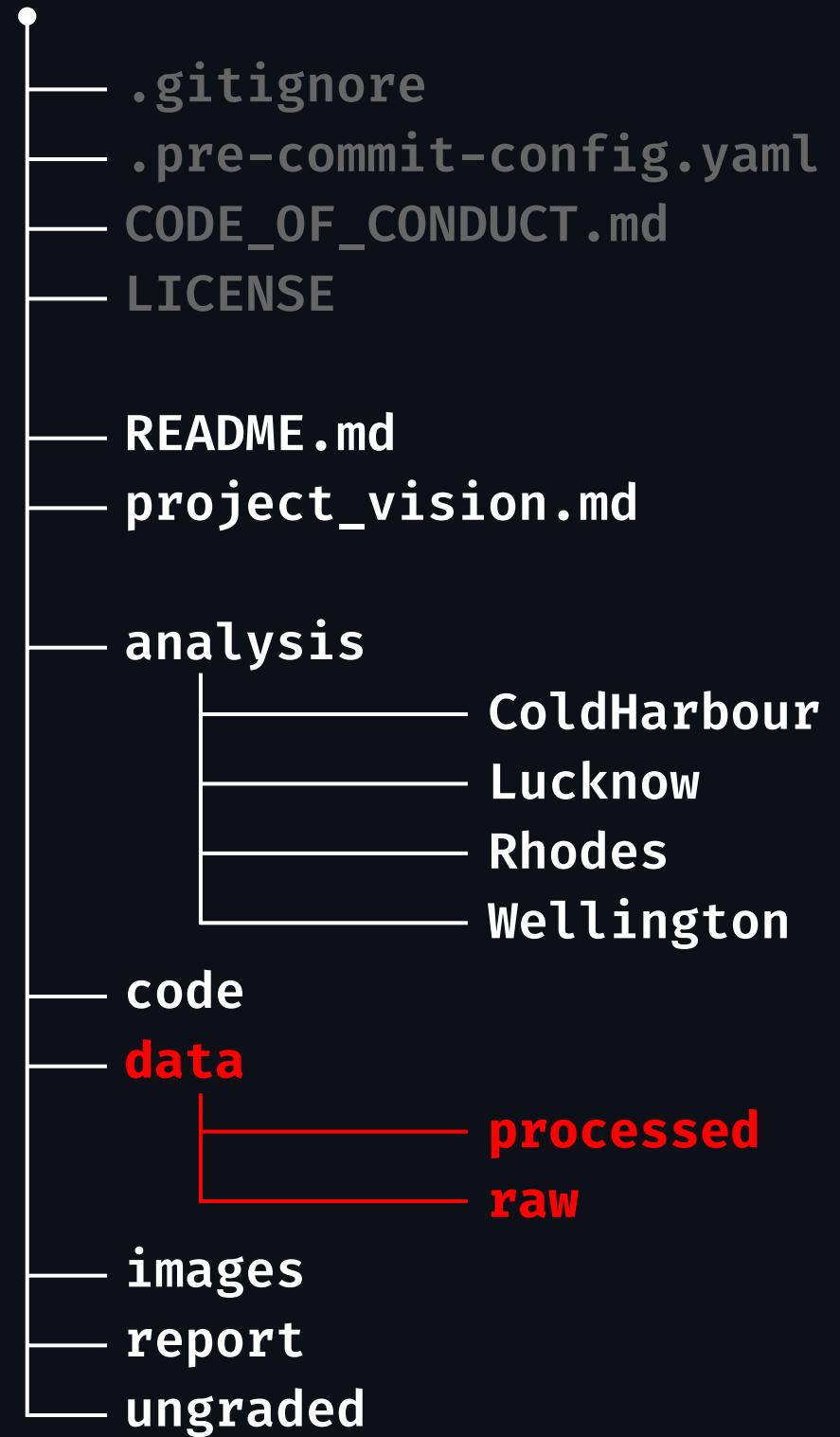
analysis
ColdHarbour
Lucknow
Rhodes
Wellington

code

data
processed
raw

images
report
ungraded
```

 firasm Add altairdata to the repo gitignore	cae1f19 · 7 months ago	4 Commits
📁 analysis	Initial commit	8 months ago
📁 code	Initial commit	8 months ago
📁 data	Initial commit	8 months ago
📁 images	Initial commit	8 months ago
📁 report	Initial commit	8 months ago
📁 ungraded	Initial commit	8 months ago
📄 .gitignore	Add altairdata to the repo gitignore	7 months ago
📄 .pre-commit-config.yaml	Initial commit	8 months ago
📄 CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago
📄 LICENSE	Initial commit	8 months ago
📄 README.md	Update README.md	8 months ago
📄 project_vision.md	Initial commit	8 months ago



 firasm Add altairdata to the repo gitignore	cae1f19 · 7 months ago	4 Commits
📁 analysis	Initial commit	8 months ago
📁 code	Initial commit	8 months ago
📁 data	Initial commit	8 months ago
📁 images	Initial commit	8 months ago
📁 report	Initial commit	8 months ago
📁 ungraded	Initial commit	8 months ago
📄 .gitignore	Add altairdata to the repo gitignore	7 months ago
📄 .pre-commit-config.yaml	Initial commit	8 months ago
📄 CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago
📄 LICENSE	Initial commit	8 months ago
📄 README.md	Update README.md	8 months ago
📄 project_vision.md	Initial commit	8 months ago

```
.gitignore
.pre-commit-config.yaml
CODE_OF_CONDUCT.md
LICENSE

README.md
project_vision.md

analysis
ColdHarbour
Lucknow
Rhodes
Wellington

code

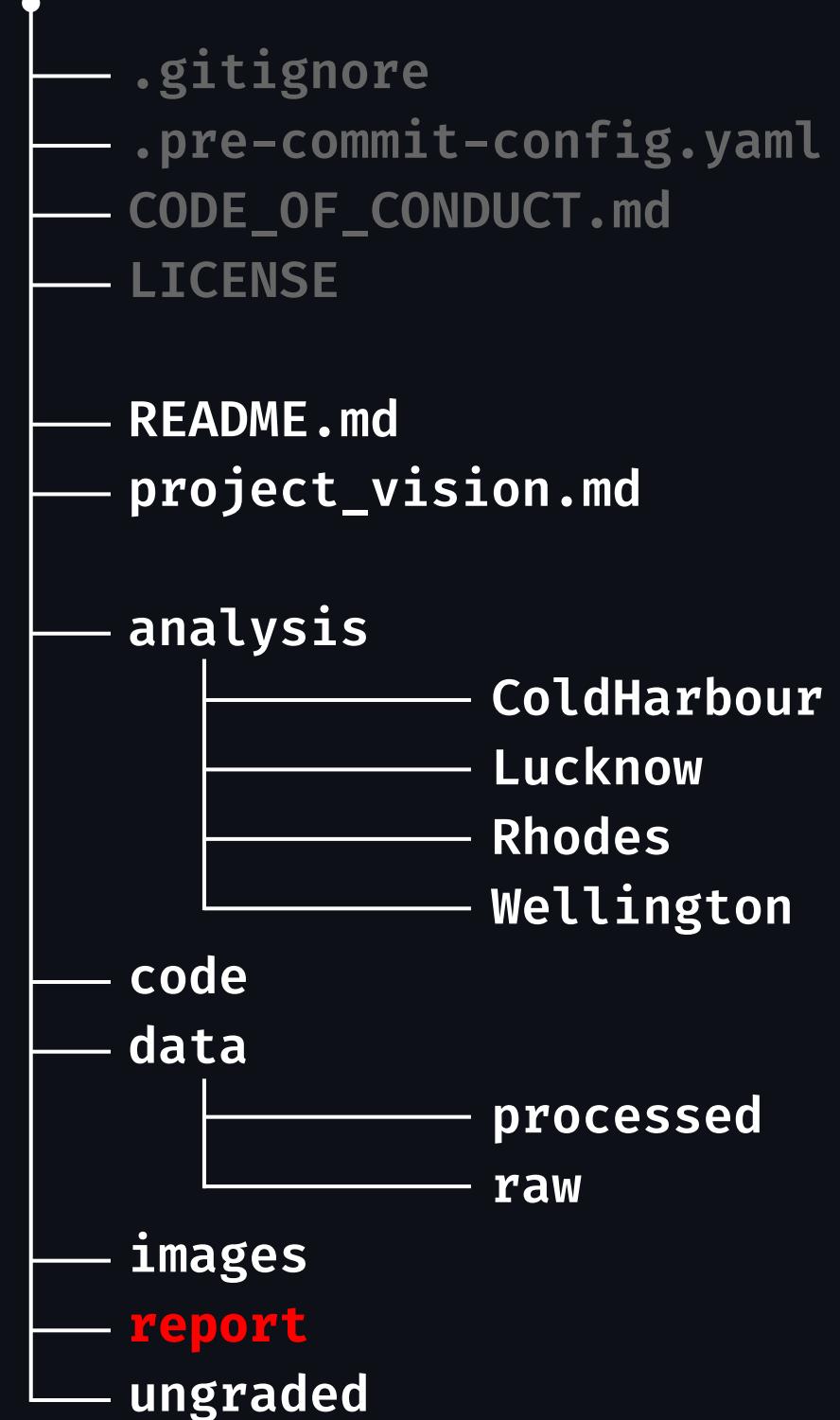
data
processed
raw

images

report

ungraded
```

 firasm Add altairdata to the repo gitignore	cae1f19 · 7 months ago	4 Commits
└ analysis	Initial commit	8 months ago
└ code	Initial commit	8 months ago
└ data	Initial commit	8 months ago
└ images	Initial commit	8 months ago
└ report	Initial commit	8 months ago
└ ungraded	Initial commit	8 months ago
└ .gitignore	Add altairdata to the repo gitignore	7 months ago
└ .pre-commit-config.yaml	Initial commit	8 months ago
└ CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago
└ LICENSE	Initial commit	8 months ago
└ README.md	Update README.md	8 months ago
└ project_vision.md	Initial commit	8 months ago



 firasm Add altairdata to the repo gitignore	cae1f19 · 7 months ago	4 Commits
📁 analysis	Initial commit	8 months ago
📁 code	Initial commit	8 months ago
📁 data	Initial commit	8 months ago
📁 images	Initial commit	8 months ago
📁 report	Initial commit	8 months ago
📁 ungraded	Initial commit	8 months ago
📄 .gitignore	Add altairdata to the repo gitignore	7 months ago
📄 .pre-commit-config.yaml	Initial commit	8 months ago
📄 CODE_OF_CONDUCT.md	Update CODE_OF_CONDUCT.md	8 months ago
📄 LICENSE	Initial commit	8 months ago
📄 README.md	Update README.md	8 months ago
📄 project_vision.md	Initial commit	8 months ago

```
.gitignore
.pre-commit-config.yaml
CODE_OF_CONDUCT.md
LICENSE

README.md
project_vision.md

analysis
ColdHarbour
Lucknow
Rhodes
Wellington

code

data
processed
raw

images

report

ungraded
```