Visualization for Data Science
Discourse with Data II
Interaction

Adminstrivia

- No lab this week
  - I heard you ooooo!!!
    - No DS 3, either split the weight between DS1/2 OR move to project OR final.
  - Work on your Project deliverable during this time.
- Tomorrow office hours online
- Technical
  - We've spent roughly half of the class time on tooling, this will shift. There will be some tutorials, but we expect most of your programming learning to come outside of class.
- Theory
  - We will start spending more time on the WHY of info. Viz so expect to sometimes being required to have assigned readings before class.

The Human-Information Interaction Epistemic Cycle

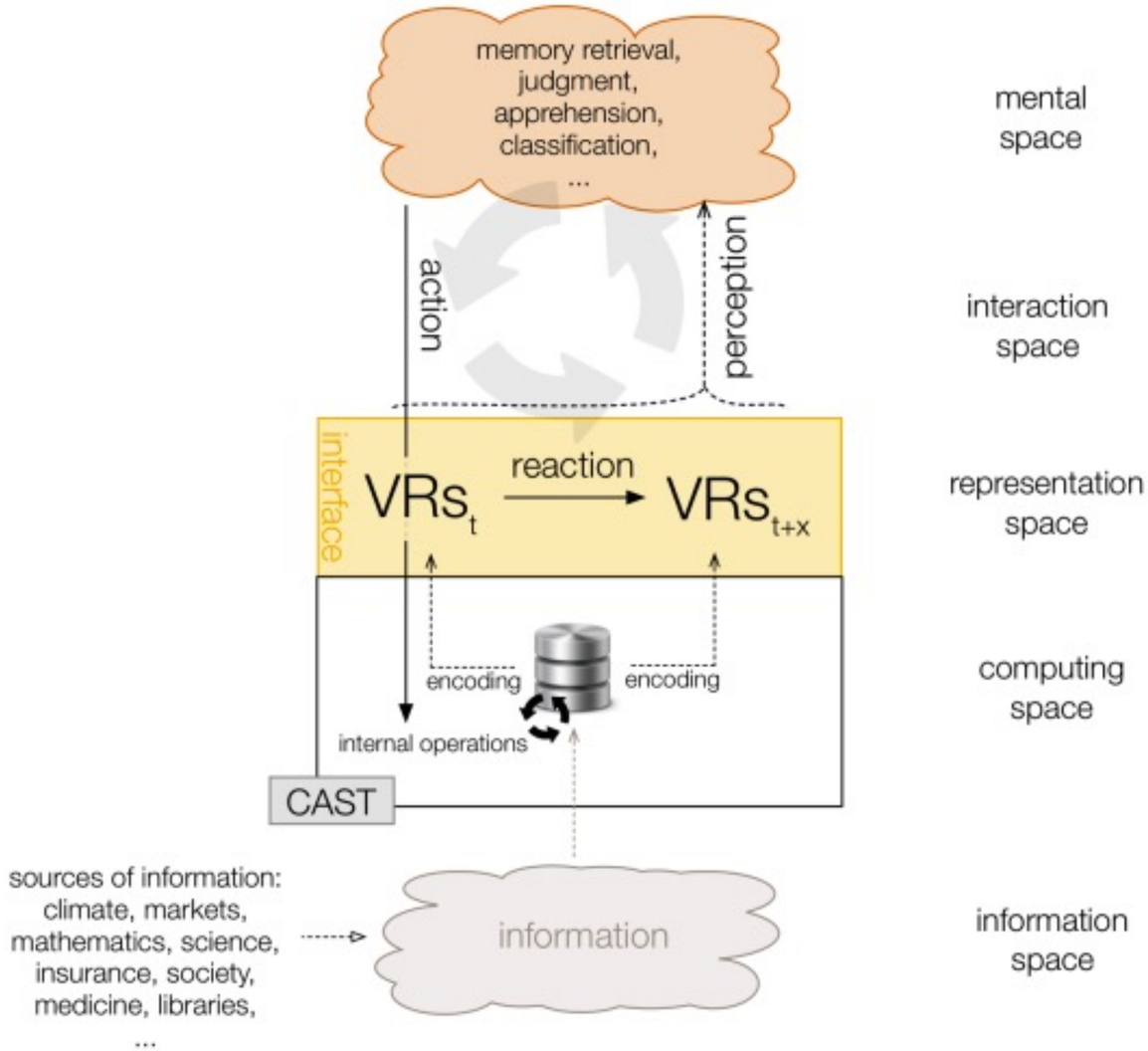
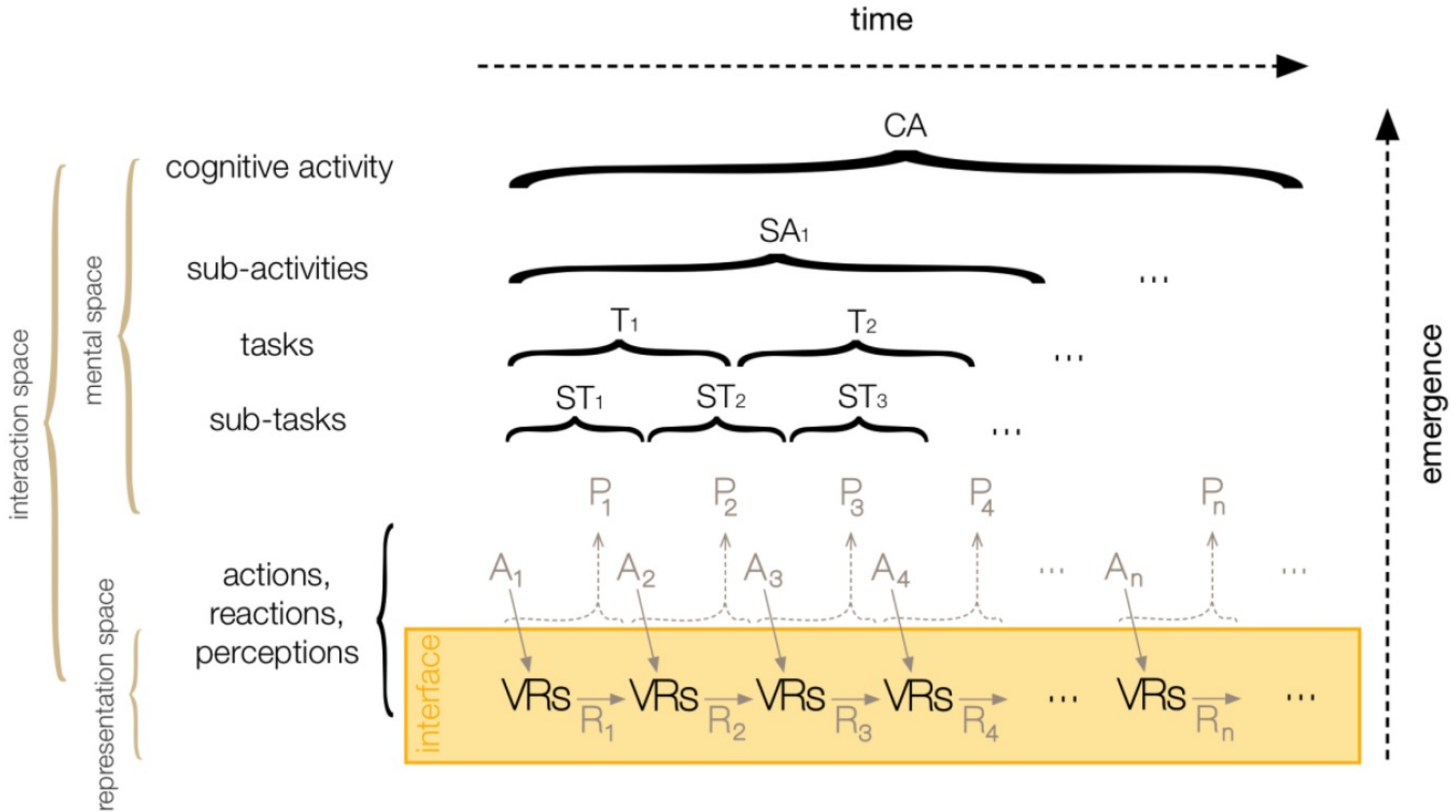


Figure 3: The Human-Information Interaction Epistemic Cycle

Sedig & Parsons

The Hierarchical Structure of a Complex Cognitive Activity



Sedig & Parsons

Approaches to Supporting the Discourse with Large Datasets

- Faceting – juxtapose, partition, superimpose
- Interaction – manipulate the external view
- Reduce
  - embed additional data into smaller glyphs
  - reduce amount of attributes visualized (e.g. maps reduces from 3D to 2D)

How to handle complexity

→ *Derive*

- derive new data to show within view
- change view over time
- facet across multiple views
- reduce items/attributes within single view

Manipulate

Change

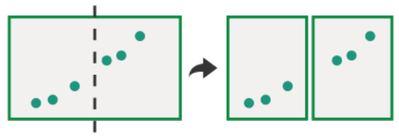
Select

Navigate

Facet

Juxtapose

Partition

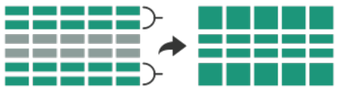


Superimpose

Reduce

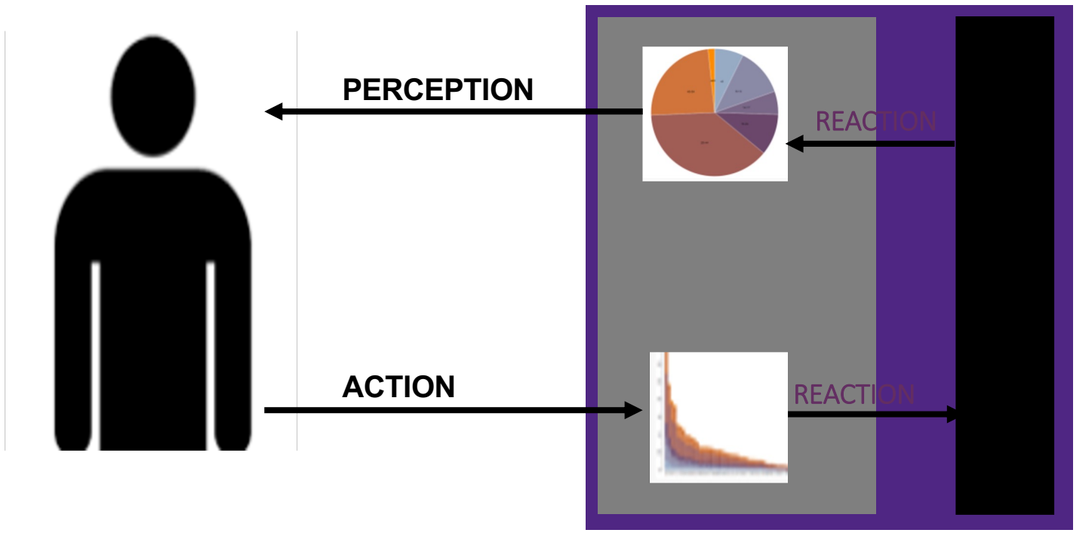
Filter

Aggregate



Embed

Interaction



Interaction

Why Interaction?

Interactions allows us to

- control flow of data,
- be active participants in the analysis of data,
- adjust features of the tool to suit the user’s needs,
- visualization of large amounts of data,
- extend/amplifies users’ sensemaking abilities,
- increase engagement (vis becomes personal to user),
- improve the discourse with information,

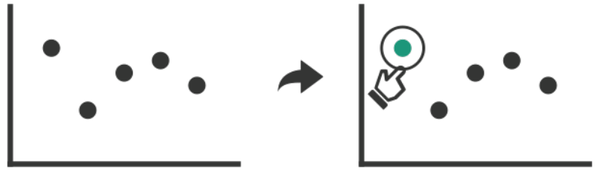
Learning Outcomes

- Describe how interaction can be used for changing data representation, transformation, and communication.
- Describe various interaction techniques and select the technique most appropriate for a given problem.
- Discuss the role of interaction in visualizations and its strength and limitations in data science
- Evaluate the effectiveness of an interaction technique based on the human-computer interaction (HCI) principle of affordances.
- Identify situations where coordinated views would be effective.
- Critique existing visualizations and suggest improvements and refinements.

Manipulate

Change over Time

Select



Navigate

→ *Zoom*
Geometric

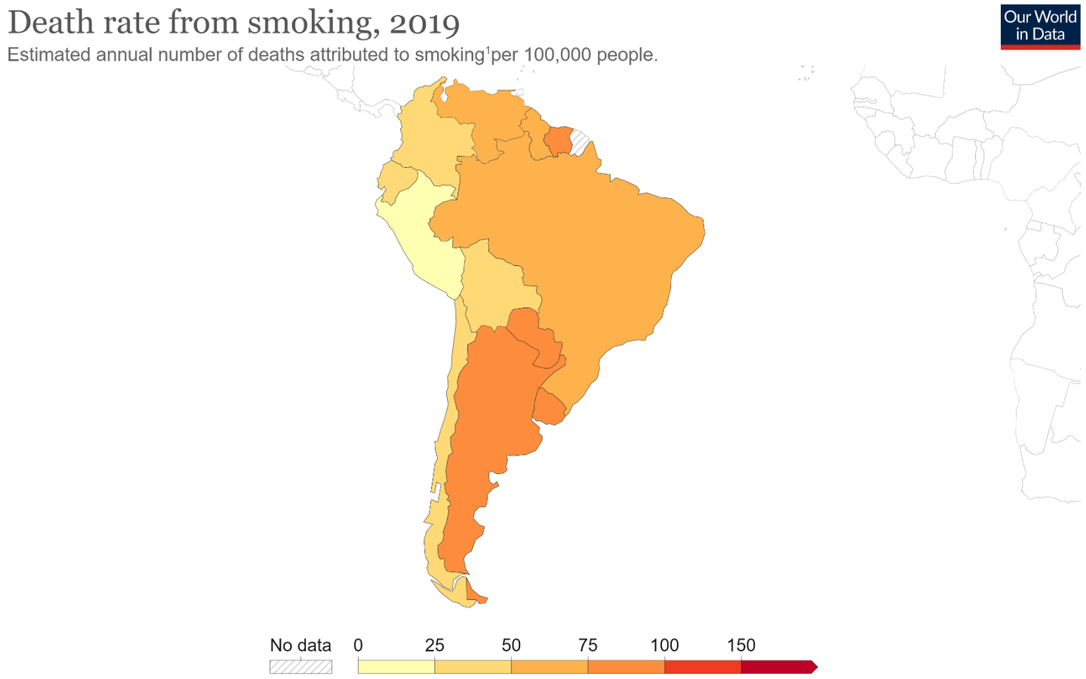
→ *Pan/Translate*

→ *Constrained*

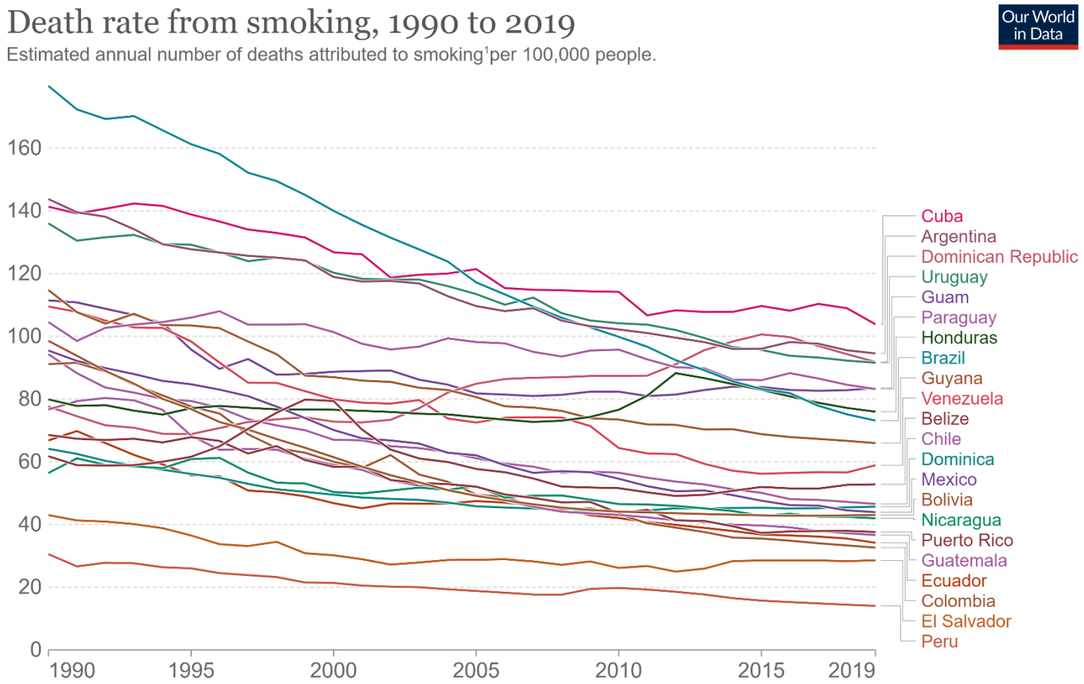
Change over time

- change any of these choices
  - encoding itself: same data, different viz. technique, e.g. first rep as a bar then as a map
  - parameters
  - arrange: rearrange, reorder, alignment
  - aggregation level, what is filtered...
  - interaction entails change
- powerful & flexible

Idiom: Change **Encodings**



1. Smoking: Tobacco smoking is the practice of burning tobacco and ingesting the smoke that is produced. Smoking is a risk factor for many diseases including heart attacks, strokes and cancer. It is the leading risk factor for death in men, globally.



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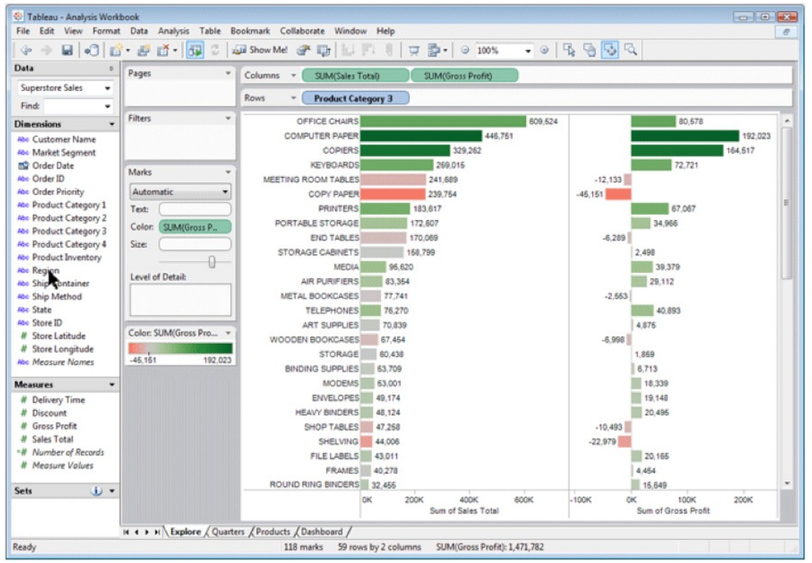
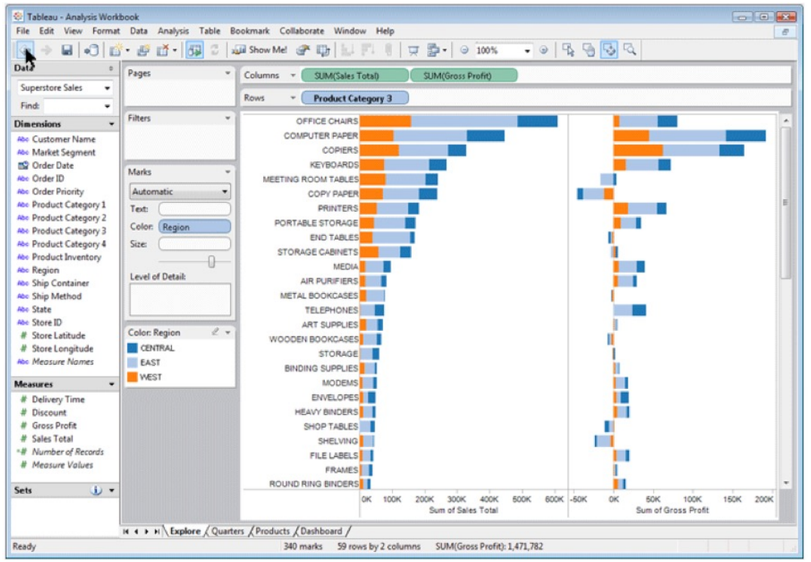
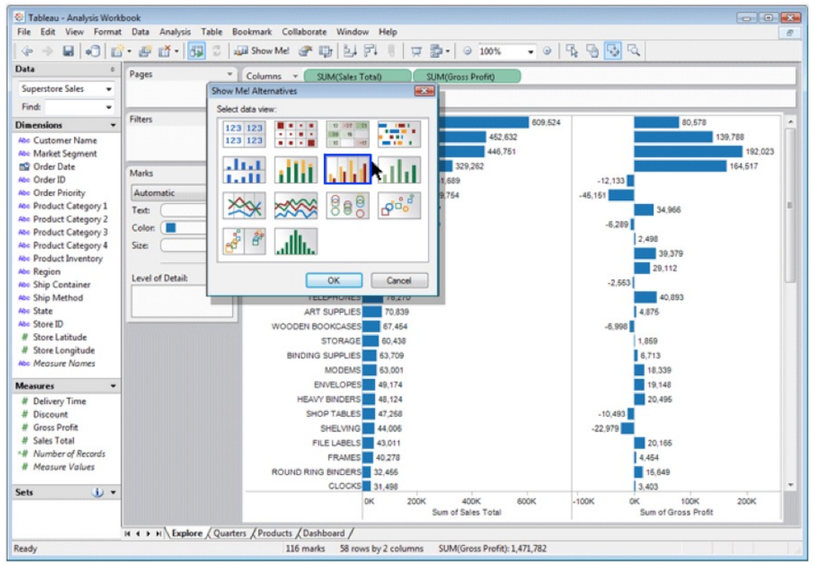
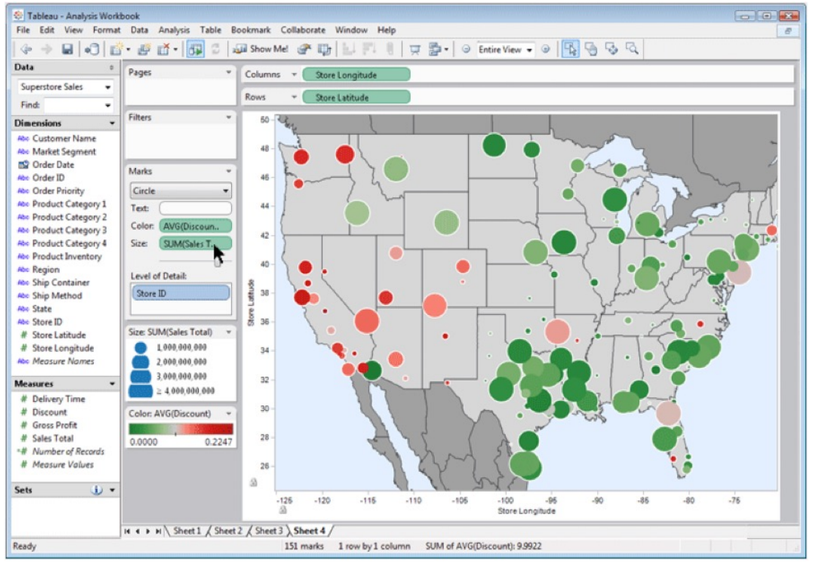
https://ourworldindata.org/smoking

Idiom: Change **Encodings**







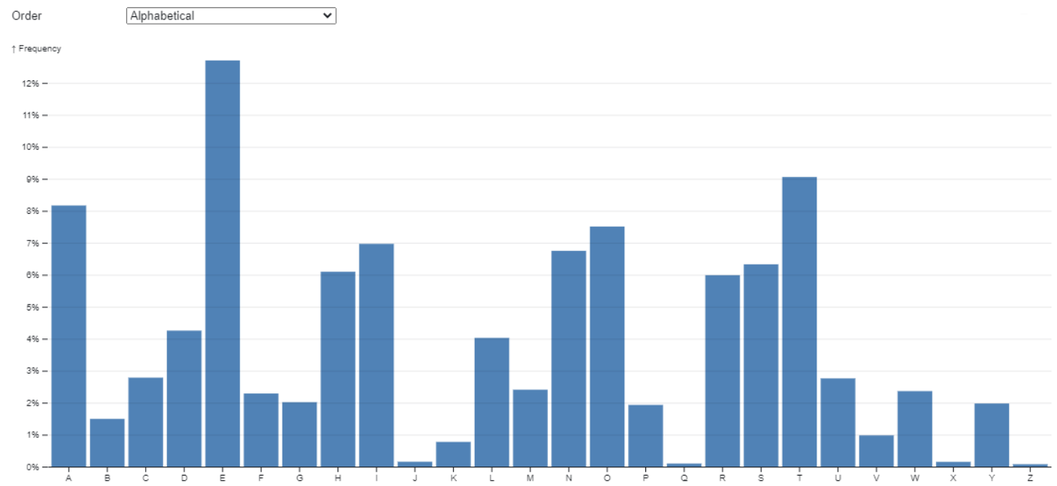


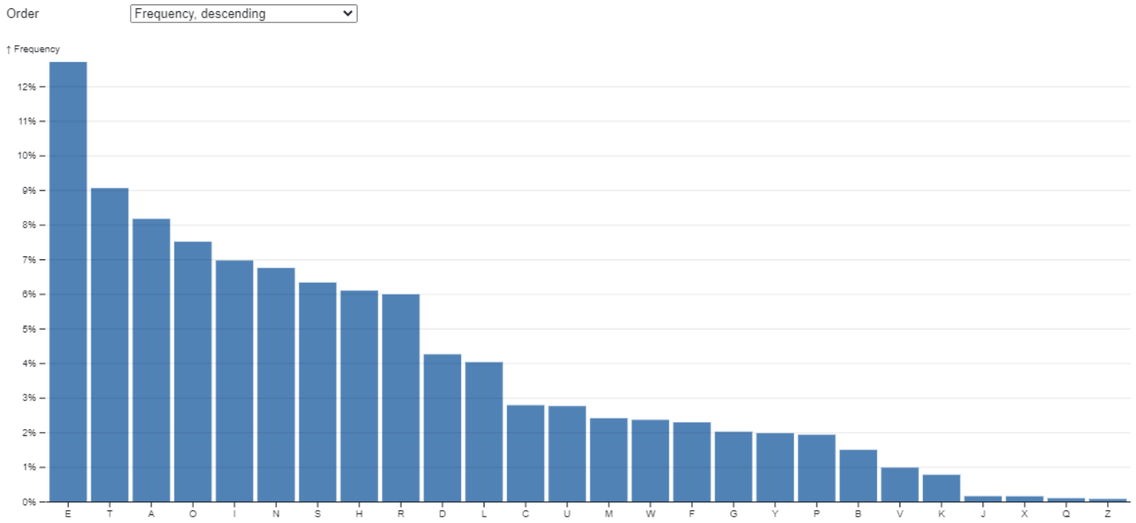
made with Tableau, http://tableausoftware.com

Idiom: **Change order/arrangement**

made with D3

- what: simple table
- how: data-driven reordering
- why: find extreme values, trends





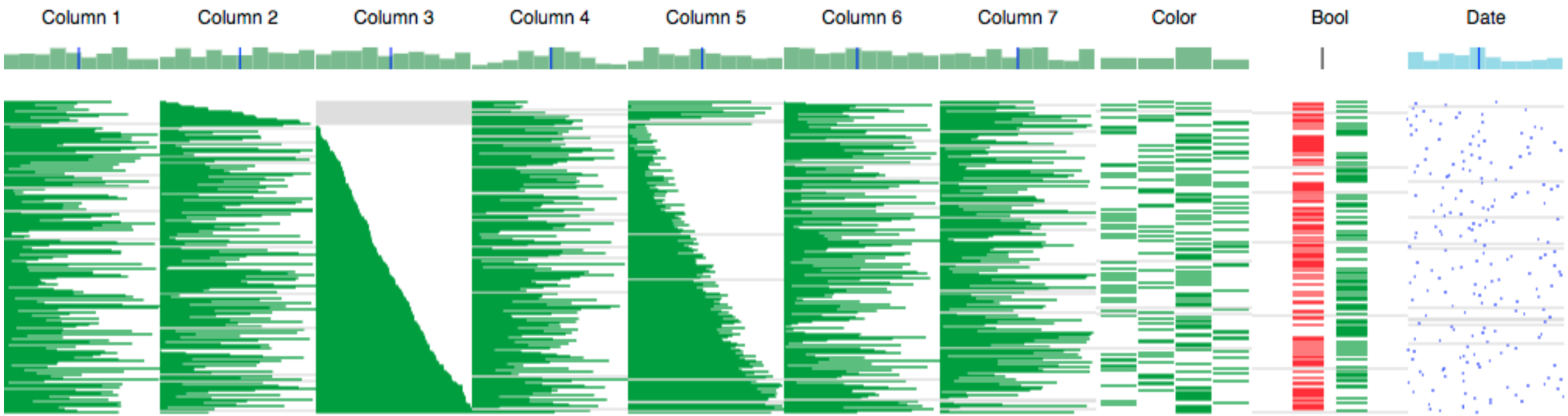
https://observablehq.com/@d3/bar-chart-transitions?collection=@d3/charts

Idiom: **Change order/arrangement**

System: **DataStripes**

made with D3

- what: table with many attributes
- how: data-driven reordering by selecting column
- why: find correlations between attributes

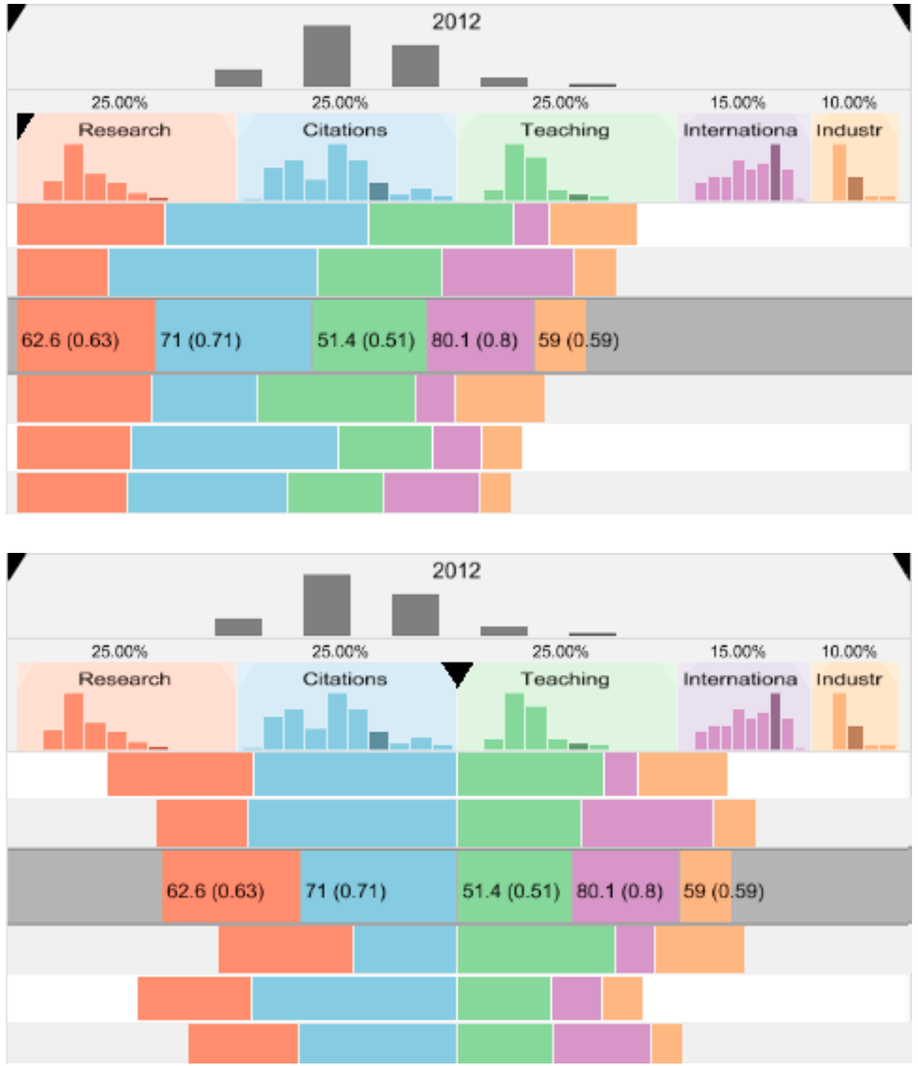


http://carlmanaster.github.io/datastripes/

Idiom: **Change alignment**

System: **LineUp**

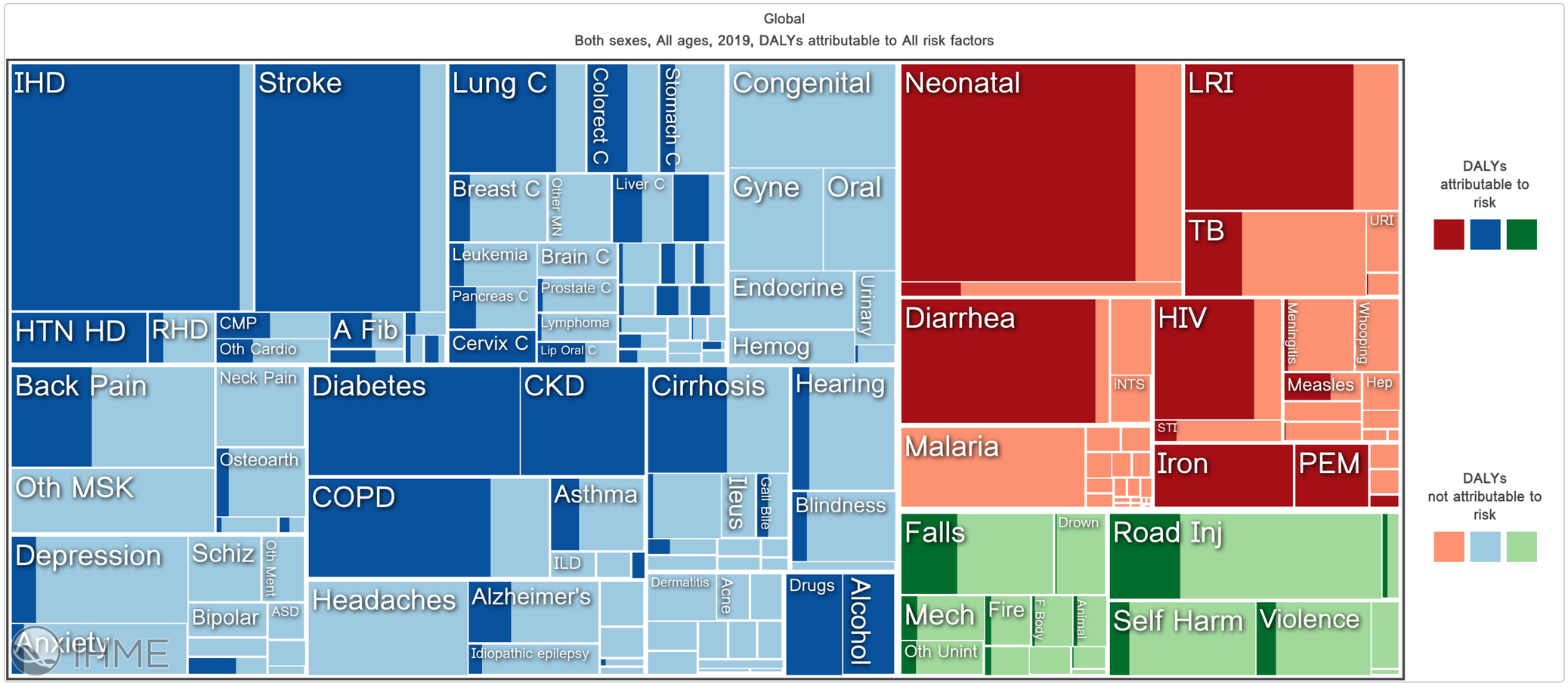
- stacked bars
  - easy to compare
    - first segment
    - total bar
- align to different segment
  - supports flexible comparison



[LineUp: Visual Analysis of Multi-Attribute Rankings.Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.]

Idiom: Change **Data and/or Parameters**

- widgets and controls
  - sliders, buttons, radio buttons, checkboxes, dropdowns/comboboxes

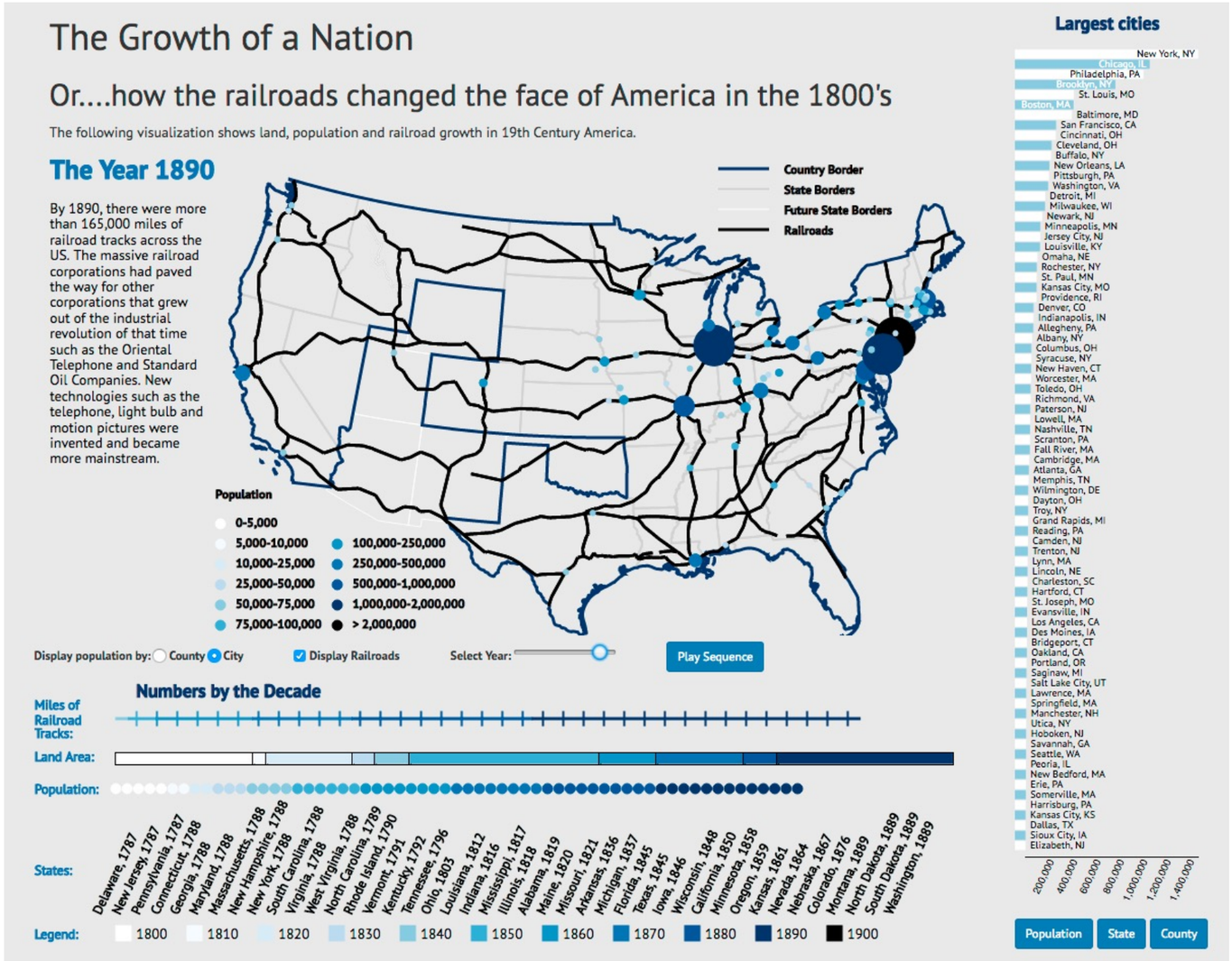


https://vizhub.healthdata.org/gbd-compare/

Idiom: Change **Data and/or Parameters**

made with D3

- pros
  - clear affordances, self-documenting (with labels)
- cons
  - uses screen space
- design choices
  - separated vs interleaved
    - controls & canvas

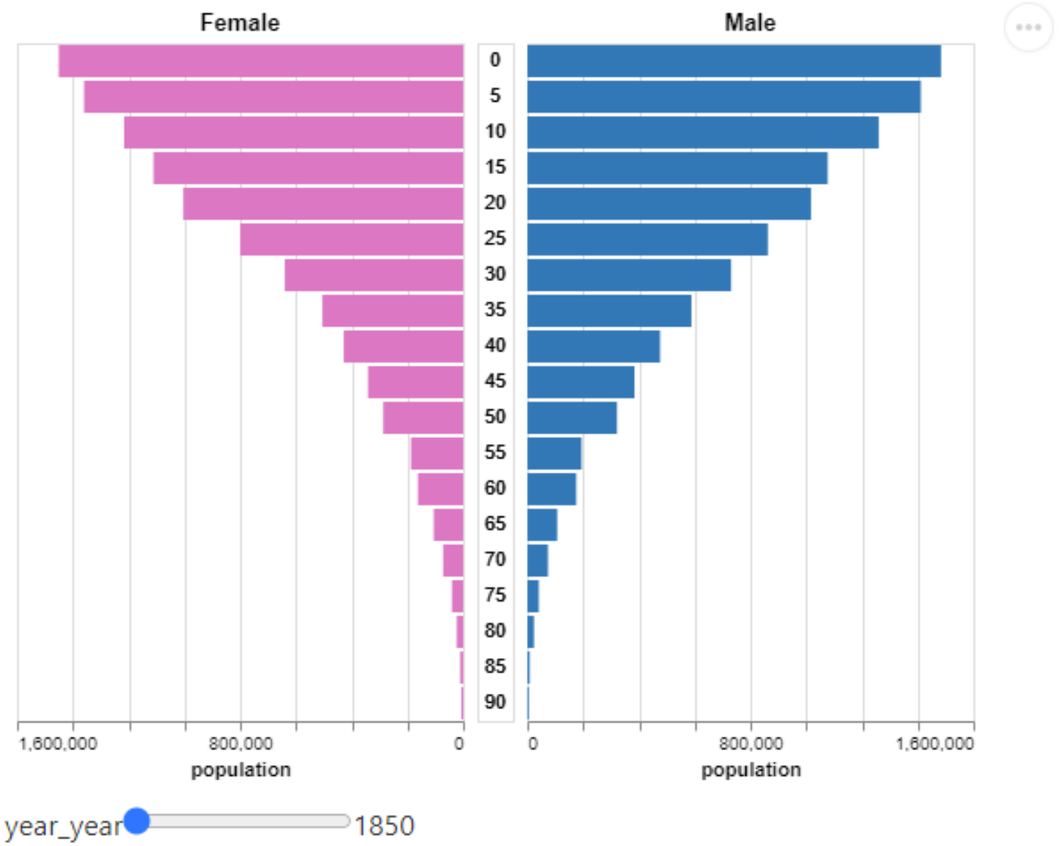


http://laurenwood.github.io/

Idiom: Change **Data and/or Parameters**

US Population Pyramid Over Time

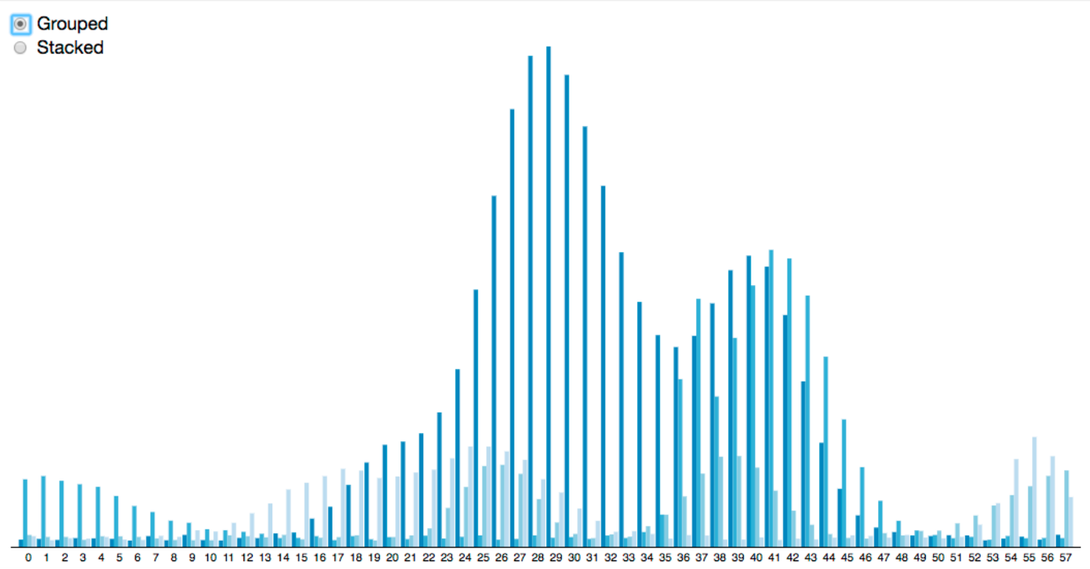
A population pyramid shows the distribution of age groups within a population. It uses a slider widget that is bound to the year to visualize the age distribution over time.

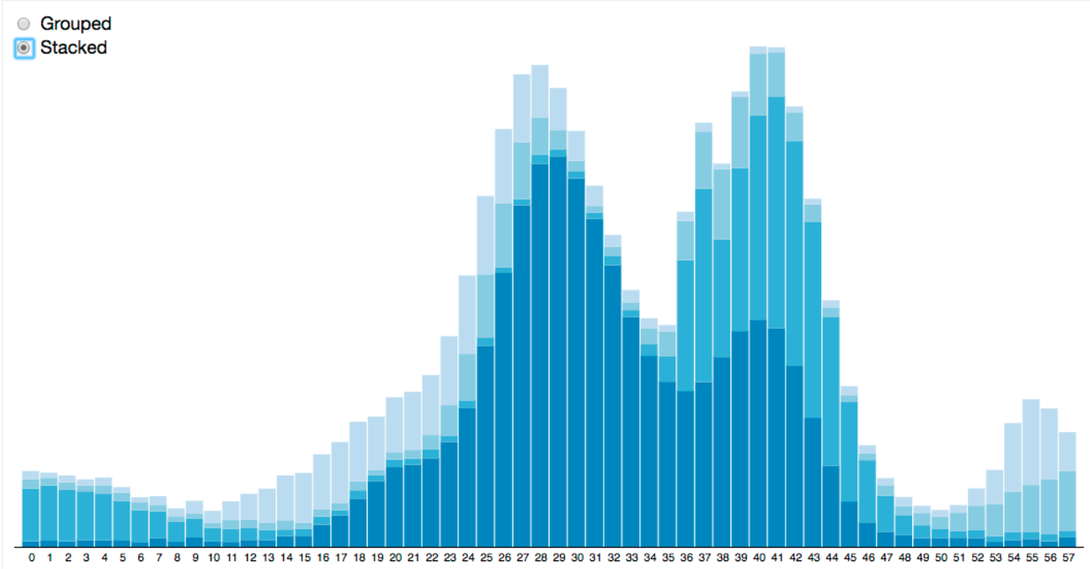


https://altair-viz.github.io/gallery/us_population_pyramid_over_time.html

Idiom: **Animated transitions - visual encoding change**

- smooth transition from one state to another
  - alternative to jump cuts, supports item tracking
    - best case for animation
  - staging to reduce cognitive load

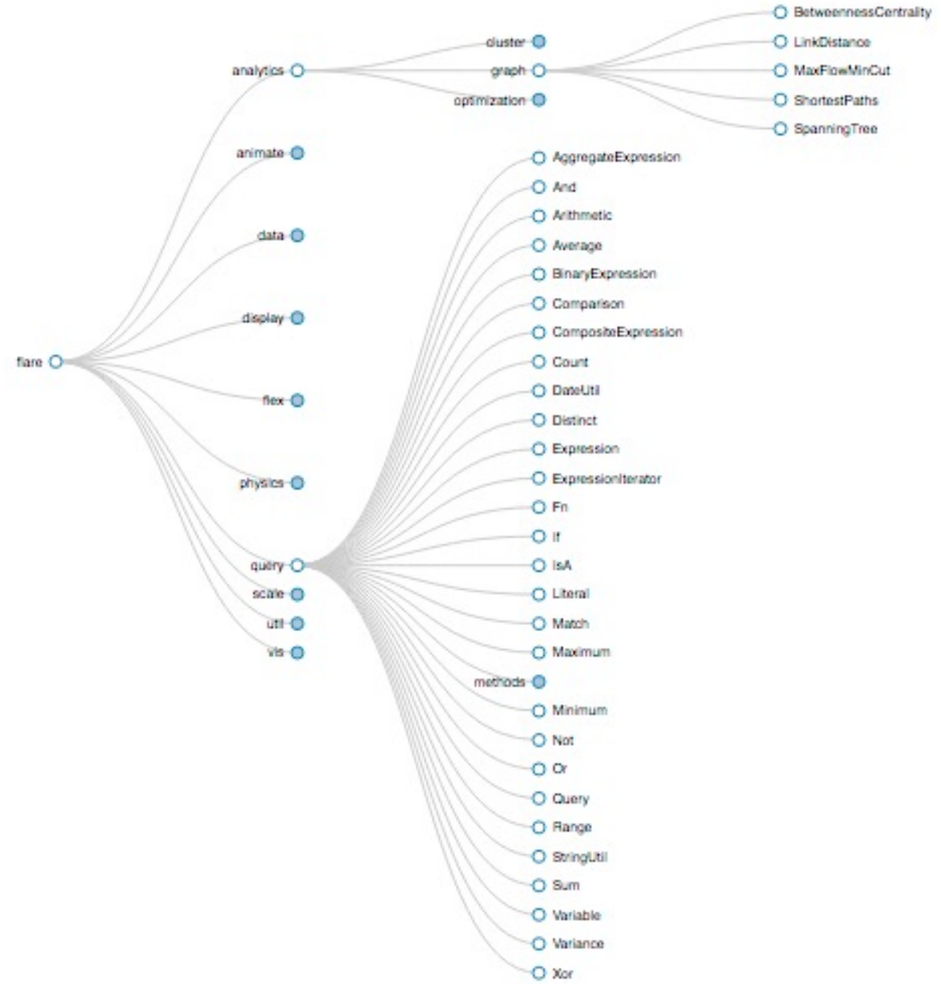




https://observablehq.com/@d3/stacked-to-grouped-bars

Idiom: **Animated transition - tree detail**

- animated transition
  - network drilldown/rollup

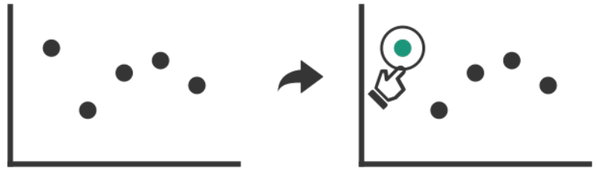


https://observablehq.com/@d3/collapsible-tree

Manipulate

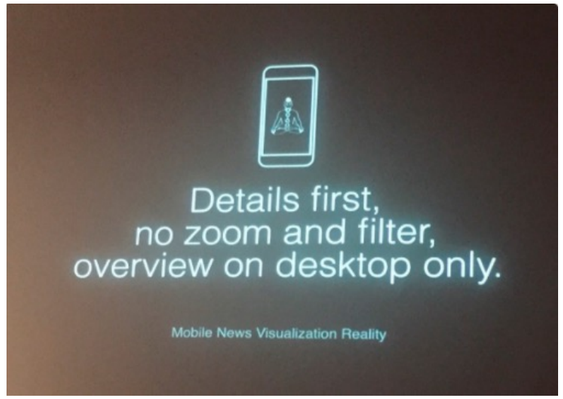
Change over Time

Select



Interaction technology

- what do you design for?
  - mouse & keyboard on desktop?
    - large screens, hover, multiple clicks
  - touch interaction on mobile?
    - small screens, no hover, just tap
  - gestures from video / sensors?
    - ergonomic reality vs movie bombast
  - eye tracking?

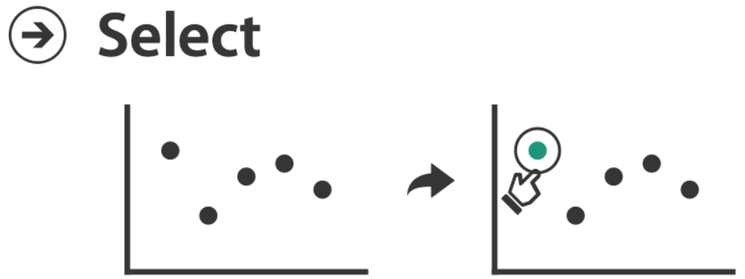


Data visualization and the news - Gregor Aisch (37 min)
vimeo.com/182590214

I Hate Tom Cruise - Alex Kauffmann (5 min)

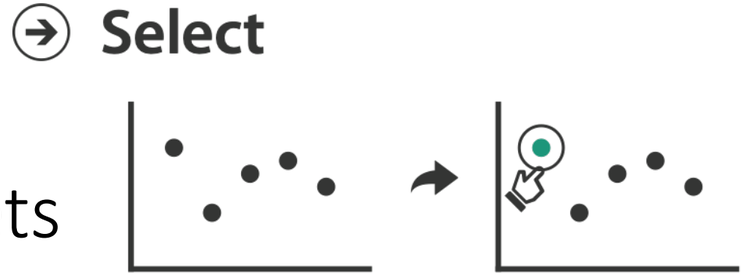
www.youtube.com/watch?v=QXLfT9sFcbc

Selection



- selection: basic operation for most interaction
- design choices
  - how many selection types?
    - interaction modalities
      - click/tap (heavyweight) vs hover (lightweight but not available on most touchscreens)
      - multiple click types (shift-click, option-click, …)
      - proximity beyond click/hover (touching vs nearby vs distant)
    - application semantics
      - adding to selection set vs replacing selection
      - can selection be null?
        - ex: toggle so nothing selected if click on background
      - primary vs secondary (ex: source/target nodes in network)
      - group membership (add/delete items, name group, …)

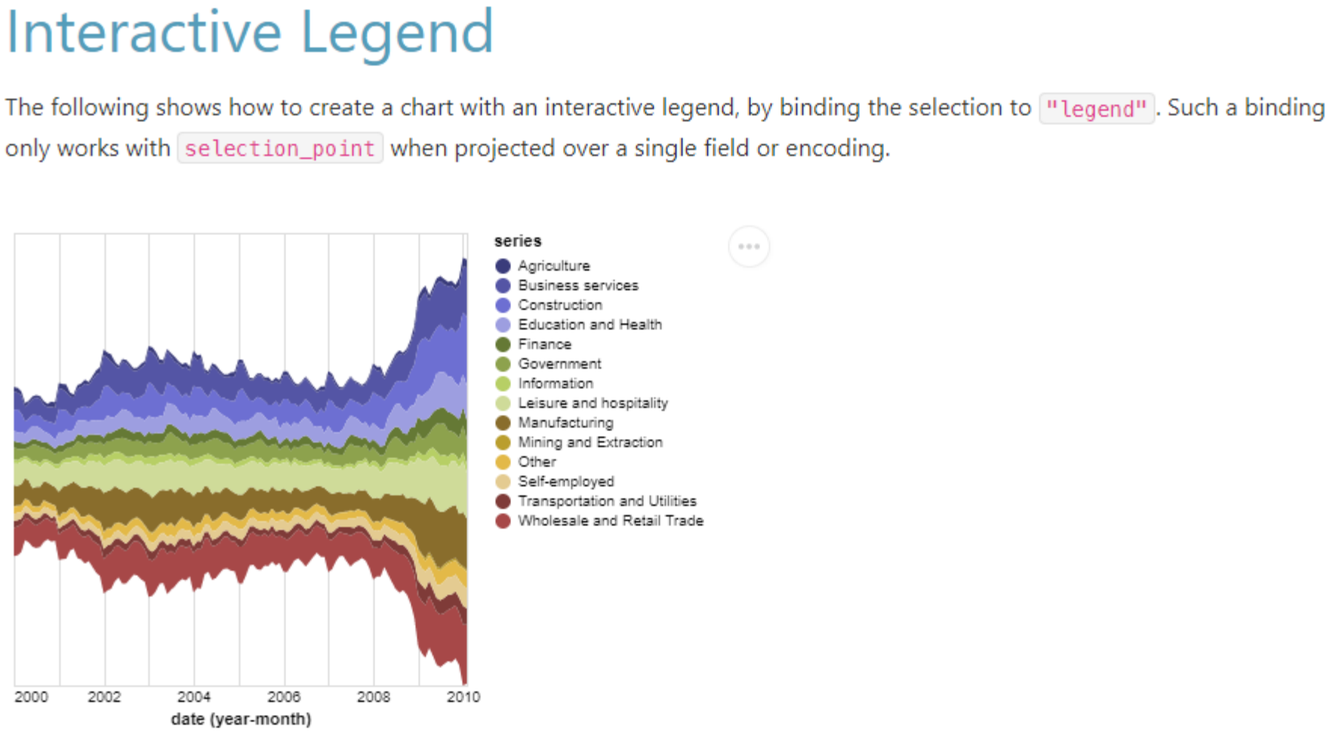
Highlighting



- highlight: change visual encoding for selection targets
  - visual feedback closely tied to but separable from selection (interaction)
- design choices: typical visual channels
  - change item color
    - but hides existing color coding
  - add outline mark
  - change size (ex: increase outline mark linewidth)
  - change shape (ex: from solid to dashed line for link mark)
- unusual channels: motion
  - motion: usually avoid for single view
    - with multiple views, could justify to draw attention to other views

Examples: Interactive Legend

- Selection
  - Type: On click
  - Semantics: Single and multiple
- Highlight
  - Color: Transparency



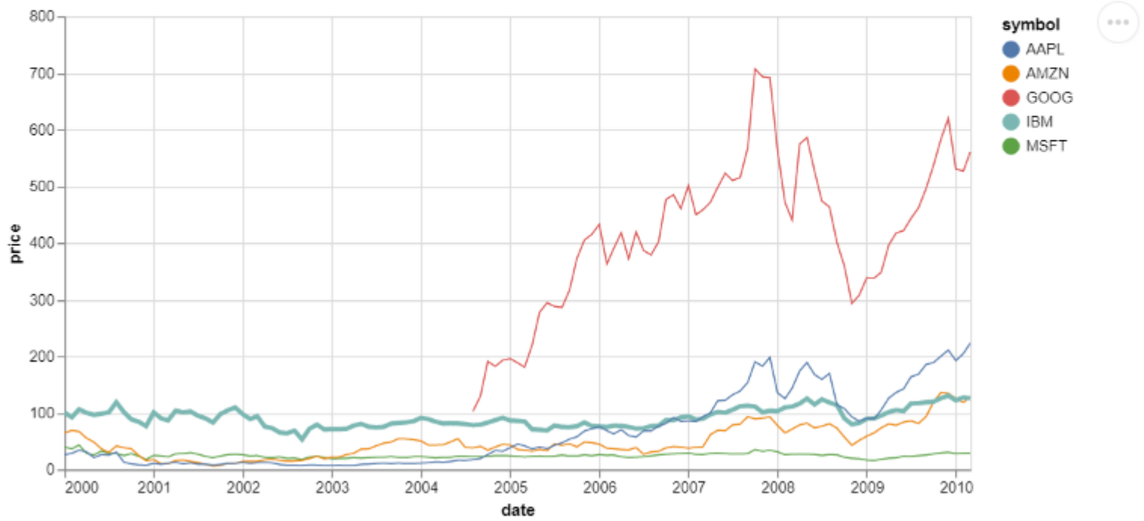
https://altair-viz.github.io/gallery/interactive_legend.html

Examples: Multi-Line Highlight

- Selection
  - Type: On Hover
  - Semantics: Single
- Highlight
  - Stroke-width

Multi-Line Highlight

This multi-line chart uses an invisible Voronoi tessellation to handle mouseover to identify the nearest point and then highlight the line on which the point falls. It is adapted from the Vega-Lite example found at https://bl.ocks.org/amitkaps/fe4238e716db53930b2f1a70d3401701



https://altair-viz.github.io/altair-viz-v4/gallery/multiline_highlight.html

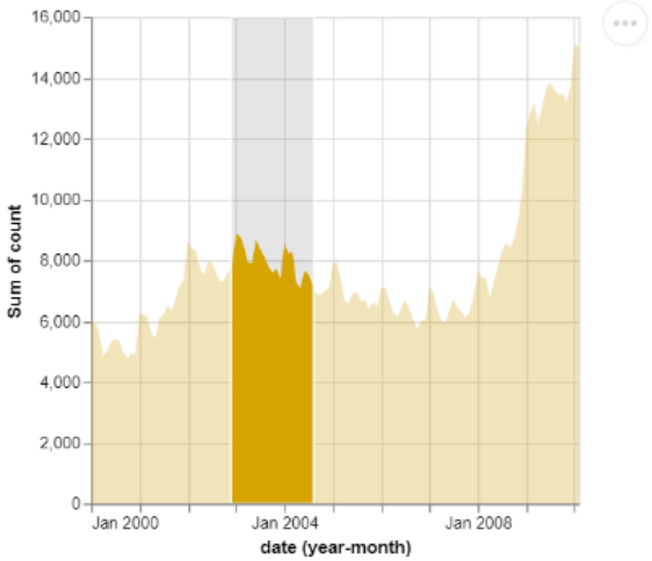
Examples: Rectangular Brush

- Selection
  - Constrained on y channel
  - Type: ???
  - Type: ???
  - Type: ???
  - Semantics: ????
- Highlight
  - ???

Using Selection Interval with mark_area

Because area is considered one object, just using the plain selector will select the entire area instead of just one part of it.

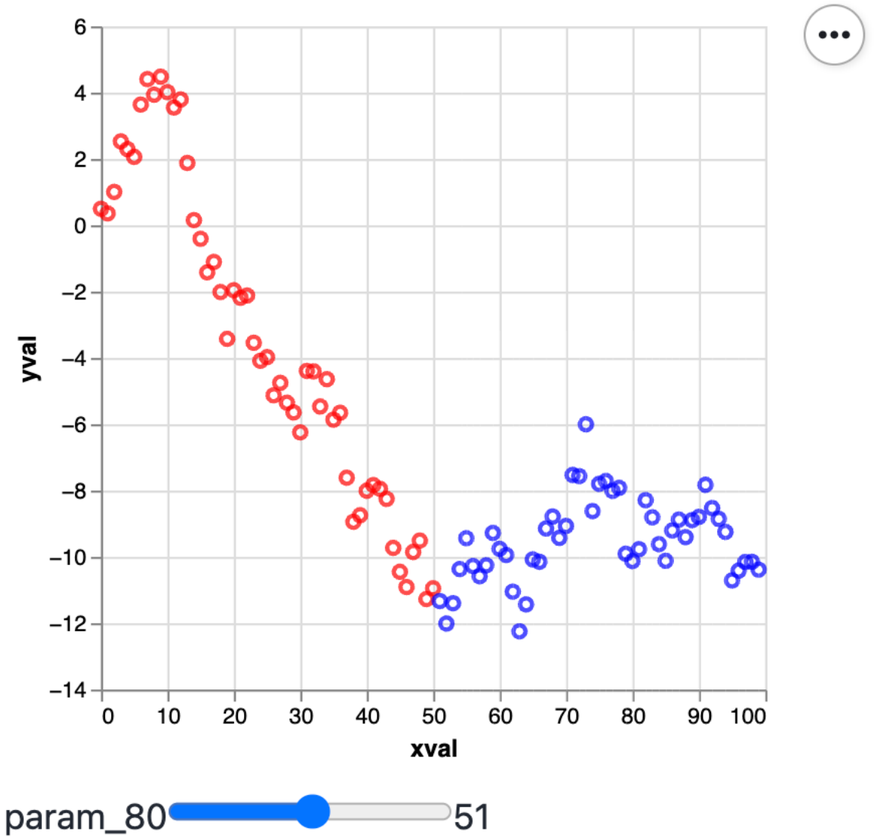
This example shows how to use two areas, one on top of the other, and a *transform_filter* to fake out this effect.



https://altair-viz.github.io/gallery/select_mark_area.html

Examples: Slider Cutoff

- Selection
  - Type: Slider
  - Semantics: Grouped interval
- Highlight
  - Color hue



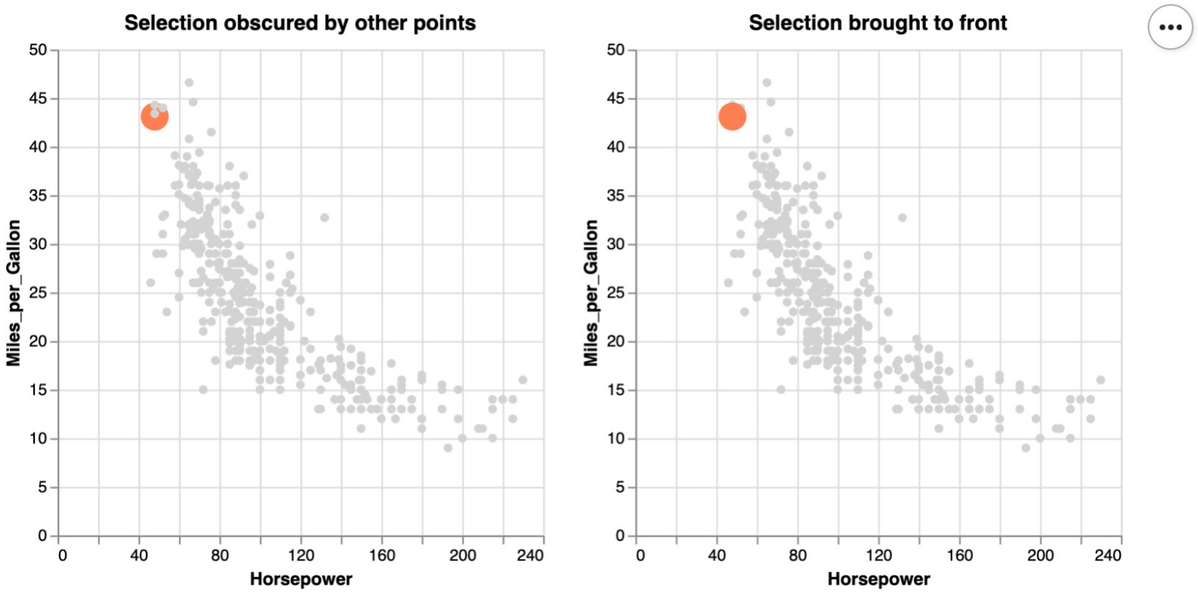
https://altair-viz.github.io/gallery/slider_cutoff.html

Examples: Hover Zorder

- Selection
  - Constrained on y channel
  - Type: ???
  - Semantics: ???
- Highlight
  - ???

Selection zorder

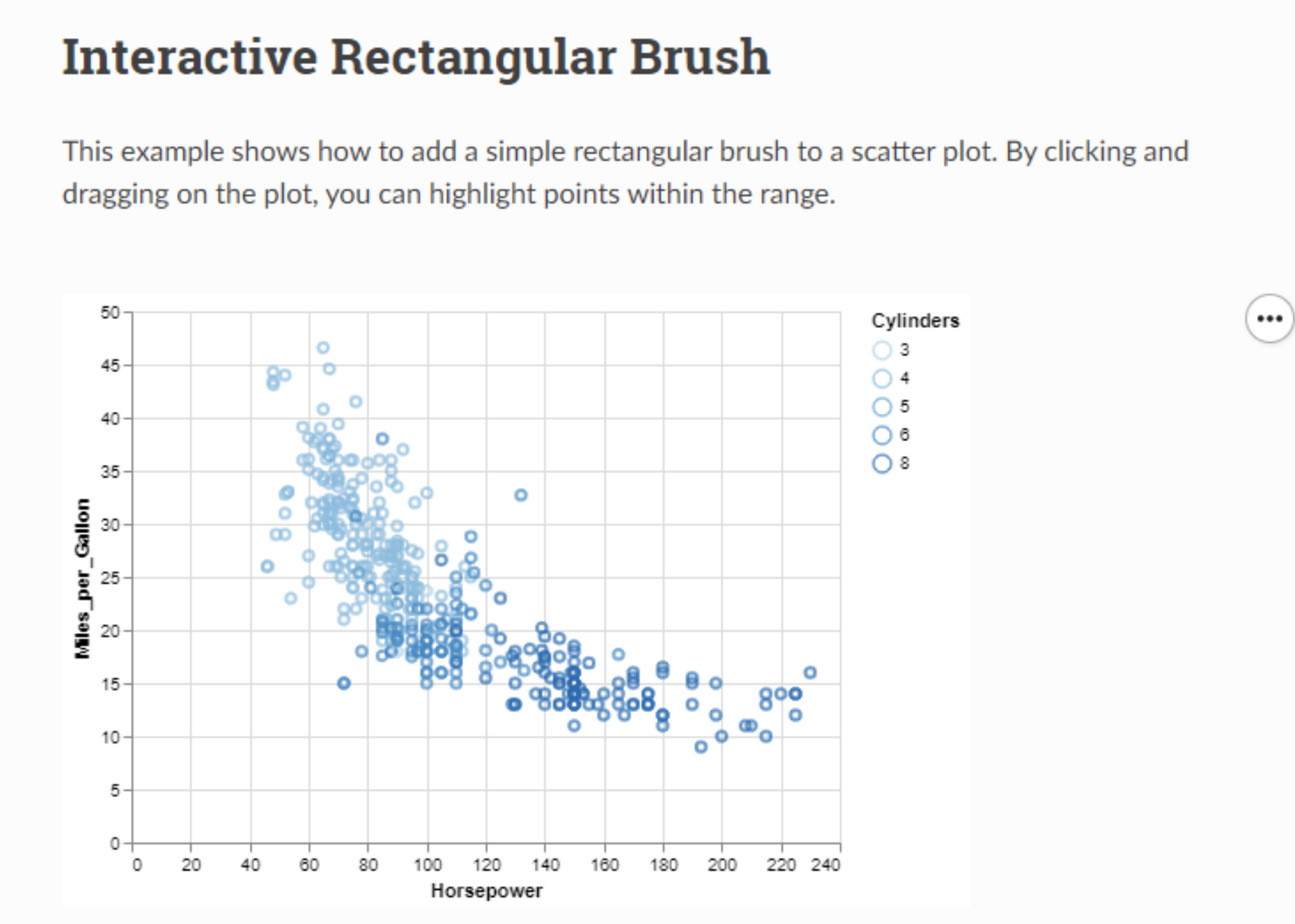
This example shows how to bring selected points to the front/foreground by using a condition to change the point's (z)order as it is hovered over with the pointer. This prevents that the selected points are obscured by those that are not selected.



https://altair-viz.github.io/gallery/selection_zorder.html

Examples: Rectangular Brush

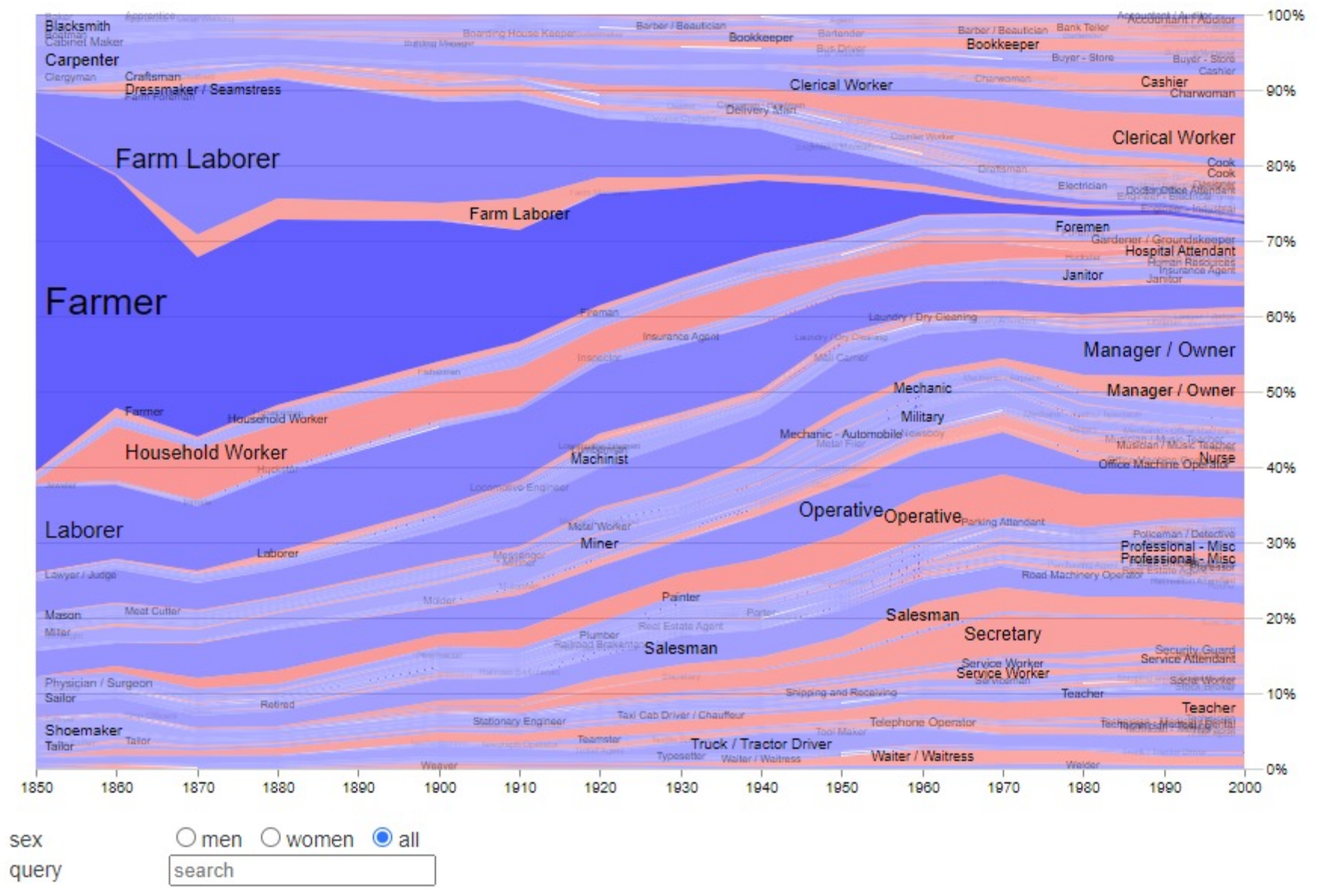
- Selection
  - Type: On shift-click
  - Semantics: Null, Group
- Highlight
  - Color: Transparency



https://altair-viz.github.io/gallery/interactive_brush.html

Examples: Job Voyager Example

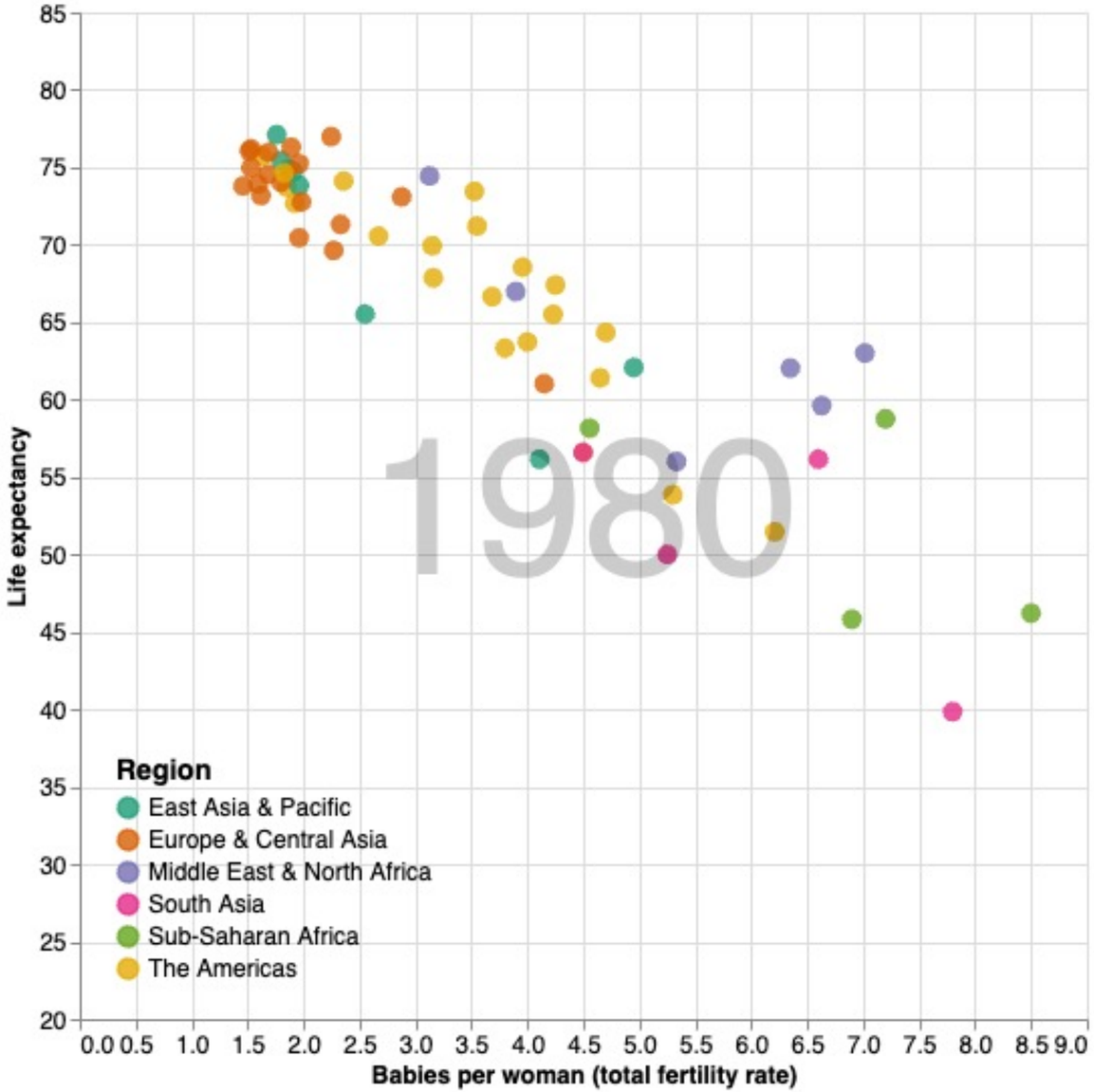
- Selection
  - On Click
  - On Type
- Highlight
  - NOPE
- Filter
  - Huh (more next Monday)



https://vega.github.io/vega/examples/job-voyager/

Examples: Hover with Search

- Selection
  - Type: ???
  - Type: ???
  - Type: ???
- Highlight
  - ???
  - ???
- ???
- ???



https://altair-viz.github.io/gallery/scatter_point_paths_hover.html

Examples: Steriods

Visit https://altair-viz.github.io/gallery/multiple_interactions.html

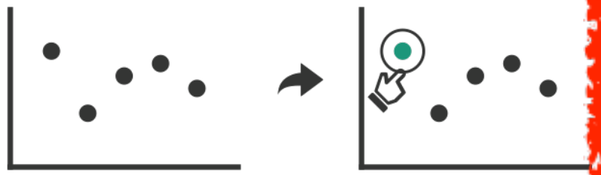
Deconstruct the interactions (ha ha ha, not the viz, the interaction)

There are multiple ones.

Manipulate

Change over Time

Select



Navigate

→ *Zoom*
Geometric

→ *Pan/Translate*

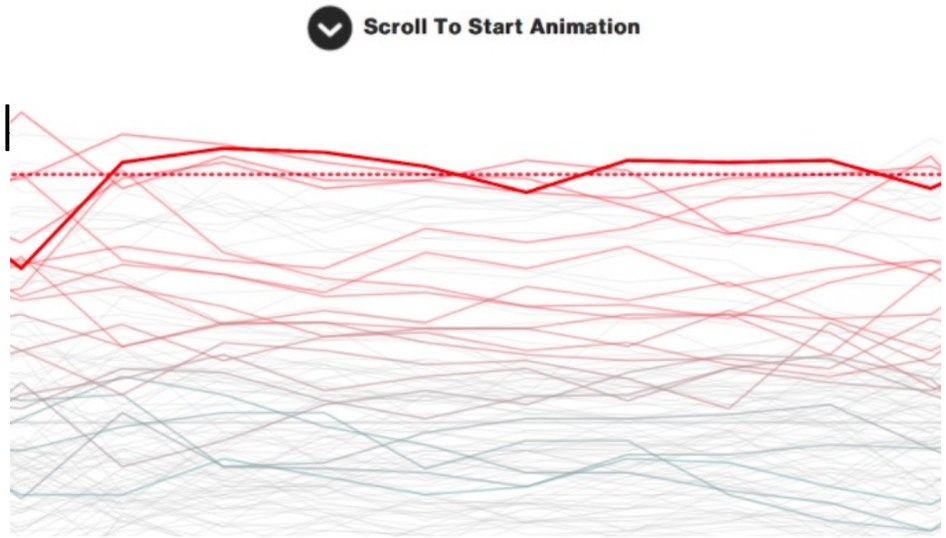
→ *Constrained*

Navigate: Changing viewpoint/visibility

- change viewpoint
  - changes which items are visible within view
- camera metaphor
  - pan/translate/scroll
    - move up/down/sideways

Idiom: **Scrollytelling**

- how: navigate page by scrolling (panning down)
- pros:
  - familiar & intuitive, from standard web browsing
  - linear (only up & down) vs possible overload of clicl
- cons:
  - full-screen mode may lack affordances
  - scrolljacking, no direct access
  - unexpected behaviour
  - continuous control for discrete steps

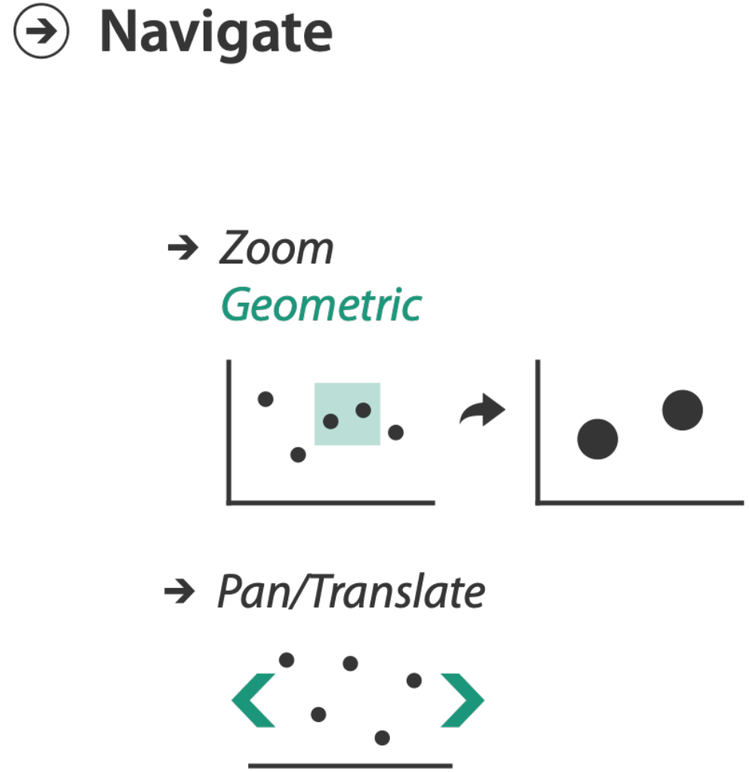


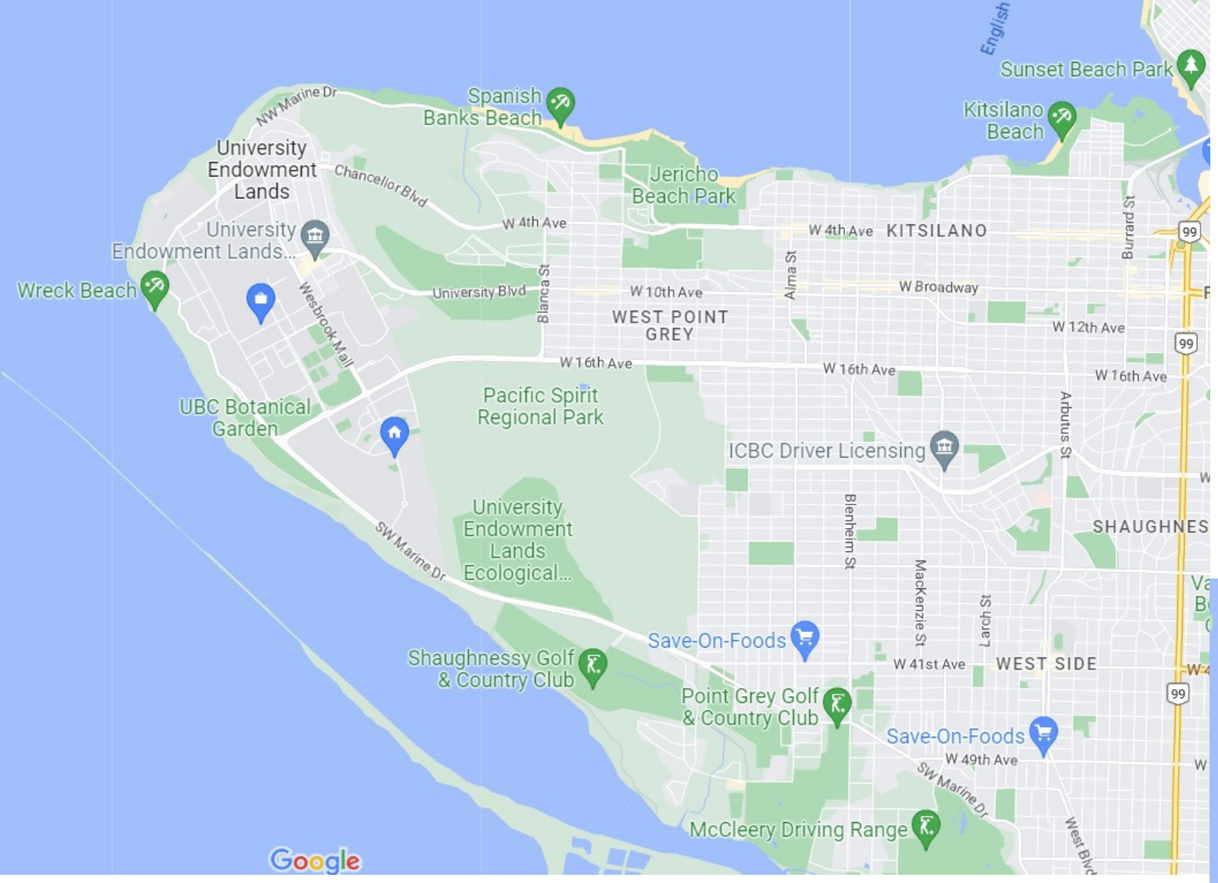
https://eagereyes.org/blog/2016/the-scrollytelling-scourge

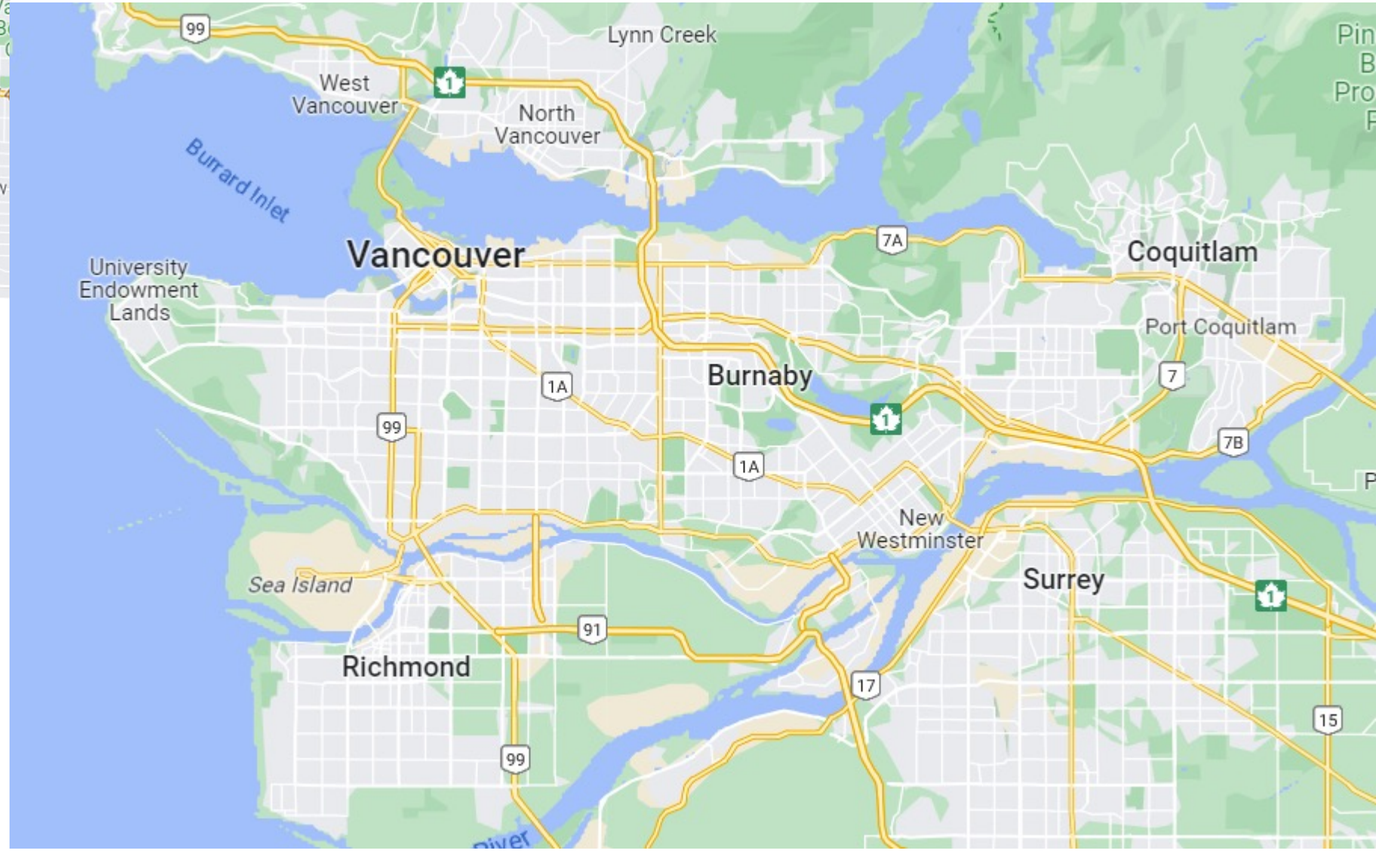
https://www.nytimes.com/interactive/2022/05/13/us/covid-deaths-us-one-million.html

Navigate: Changing viewpoint/visibility

- change viewpoint
  - changes which items are visible within view
- camera metaphor
  - pan/translate/scroll
    - move up/down/sideways
  - rotate/spin
    - typically in 3D
  - zoom in/out
    - enlarge/shrink world == move camera closer/further
    - geometric zoom: standard, like moving physical object

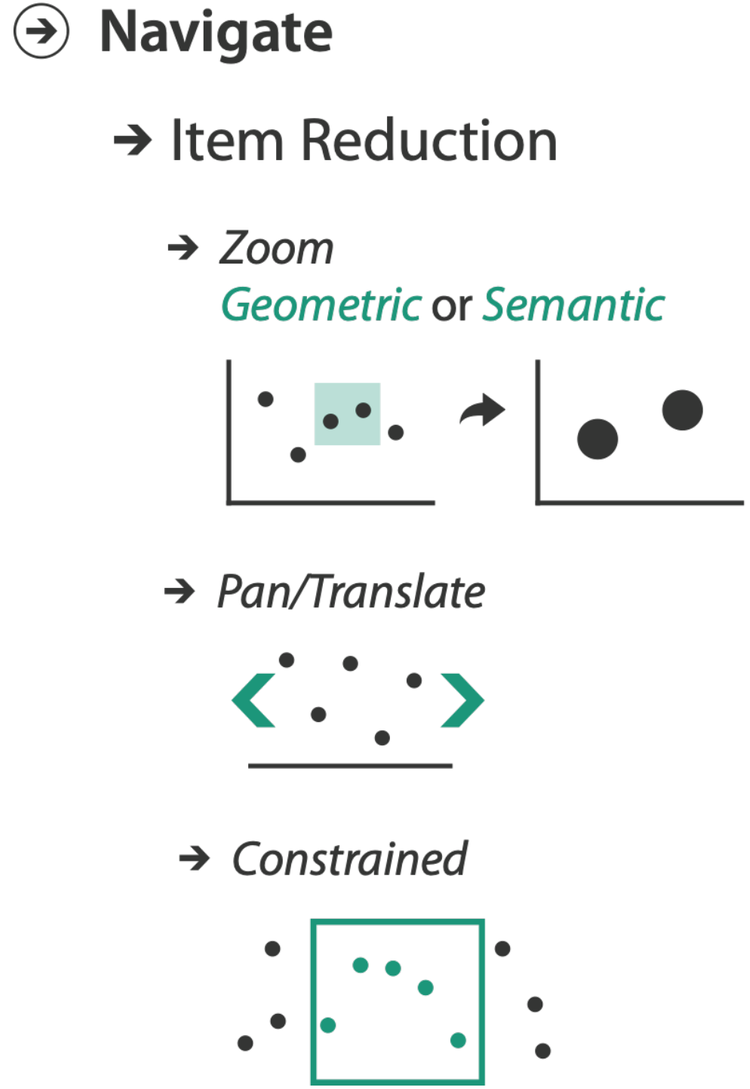



Sunset Beach Park
Spanish Banks Beach
Kitsilano Beach
NW Marine Dr
University Endowment Lands
Chancellor Blvd
Jericho Beach Park
W 4th Ave
KITSILANO
University Endowment Lands...
Wreck Beach
Alma St
Burrard St
University Blvd
W 10th Ave
W Broadway
WEST POINT GREY
Blanca St
Westbrook Mall
W 12th Ave
W 16th Ave
Pacific Spirit Regional Park
UBC Botanical Garden
ICBC Driver Licensing
Arbutus St
SHAUGHNES
University Endowment Lands Ecological...
SW Marine Dr
Blenheim St
Mackenzie St
Larch St
Save-On-Foods
Shaughnessy Golf & Country Club
W 41st Ave
WEST SIDE
Point Grey Golf & Country Club
Save-On-Foods
W 49th Ave
SW Marine Dr
McCleery Driving Range
West Blvd
99
Google


99
Lynn Creek
West Vancouver
North Vancouver
Burrard Inlet
Vancouver
University Endowment Lands
7A
Coquitlam
Port Coquitlam
Burnaby
1A
7
99
7B
New Westminster
Sea Island
Surrey
91
Richmond
17
15
99

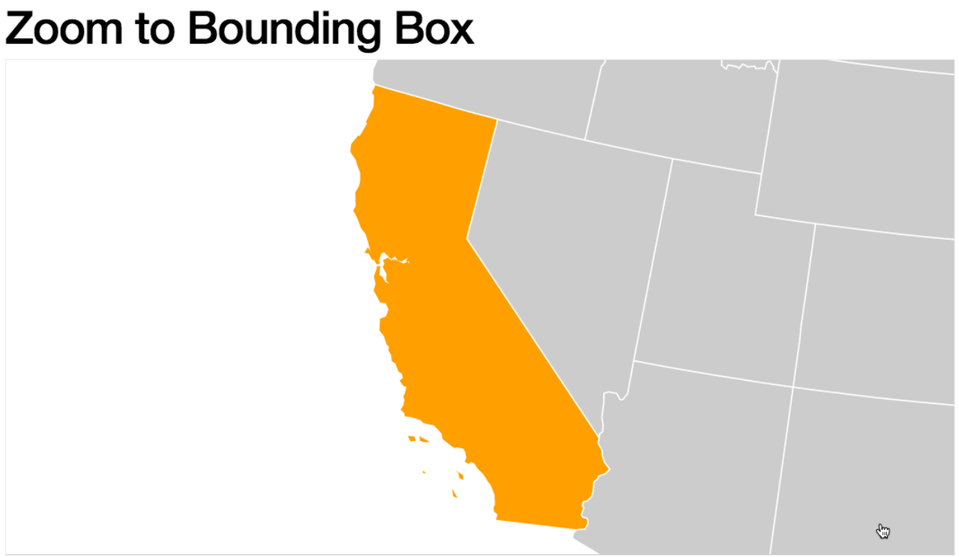
Navigate: Unconstrained vs constrained

- unconstrained navigation
  - easy to implement for designer
  - hard to control for user
    - easy to overshoot/undershoot
- constrained navigation
  - typically uses animated transitions
  - trajectory automatically computed based on selection
    - just click; selection ends up framed nicely in final viewport



Idiom: **Animated transition + constrained navigation**

- example: geographic map
  - simple zoom, only viewport changes, shapes preserved



https://observablehq.com/@d3/zoom-to-bounding-box

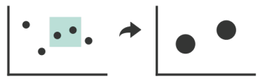
Interaction Taxonomies

Manipulate

- **Change View Over Time**

- **Select**

- **Navigate**
  - → Item Reduction
    - → *Zoom*
      Geometric or *Semantic*



    - → *Pan/Translate*

    - → *Constrained*

  - → Attribute Reduction
    - → *Slice*

    - → *Cut*

    - → *Project*

Table 1. Infovis Taxonomies Relevant to Interaction Techniques

Publications	Taxonomic units
Taxonomies of low-level interaction techniques	
Shneiderman (1996) [37]	Overview, zoom, filter, details-on-demand, relate, history, and extract
Buja, Cook, and Swayne (1996) [9]	Focusing (choice of [projection, aspect ratio, zoom, pan], choice of [variable, order, scale, scale-aspect ratio, animation, and 3-D rotation]), linking (brushing as conditioning / sectioning / database query), and arranging views (scatter plot matrix and conditional plot)
Chuah and Roth (1996) [13]	Basic visualization interaction (BVI) operations: graphical operations (encode data, set graphical value, manipulate objects), set operations (create set, delete set, summarize set, other), and data operations (add, delete, derived attributes, other)
Dix and Ellis (1998) [15]	Highlighting and focus, accessing extra information – drill down and hyperlinks, overview and context, same representation / changing parameters, same data / changing representation, linking representation – temporal fusion
Keim (2002) [24]	Dynamic projections, interactive filtering, interactive zooming, interactive distortion, interactive linking and brushing
Wilkinson (2005) [54]	Filtering (categorical/continuous/multiple/fast filtering), navigating (zooming/panning/lens), manipulating (node dragging/categorical reordering), brushing and linking (brush shapes/brush logic/fast brushing), animating (frame animation), rotating, transforming (specification/assembly/display/tap/2 taps/3 taps)
Taxonomical dimensions of interaction techniques	
Tweedie (1997) [47]	Interaction types (manual, mechanized, instructable, steerable, and automatic) and directness (direct and indirect manipulation)
Spence (2007) [38]	Interaction modes (continuous, stepped, passive, and composite interaction)
A taxonomy of interaction operations	
Ward and Yang (2004) [50]	interaction operators (navigation, selection, distortion), interaction spaces (screen-space, data value-spaces, data structure-space, attribute-space, object-space, and visualization structure-space), and interaction parameters (focus, extents, transformation, and blender)
Taxonomies of user tasks	
Zhou and Feiner (1998) [56]	Relational visual tasks (associate, background, categorize, cluster, compare, correlate, distinguish, emphasize, generalize, identify, locate, rank, reveal, switch) and direct visual organizing and encoding tasks (encode)
Amar, Eagan, and Stasko (2005) [4]	Retrieve value, filter, compute derived value, find extremum, sort, determine range, characterize distribution, find anomalies, cluster, and correlate

https://faculty.cc.gatech.edu/~john.stasko/papers/infovis07-interaction.pdf

	Action
Unipolar	Annotating
	Arranging
	Assigning
	Blending
	Cloning
	Comparing
	Drilling
	Filtering
	Measuring
	Navigating
	Scoping
	Searching
	Selecting
	Sharing
	Transforming
	Translating

https://aisel.aisnet.org/thci/vol5/iss2/1/

Interaction benefits

- major advantage of computer-based vs paper-based visualization
- flexible, powerful, intuitive
    - exploratory data analysis: change as you go during analysis process
    - fluid task switching: different visual encodings support different tasks
- animated transitions provide excellent support
    - empirical evidence that animated transitions help people stay oriented
- be active participants in the analysis of data,
- adjust features of the tool to suit the user's needs,
- visualization of large amounts of data,
- extend/amplifies users' sensemaking abilities,
- increase engagement (vis becomes personal to user),

Interaction limitations

- Requires human time and attention
- Increases perceptual and exploration costs
- Limited performance gains
  - studies find no increase in performance (Moscaet al., 2021)
  - users may not interact as planned by designer
    - NYTimes logs show ~90% don’t interact beyond scrollytelling - Aisch, 2016
- interaction has a time cost
  - sometimes minor, sometimes significant
  - degenerates to human-powered search in worst case
- remembering previous state imposes cognitive load
- controls may take screen real estate
  - or invisible functionality may be difficult to discover (lack of affordances)

Get Stepping

- That was a lot. On Wednesday we will focus on implementation.
- TUTORIAL 9 is you on your own ooooo
  - Read through https://altair-viz.github.io/user_guide/interactions/index.html and it's subpages (Parameters, Conditions & Filters; Bindings & Widgets; Expressions)
  - Take 3 altair vizzes and re-implement the interaction using your own data. Here are some suggestions.
    - https://altair-viz.github.io/gallery/interactive_legend.html apply this to a bar chart as opposed to area chart.
    - https://altair-viz.github.io/gallery/interactive_bar_select_highlight.html keep as bar chart, but make the highlight more noticeable
    - https://altair-viz.github.io/gallery/selection_histogram.html use your own dataset, just make sure you understand what is going on, try to change the brush so it is constrained to only the x axis.