

Lesson 3:

Interactivity in Visual Analytics

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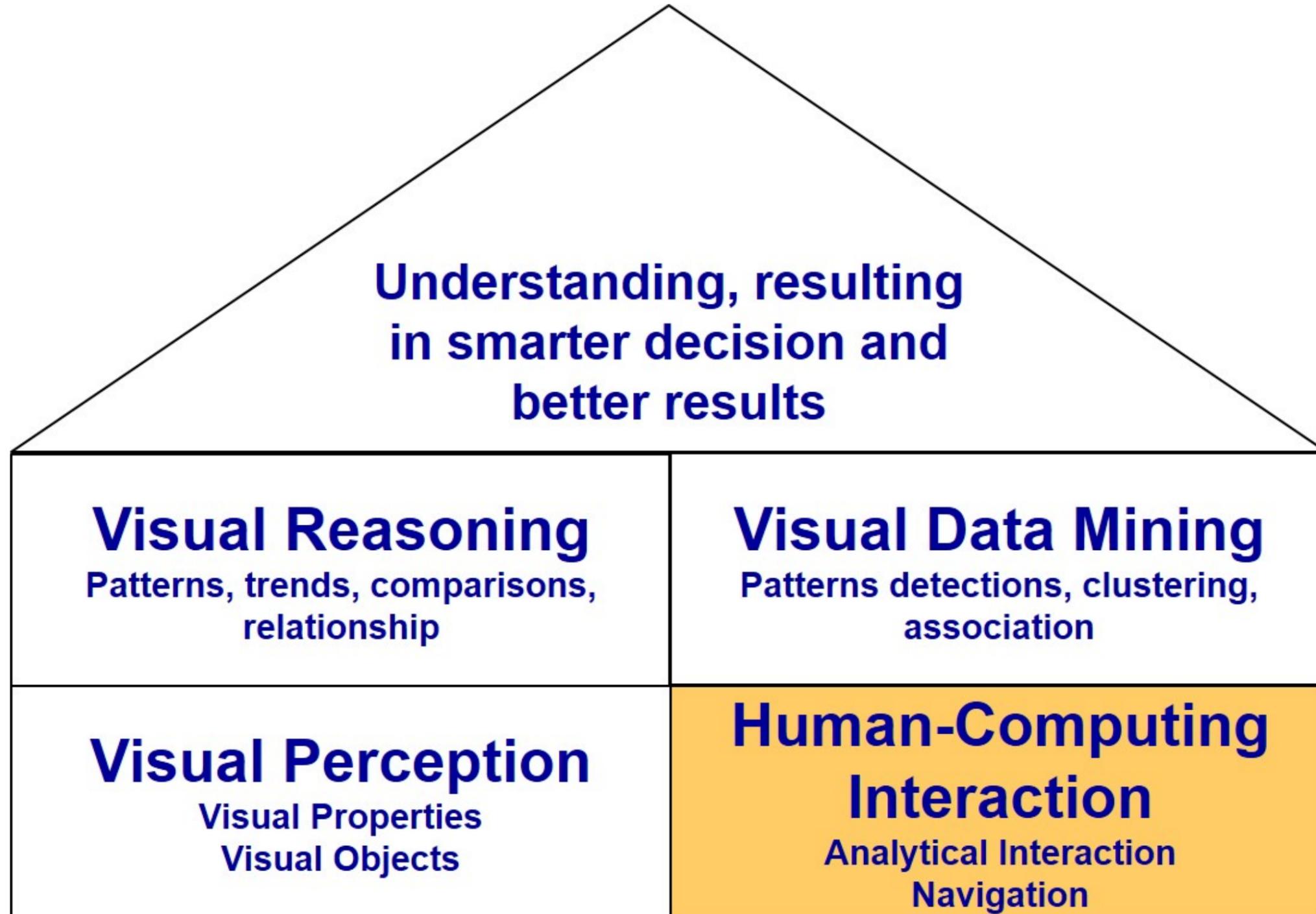
School of Computing and Information Systems,
Singapore Management University

16 Feb 2023

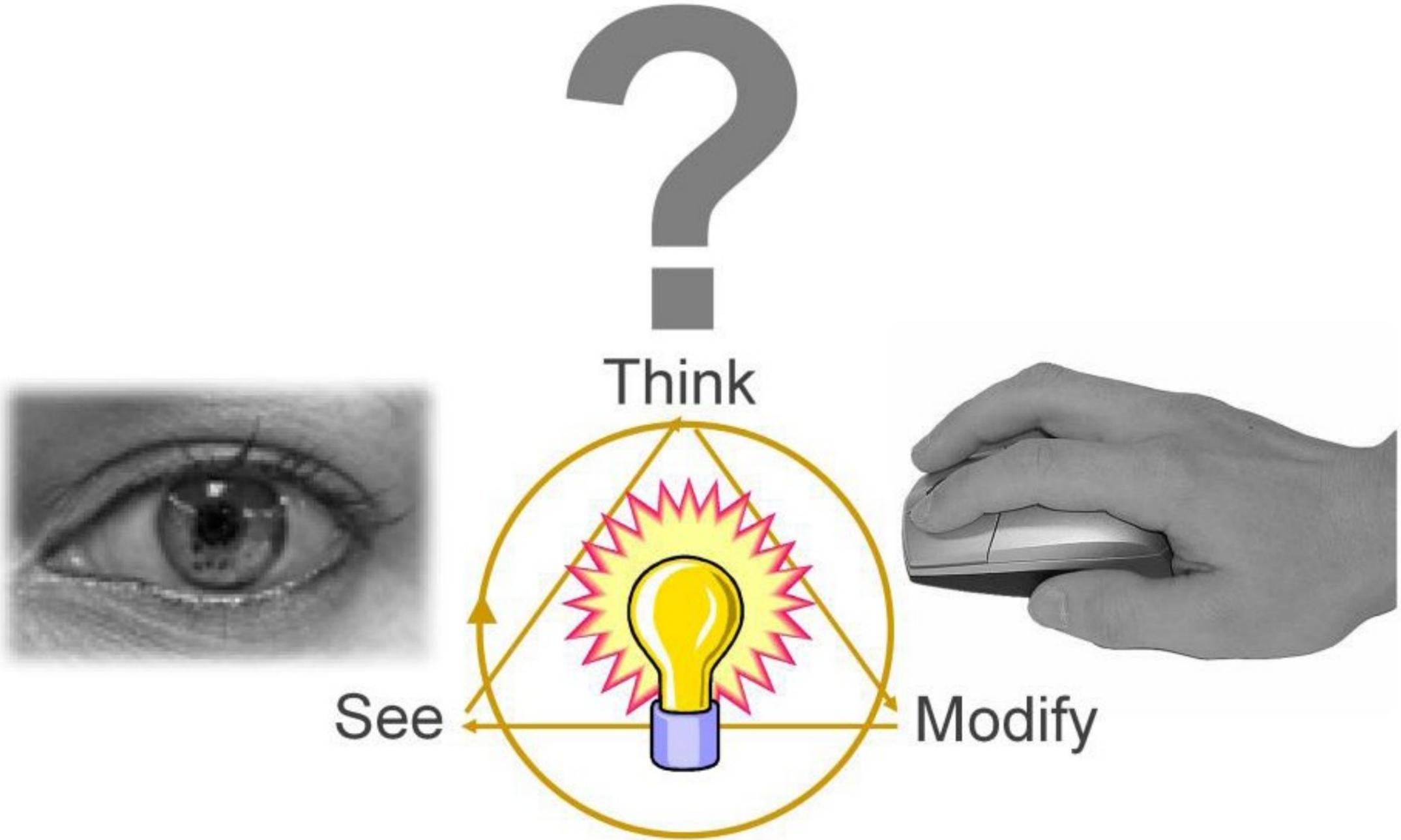
What will you learn from this lesson?

- Typology of Interactive Techniques
 - Data & view specification
 - View Manipulation
 - Process and Provenance
- Interactive Design Primitive
- Animation: Principles and Best Practices

Building Block of Visual Analytics



Revisiting Visual Analytics Framework



Taxonomy of Interactive Dynamics

Data and View Specification

Visualize data by choosing visual encodings.

Filter out data to focus on relevant items.

Sort items to expose patterns.

Derive values or models from source data.

View Manipulation

Select items to highlight, filter, or manipulate them.

Navigate to examine high-level patterns and low-level detail.

Coordinate views for linked, multidimensional exploration.

Organize multiple windows and workspaces.

Process and Provenance

Record analysis histories for revisitation, review, and sharing.

Annotate patterns to document findings.

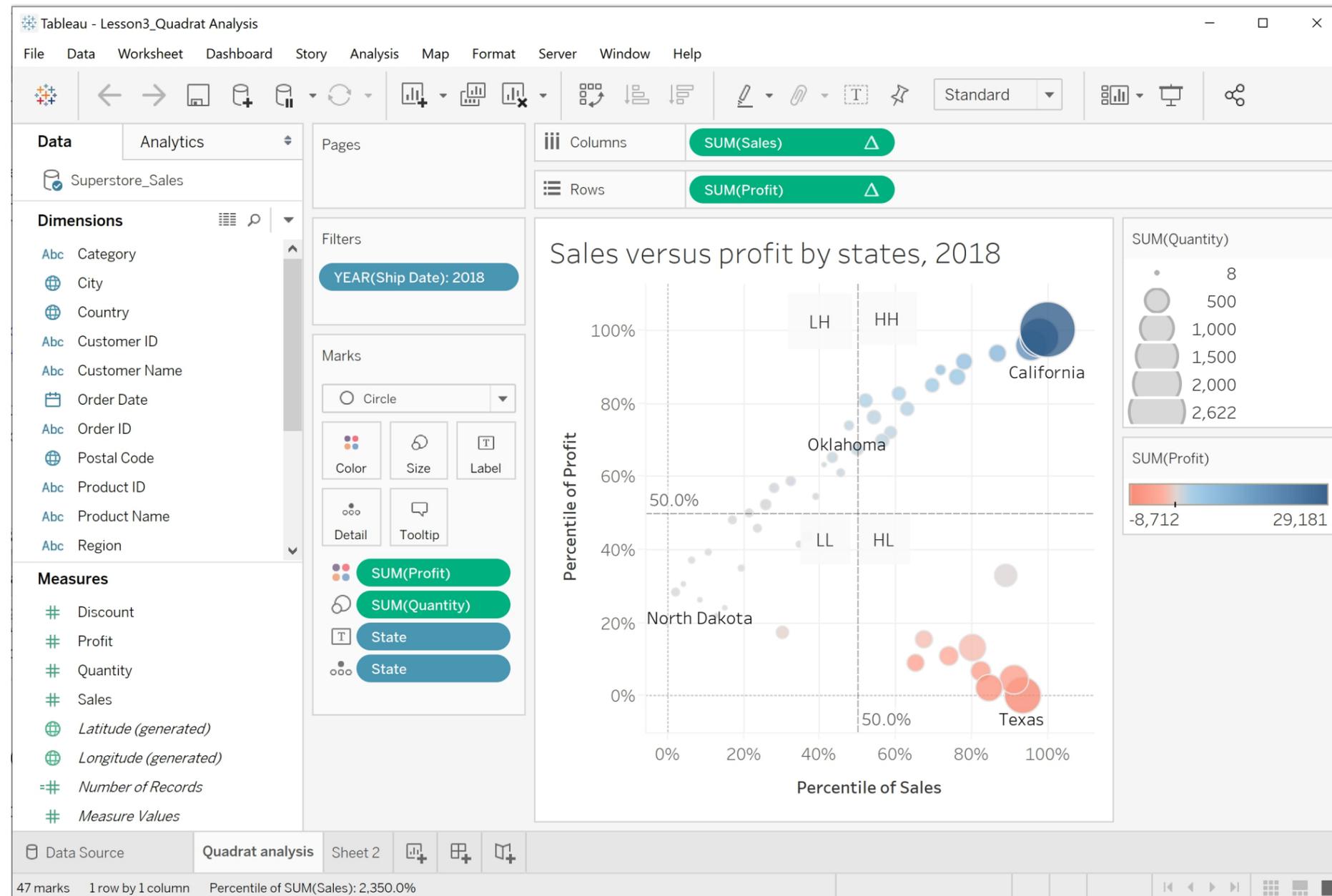
Share views and annotations to enable collaboration.

Guide users through analysis tasks or stories.

Source: Heer, J. & Shneiderman, B. (2012) “[Interactive Dynamics for Visual Analytics](#)” *ACM Queue*, Vol. 55, No. 4, pp 45-54.

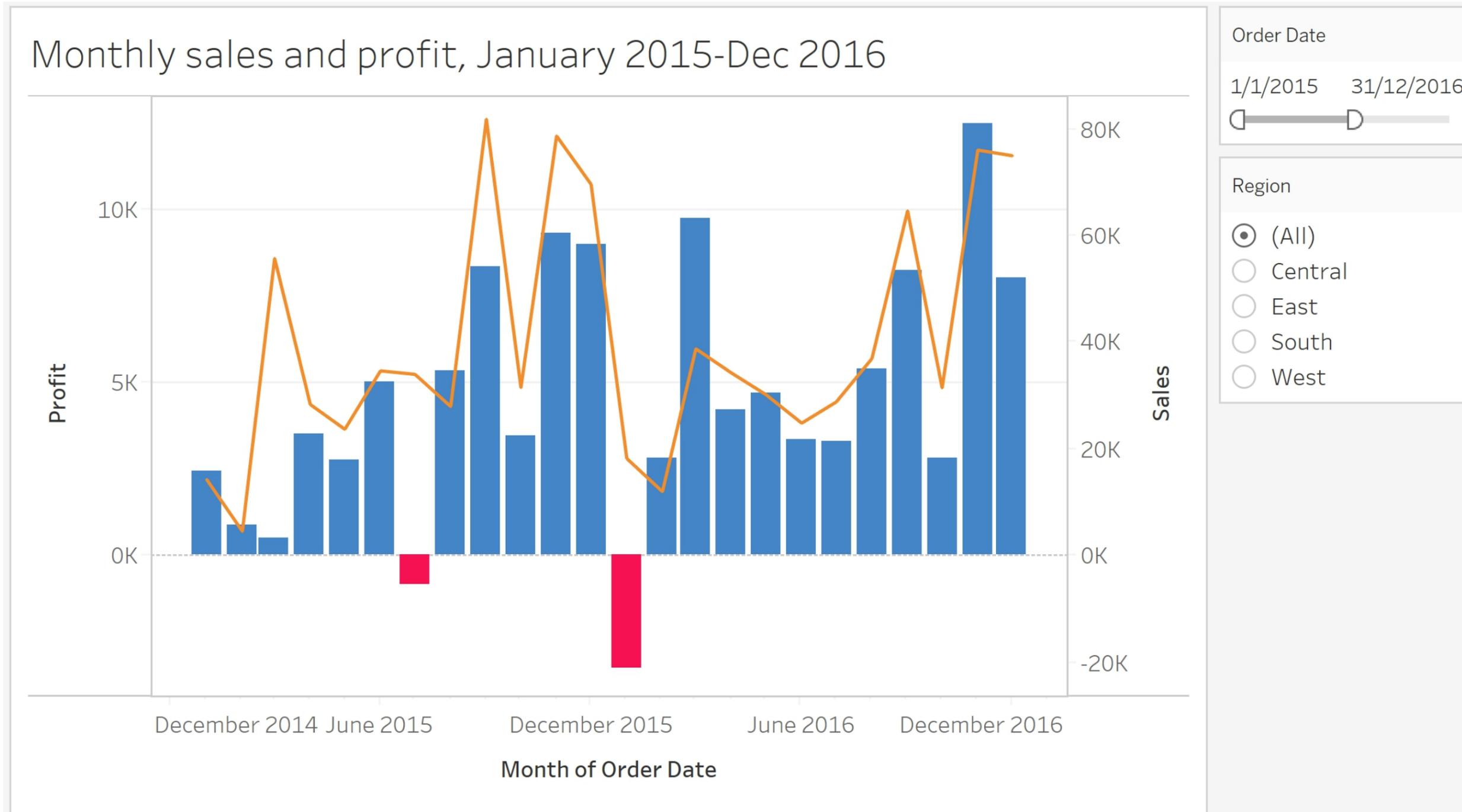
Data & view specification

- Visualise data by choosing visual encodings.
- Polaris of Tableau



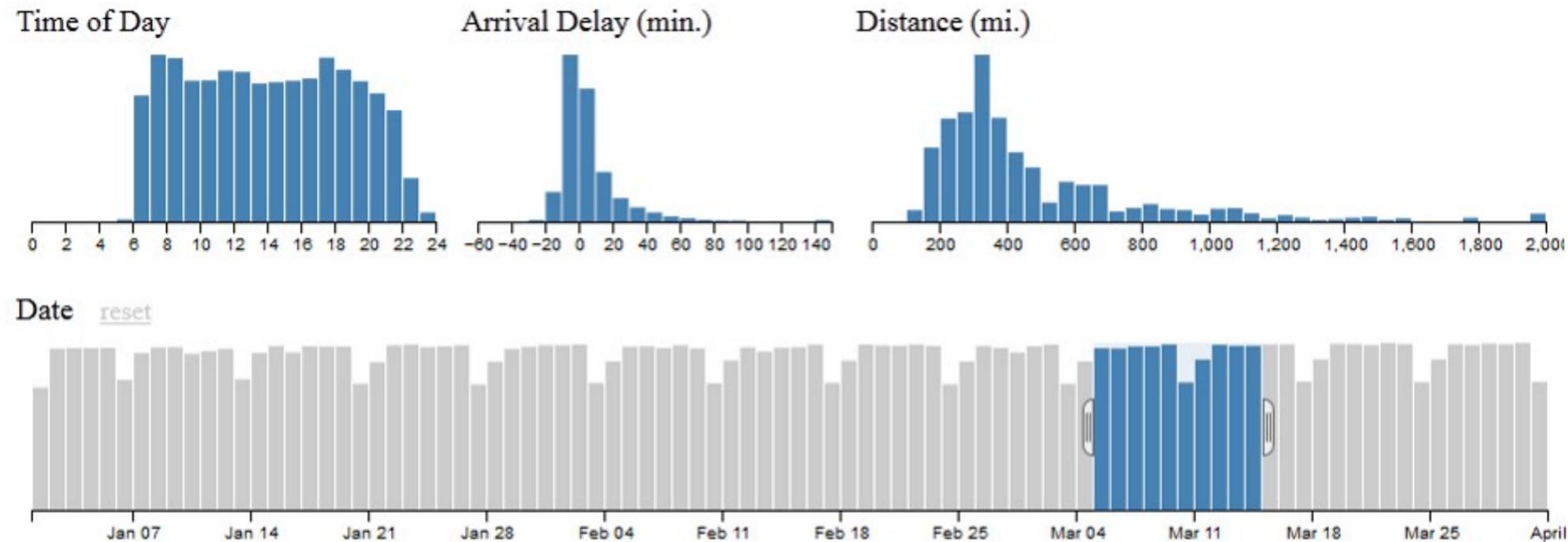
Data & view specification

- Filter out data to focus on relevant items.



Data & view specification

- **Slicer** is an axis-parallel selection tool, which selects a range along an axis, where the end-point of the interval can be modified dynamically.



March 14, 2001

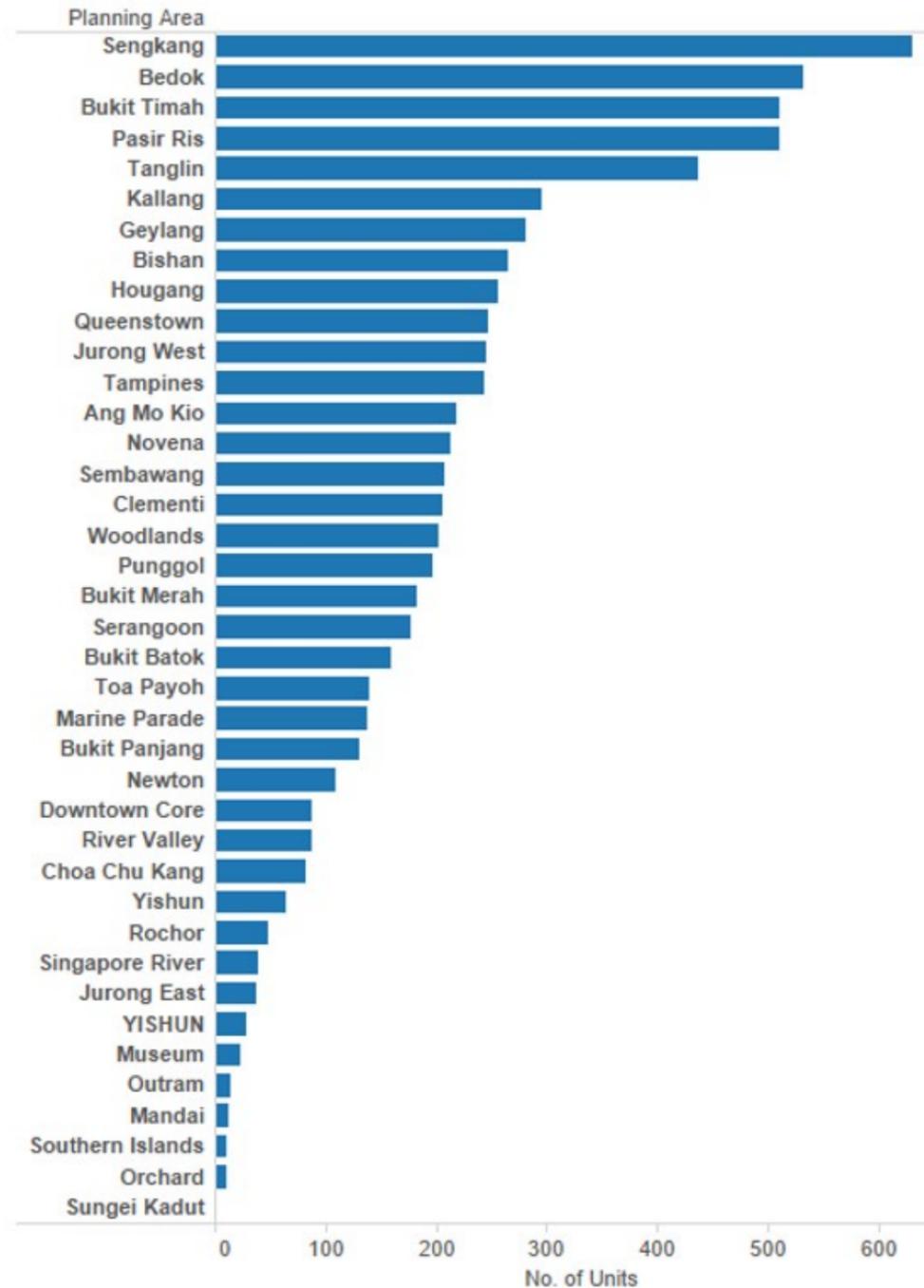
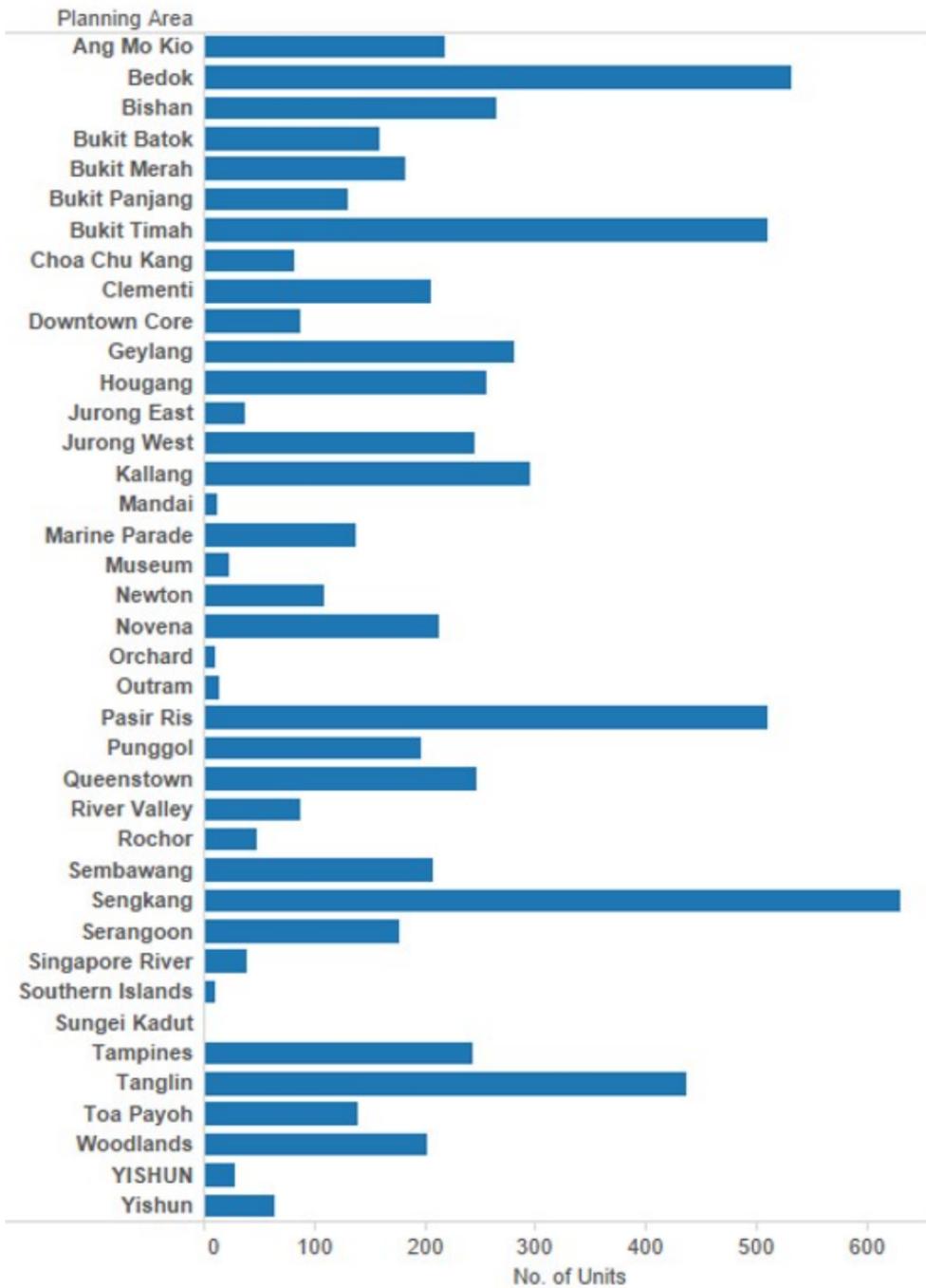
04:38 PM	ONT	SMF	389 mi.	+3 min.
11:50 PM	MDW	BWI	611 mi.	+186 min.
11:50 PM	MCI	MDW	405 mi.	-10 min.
11:49 PM	STL	MDW	251 mi.	+45 min.

26,093 of 231,083 flights selected.

Source: [crossfilter](#)

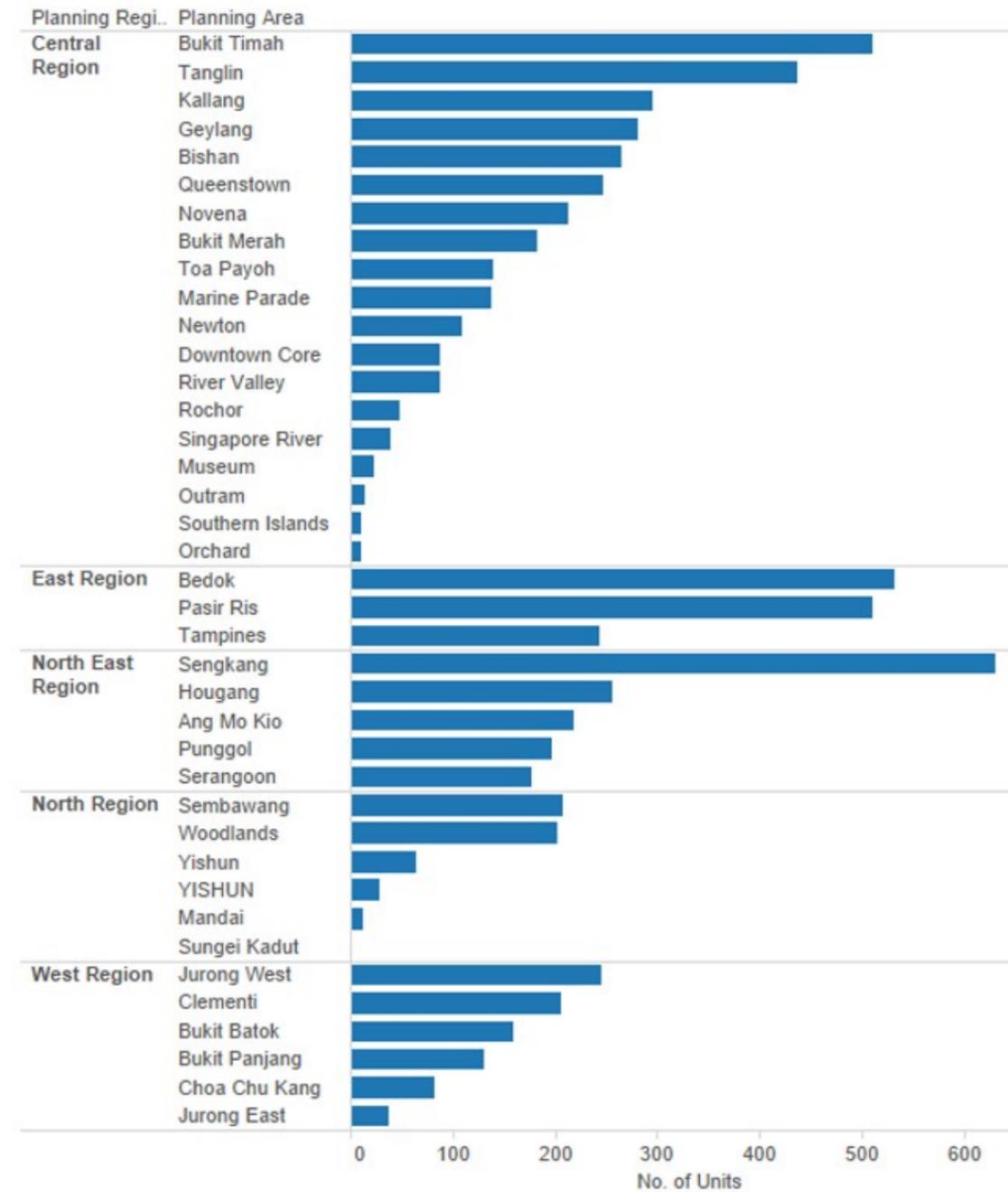
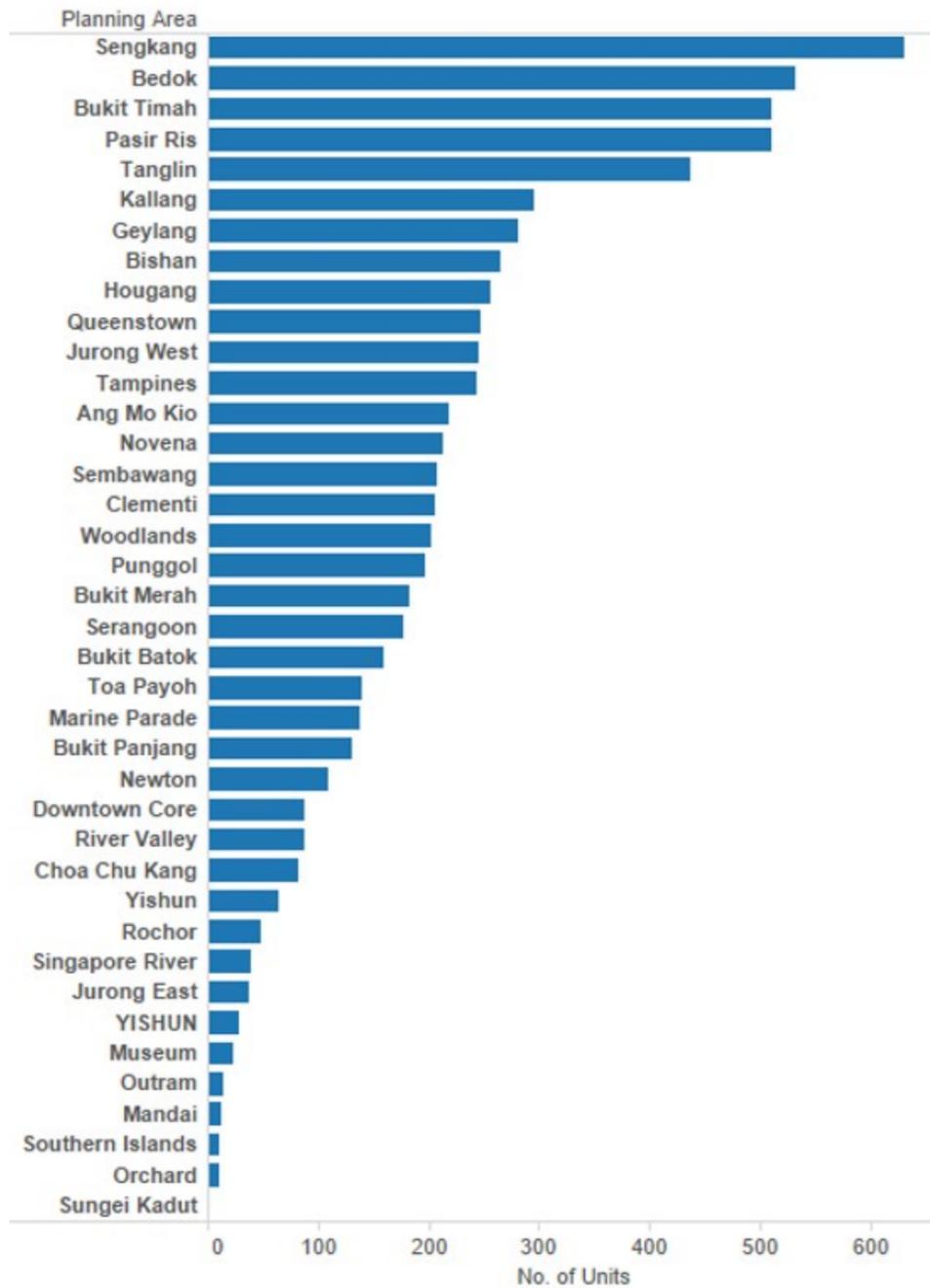
Data & view specification

- Sort items to expose patterns.



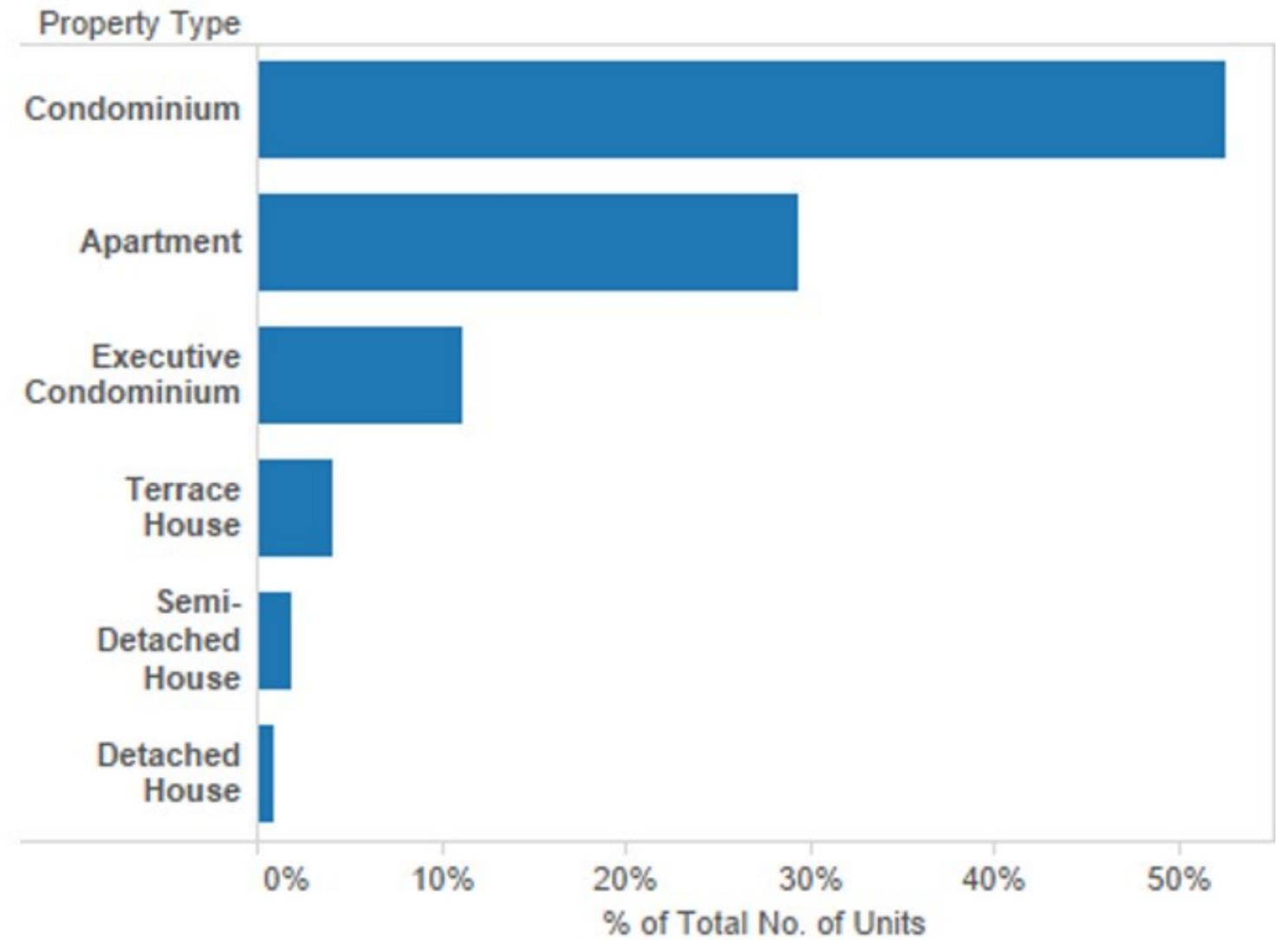
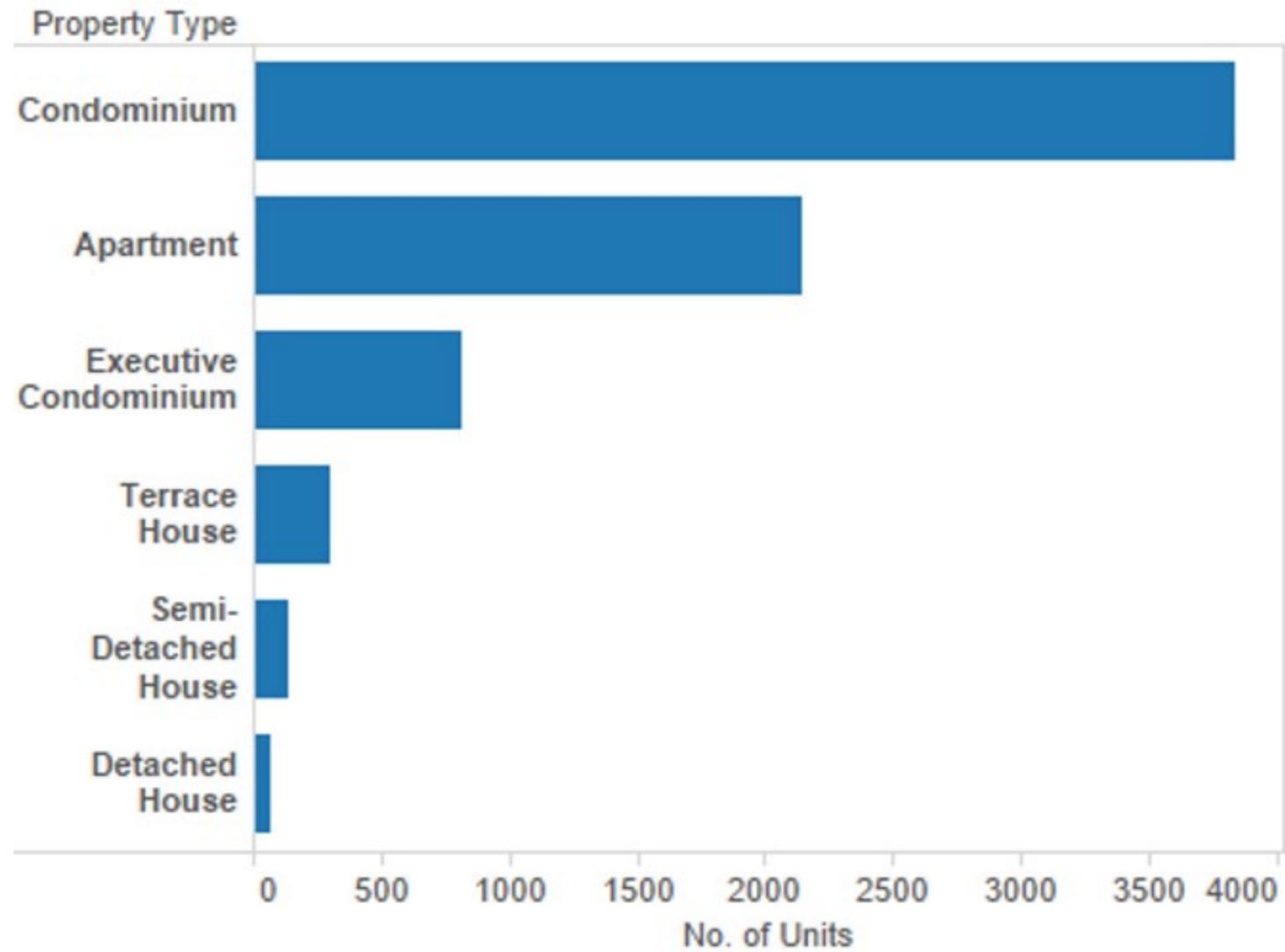
Data & view specification

- Hierarchical sorting



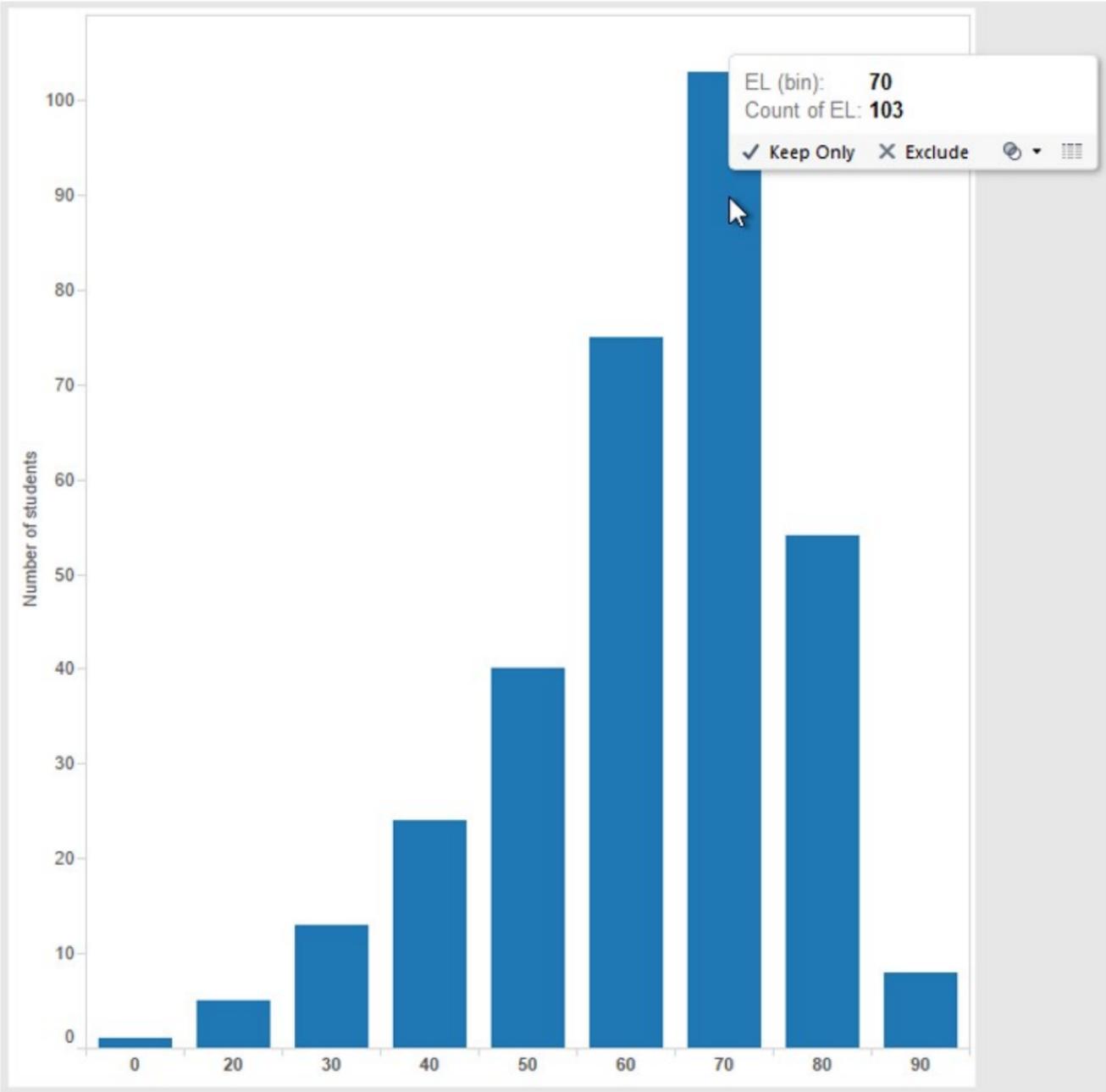
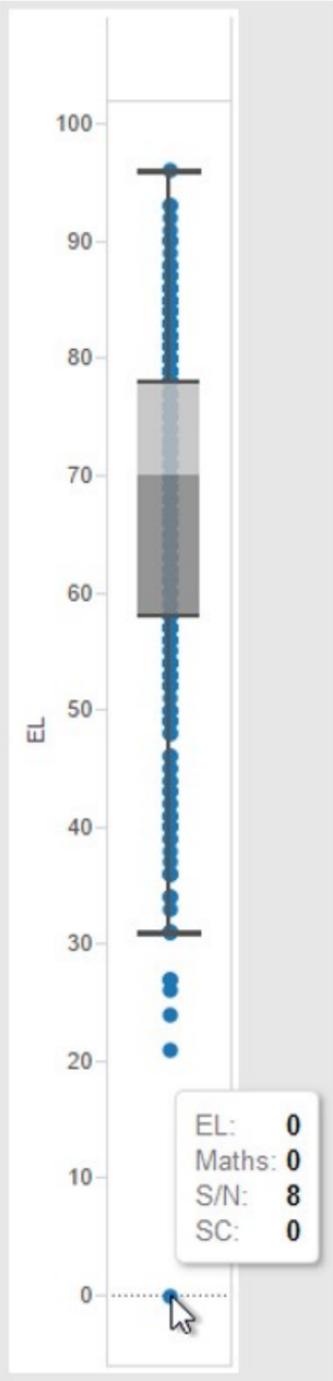
Data & view specification

- Derive values or models from source data.



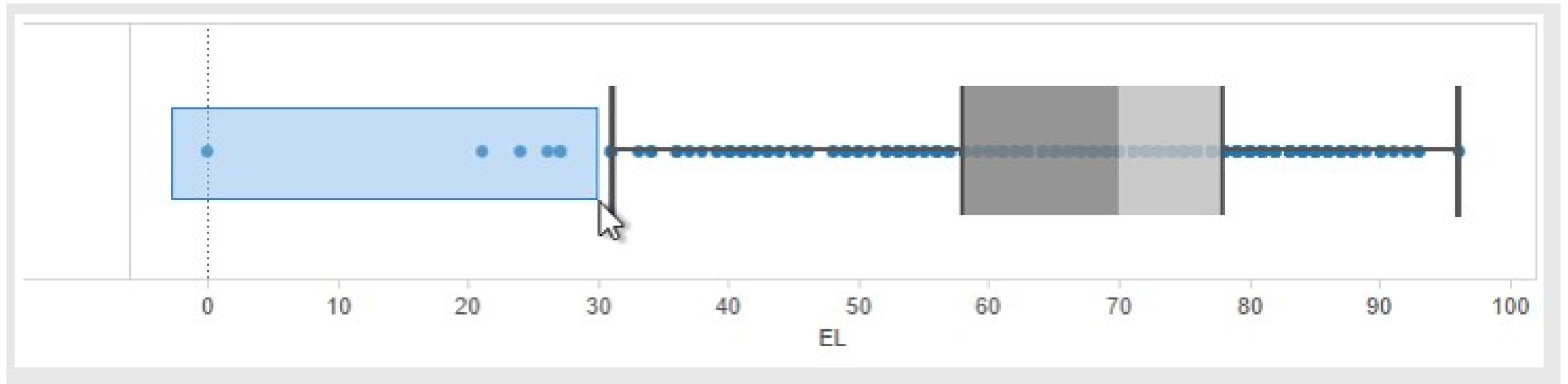
View Manipulation: Selection functions

- **Pointer** selects a single object in a plot.



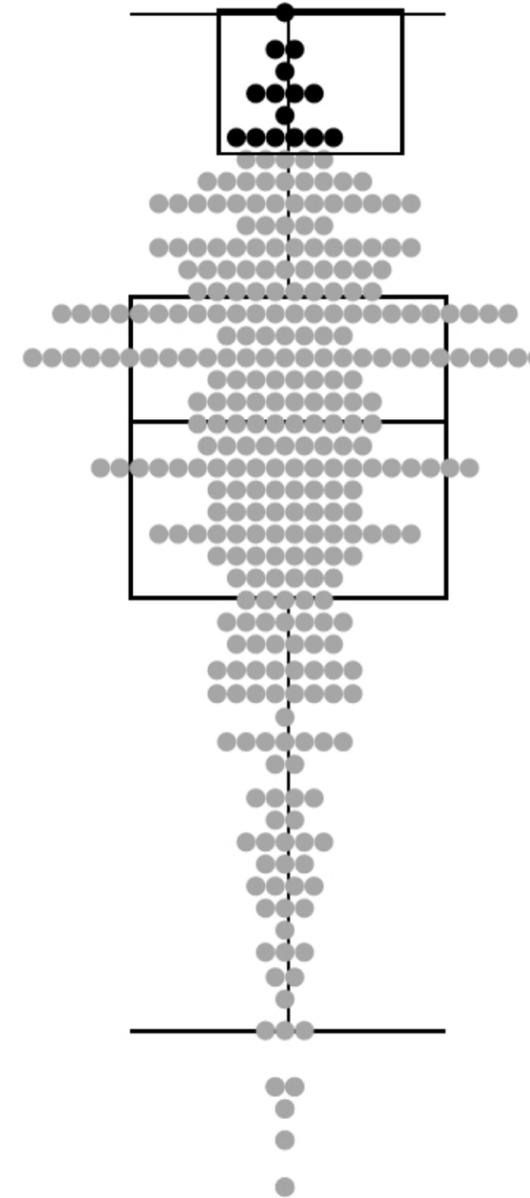
View Manipulation: Selection functions

- Drag-box selects a rectangular region in a box.



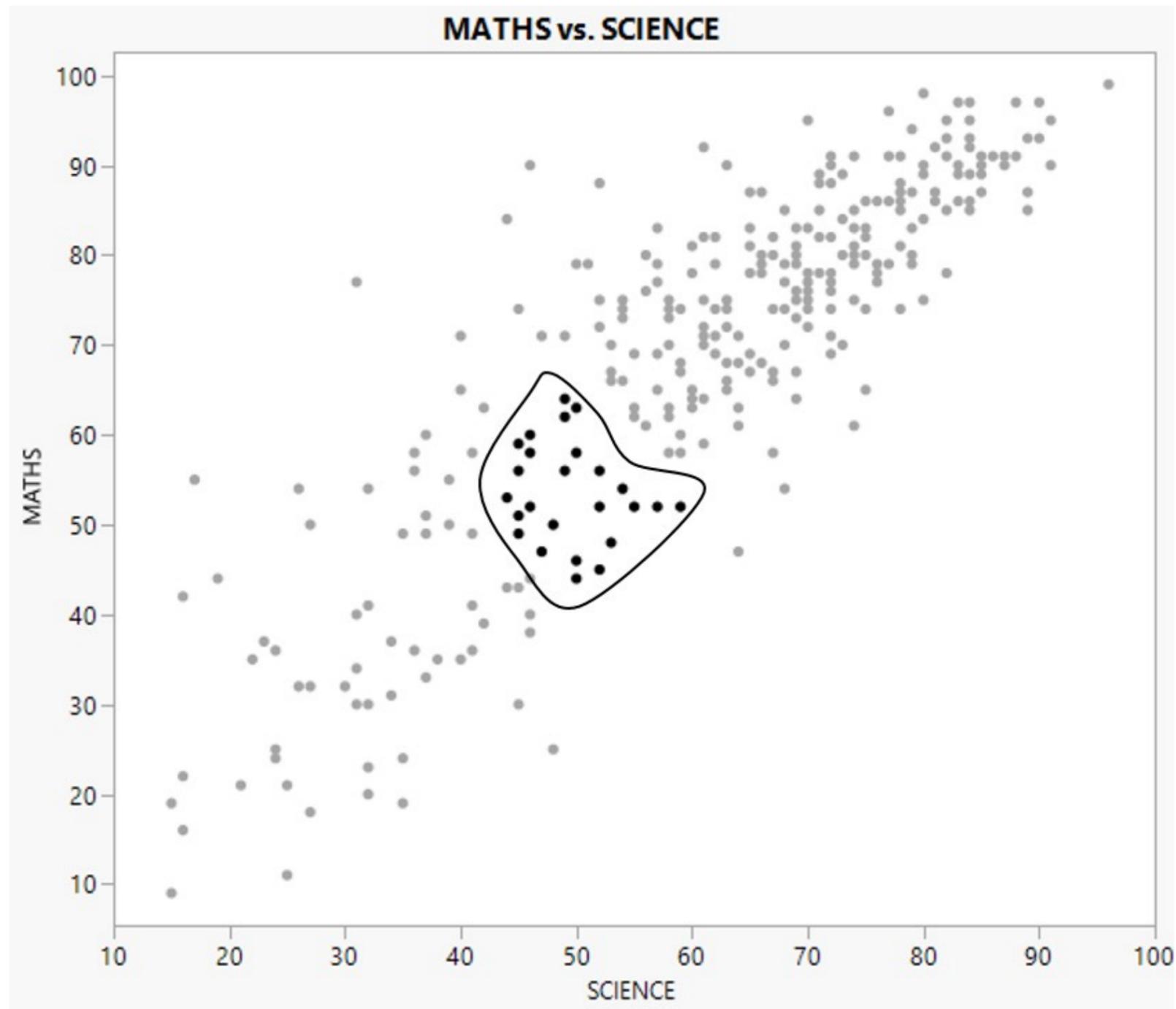
View Manipulation: Selection functions

- **Brush** is a generalisation of the drag-box. Once a rectangular region is defined, the brush allows users to move that region across a plot and thus dynamically change the selected subset.



View Manipulation: Selection functions

- **Lasso** allows users to define an arbitrary contiguous shape to select data.



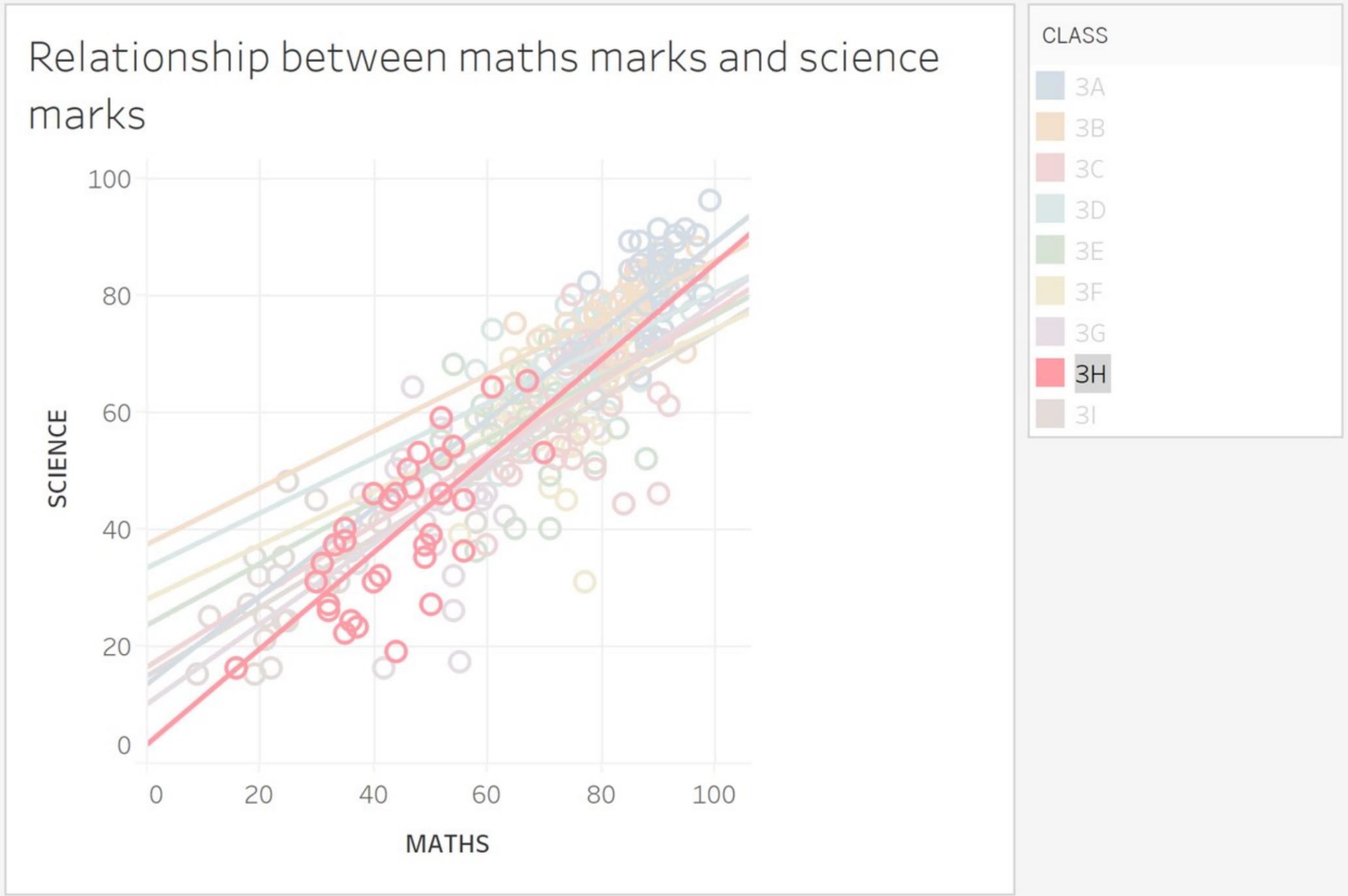
View Manipulation: Selection modes



Reference: [Mondrian](#)

View Manipulation: Highlighting

- Selected records are highlighted.



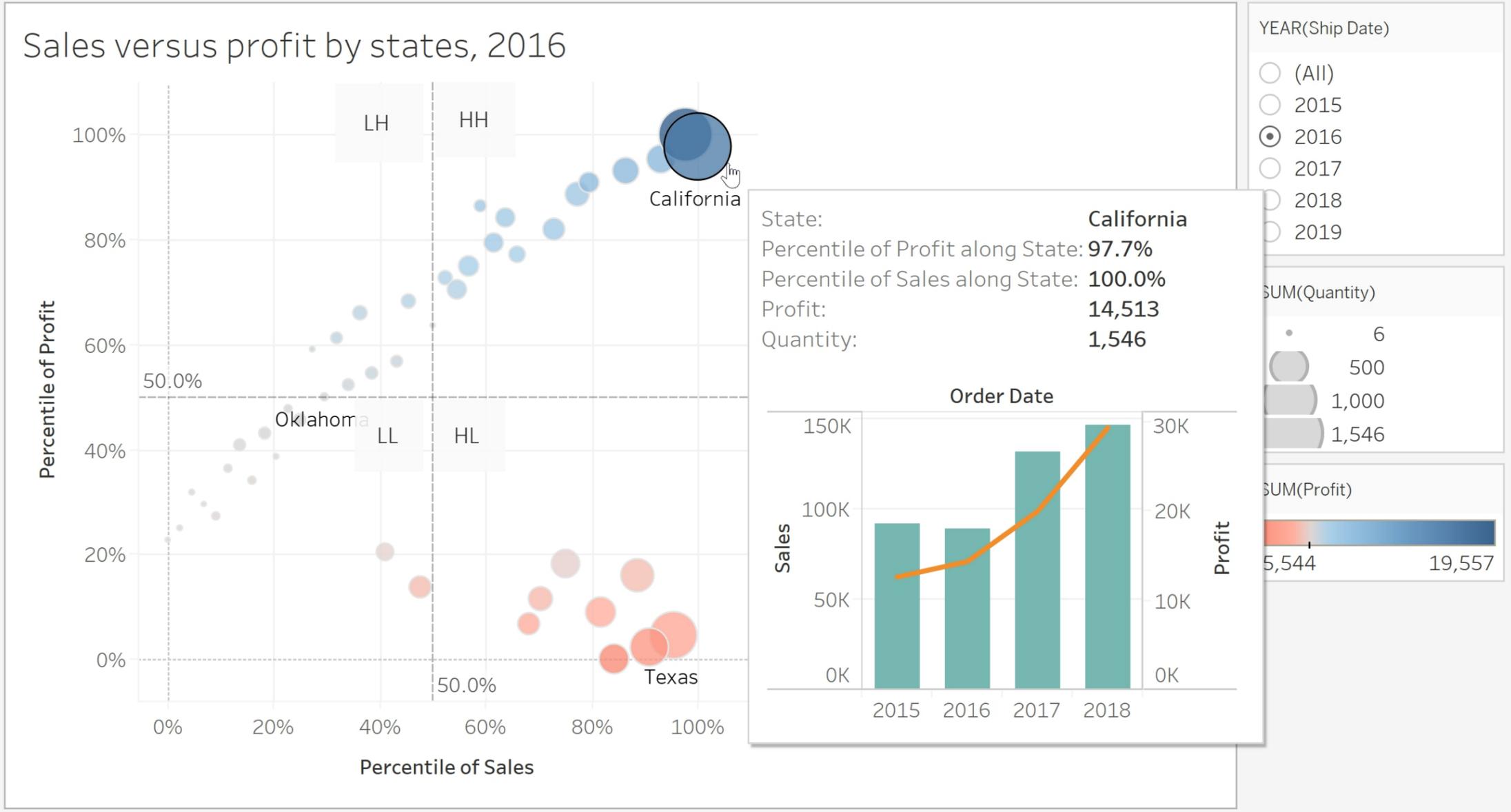
View Manipulation

- **Navigate** to examine high-level patterns and low-level detail.
- Shneiderman's mantra

**“Overview first,
zoom and filter,
then details-on-demand”**

View Manipulation

- The scatter plot provides an overview and the bar and line graphs provide detail sales and profits trends overtime.

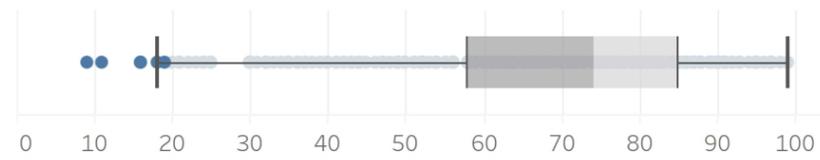


View Manipulation

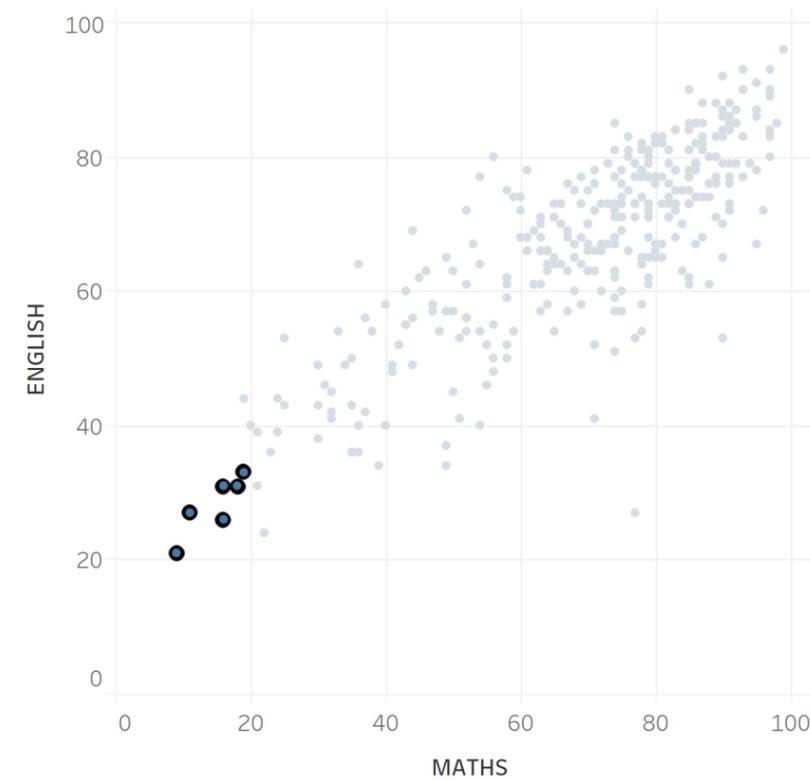
- **Coordinate** views for linked, multi-dimensional exploration

Scatterplot with marginal boxplot

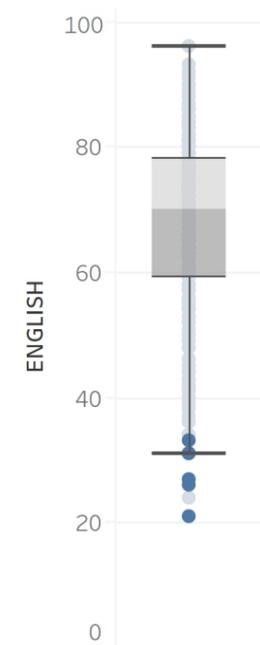
Maths



English versus Maths



English



View Manipulation

- Organise multiple windows and workspaces.

2017 VAST CHALLENGE

The Problem
Mistford is a mid-size city located to the southwest of a large nature preserve. Mitch Vogel is a post-doc student studying ornithology at Mistford College and has been discovering signs that the number of nesting pairs of the Rose-Crested Blue Pipit, a popular local bird due to its attractive plumage and pleasant songs, is decreasing!

The Tasks
Examine the movement of traffic through the Boonsong Lekagul Nature Preserve to validate the hypothesis that there is some link between the traffic going through the preserve and the decline in the nesting Rose-crested Blue Pipit—maybe the traffic noises are drowning out mating calls! Or perhaps he can discover some odd goings on in the traffic patterns—perhaps campers are invading the bird's habitat areas?

Demystifying with Visual Analytics

- 1. Activity Overview**
Hourly & daily traffic size at various checkpoints in the reserve
- 2. Pattern Analysis**
Gantt bars and heatmaps to visualize the daily and longer period patterns of life in the reserve
- 3. Path Analysis**
Heatmap and animated map to visualize the most frequently travelled paths
- 4. Movement Anomaly**
Gantt chart and heatmap to discover unusual movements in the reserve
- 5. Duration Anomaly**
Scatter plot and heatmap to discover the outliers in reserve stay durations

Type of Visitors
The visitors were divided into 6 segments based on their vehicles and activity patterns

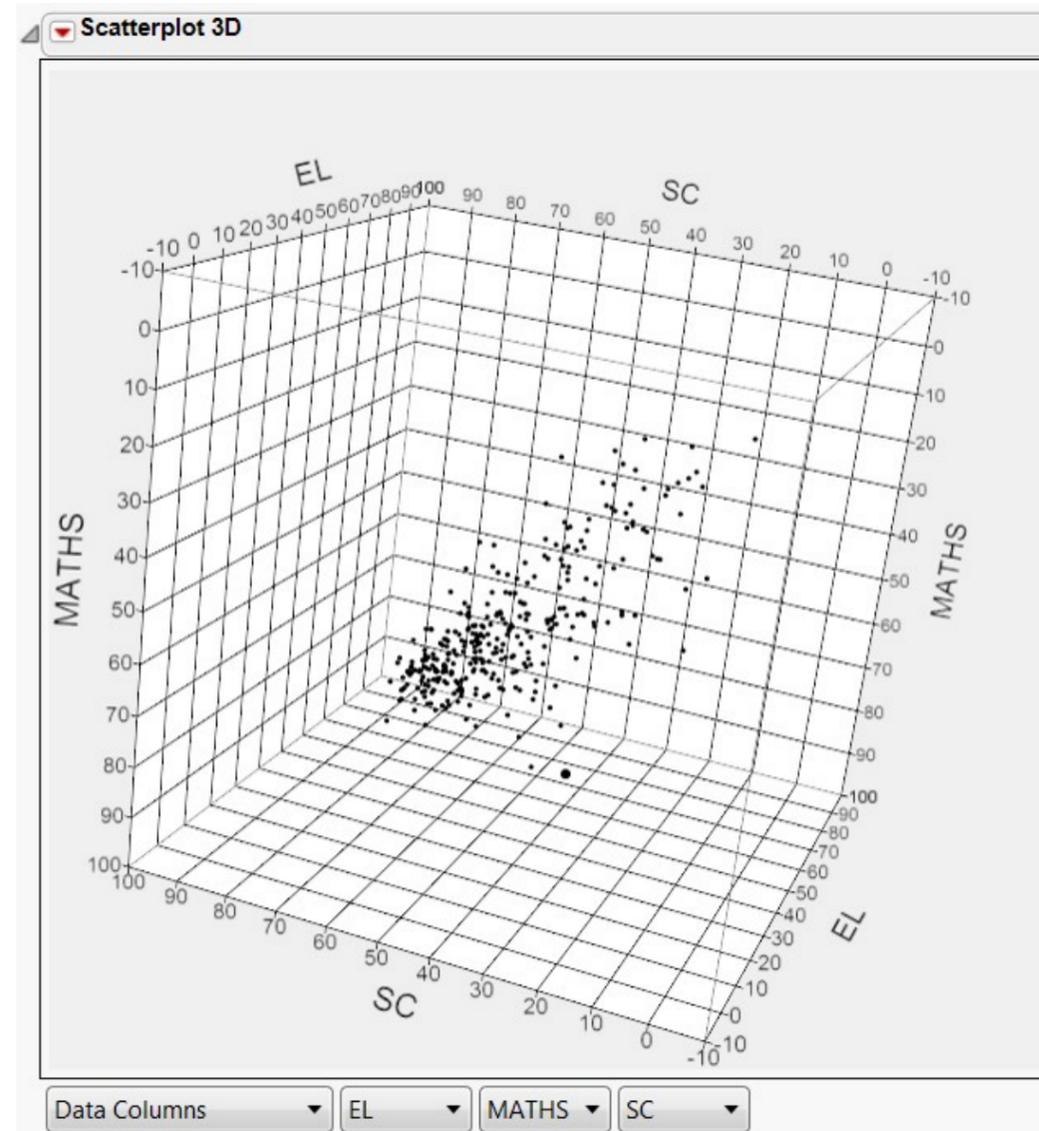
Visitor Type	Is Ranger?	Entrance to entrance only?	4 Axle Truck?	Visited Camps?	>1 day stay?	No of Cars	% of Total
Day Camper	No	No	No	Yes	Yes	3,139	83.93%
Extended Campers	No	No	No	Yes	No	6,521	99.66%
				No	Yes	16	8.79%
Pass-by	No	Yes	No	Yes	No	1,337	19.10%
				No	Yes	2	8.00%
				Yes	No	225	18.46%
Ranger	Yes	No	No	No	Yes	375	5.36%
				Yes	No	22	0.34%
				Yes	Yes	601	16.07%
Sightseeing	No	No	No	No	No	166	91.21%
				Yes	Yes	5,287	75.54%
Service Trucks	No	No	Yes	No	No	23	92.00%
				Yes	Yes	994	81.54%

Type of Visitors by Car Type

Source: [VAST Challenge 2017 MC1 by Yifi](#)

View Manipulation: Rotating

- Touring view with JMP's 3D scatterplot

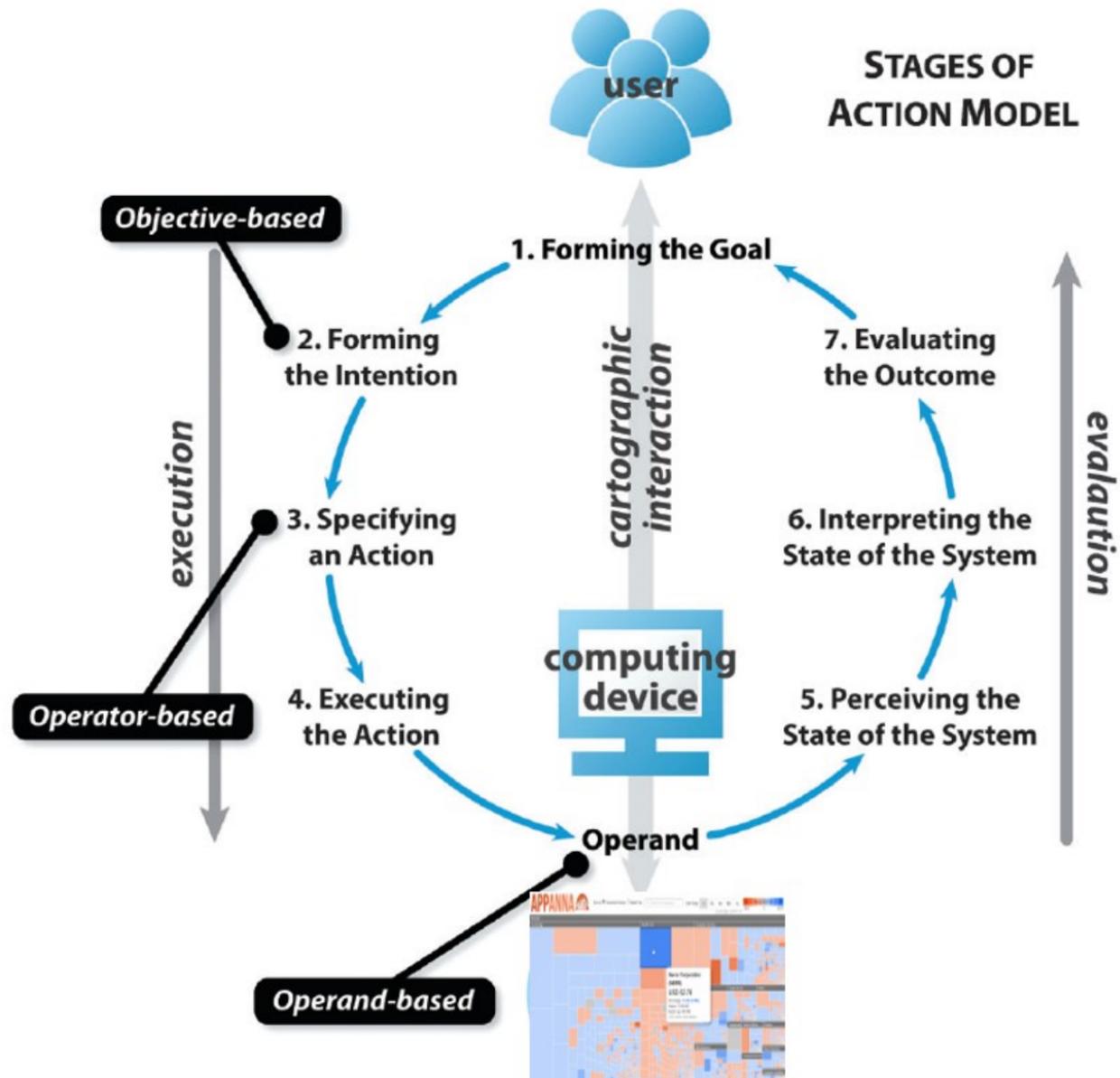


Process and Provenance

- **Record** analysis histories for revisitation, review and sharing.
- **Annotate** patterns to determine findings.
- **Share** views and annotations to enable collaboration.
- **Guide** users through analysis tasks or stories.

Interactive Design Primitive

A framework for effective interactive design in visual analytics application.



Source: Roth, R.E. (2012) "Cartographic Interaction Primitive: Framework and Synthesis". The Cartographic Journal, Vol. 49, No. 4 pp. 376-395.

Interactive Design Primitive

Visual Analytics Objective Primitives

objectives

geographic insight

- | | | |
|---------------------|---|---|
| 1. <i>identify</i> | → | <i>e.g., ID, locate</i> |
| 2. <i>compare</i> | → | <i>e.g., difference, change</i> |
| 3. <i>rank</i> | → | <i>e.g., anomaly, outlier</i> |
| 4. <i>associate</i> | → | <i>e.g., correlation, trend, cause-effect</i> |
| 5. <i>delineate</i> | → | <i>e.g., cluster, hotspot, spike</i> |

Interactive Analytics Operator Primitives

operators

- | | |
|------------------------------|-----------------------------|
| 1. <i>reexpress</i> | 7. <i>pan</i> |
| 2. <i>arrange</i> | 8. <i>zoom</i> |
| 3. <i>sequence</i> | 9. <i>filter</i> |
| 4. <i>resymbolize</i> | 10. <i>search</i> |
| 5. <i>overlay</i> | 11. <i>retrieve</i> |
| 6. <i>reproject</i> | 12. <i>calculate</i> |

Interactive Design Primitive

objectives

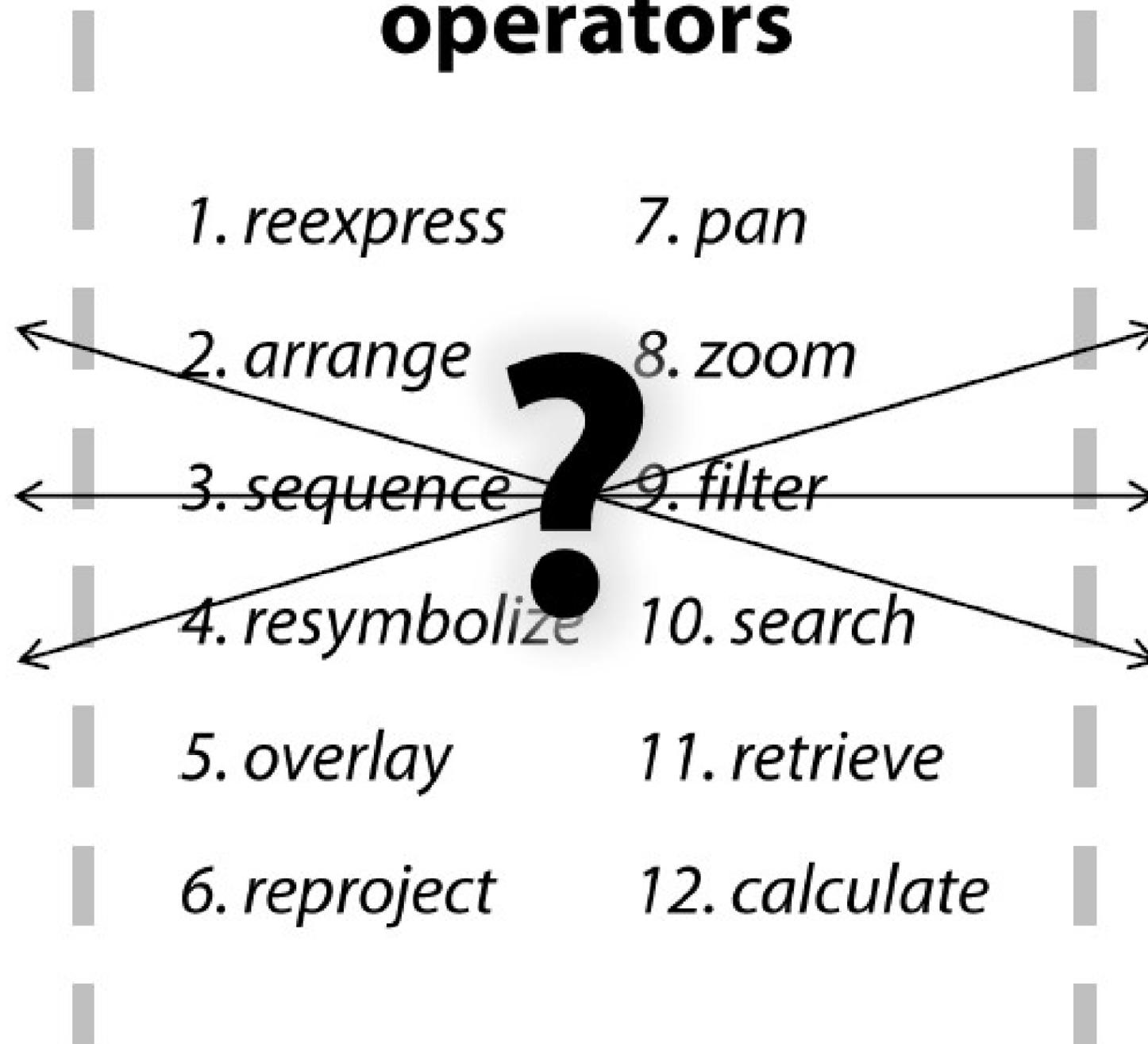
1. *identify*
2. *compare*
3. *rank*
4. *associate*
5. *delineate*

operators

1. *reexpress*
2. *arrange*
3. *sequence*
4. *resymbolize*
5. *overlay*
6. *reproject*
7. *pan*
8. *zoom*
9. *filter*
10. *search*
11. *retrieve*
12. *calculate*

operands

1. *space-alone*
2. *attributes-in-space*
3. *space-in-time*



Animation in Visual Analytics

- The purpose of animation is to facilitate perception of changes when transitioning between related data graphics
- Do not confine to time-series data only

The Original Design

The New York Times recently published an interactive graphic for exploring different types of American households. [Go check it out.](#)



Source: [How Many Households](#)

Why using Animation in Visual Analytics

- Motion is highly effective at attracting attention.
- Animation facilitates object constancy for changing objects.
- Animated behaviours can give rise to perceptions of causality and intentionality, communicating cause-and-effect relationships and establishing narrative.
- Animation can be emotionally engaging, engendering increased interest or enjoyment.

Principles of Animation

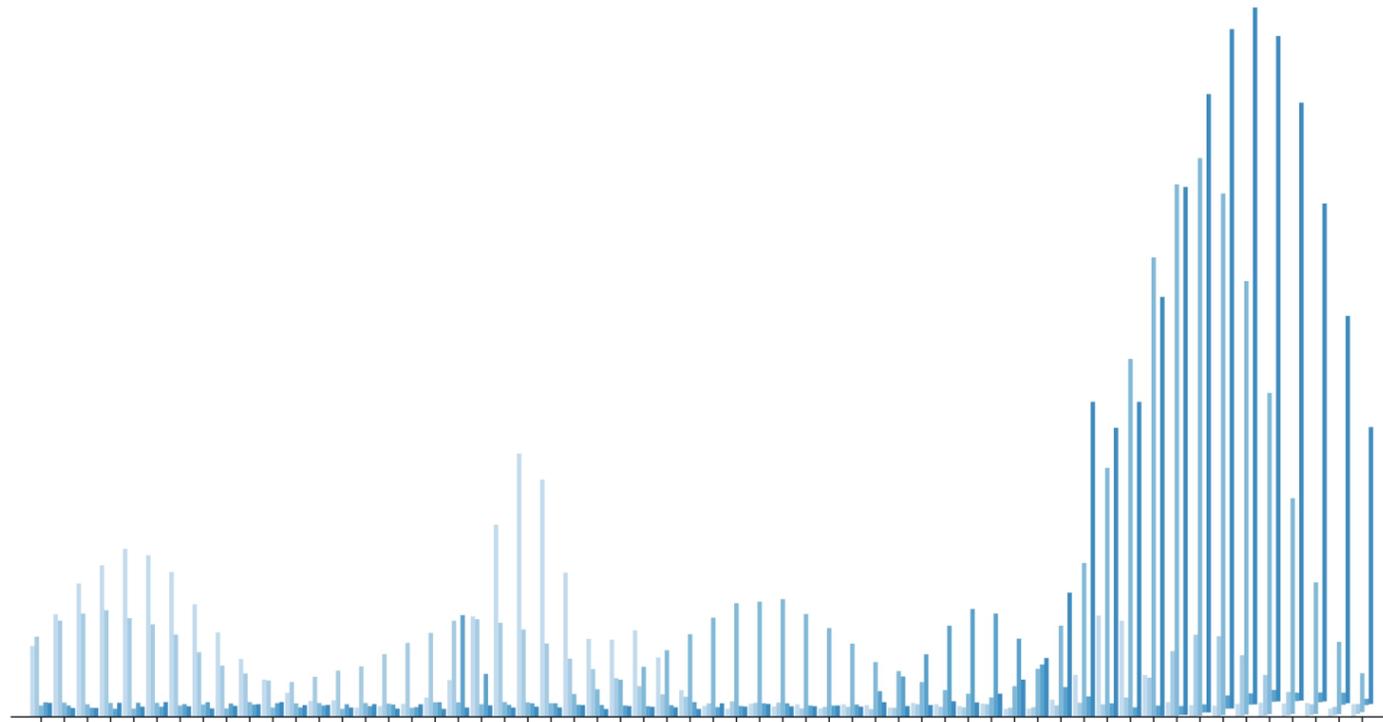
- *Congruence* principle states that the structure and content of the external representation should correspond to the desired and content of the internal representation.
- Maintain valid data graphics during transitions
- Use consistent semantic-syntactic mappings
- Respect semantic correspondence
- Avoid ambiguity
- *Apprehension* principle states that the structure and content of the external representation should be readily and accurately perceived and comprehended.
- Group similar transitions
- Minimise occlusion
- Maximise predictability
- Use simple transitions
- Use staging for complex transitions
- Make transitions as long as needed, but no longer

Source: Heer, J and Robertson G. (2007) [Animated Transitions in Statistical data Graphics](#), IEEE Transactions on Visualization and Computer Graphics, Vol. 13, No. 6, 1240-1247 and the [video](#).

Animation in Action

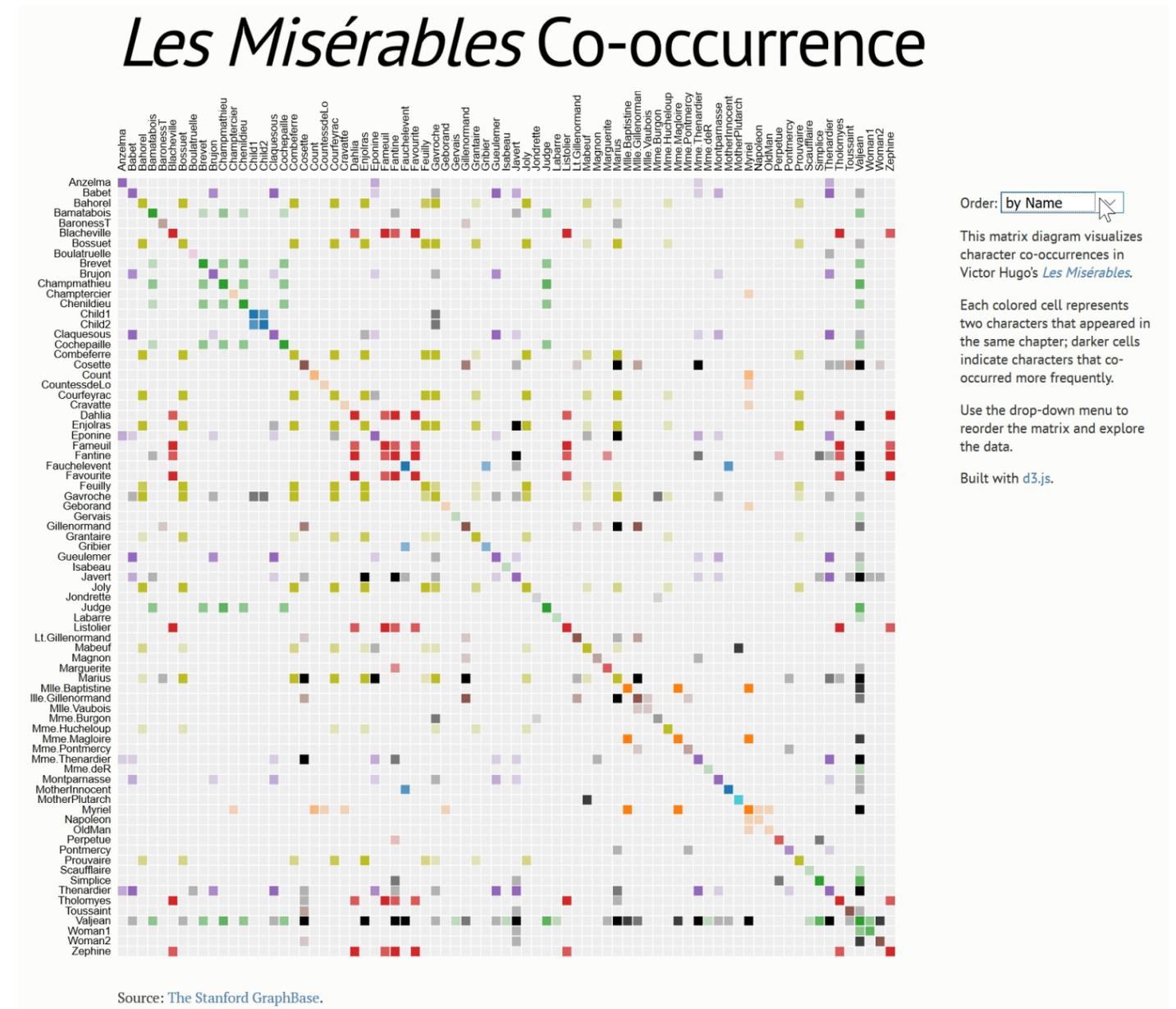
Stacked-to-Grouped Bars

○ Stacked ● Grouped



Source: [Stacked to Grouped Bars](#)

Animated Co-occurrence matrix



Source: [Miserables](#)

References

- [Dynamics for Visual Analysis](#)
- [Animated Transitions in Statistical Data Graphics](#), IEEE Transactions on Visualization and Computer Graphics, Vol. 13, No. 6, 1240-1247 and the [video](#)
- [Coordinated Highlighting in Context](#)
- [Cartographic Interaction Primitive: Framework and Synthesis](#)

