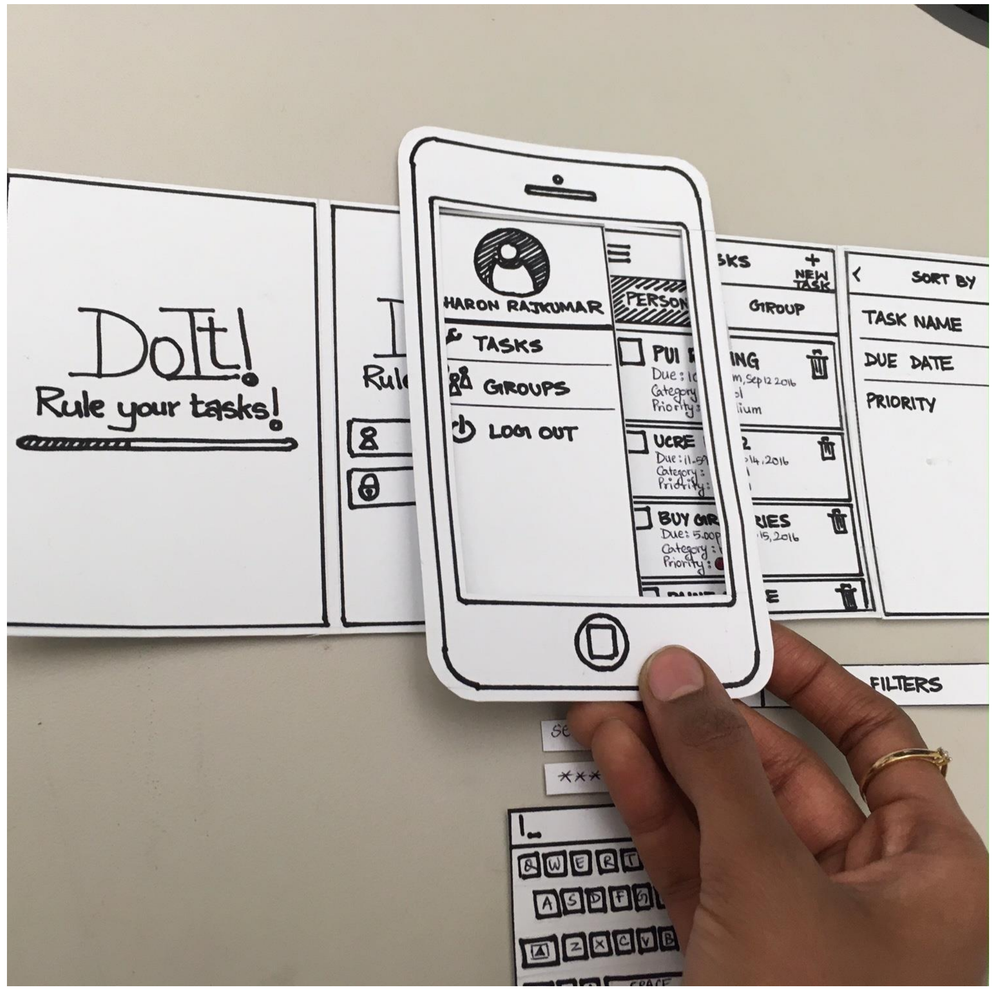
Cody Dunne
Northeastern University

Interaction & Animation

Goals for Today

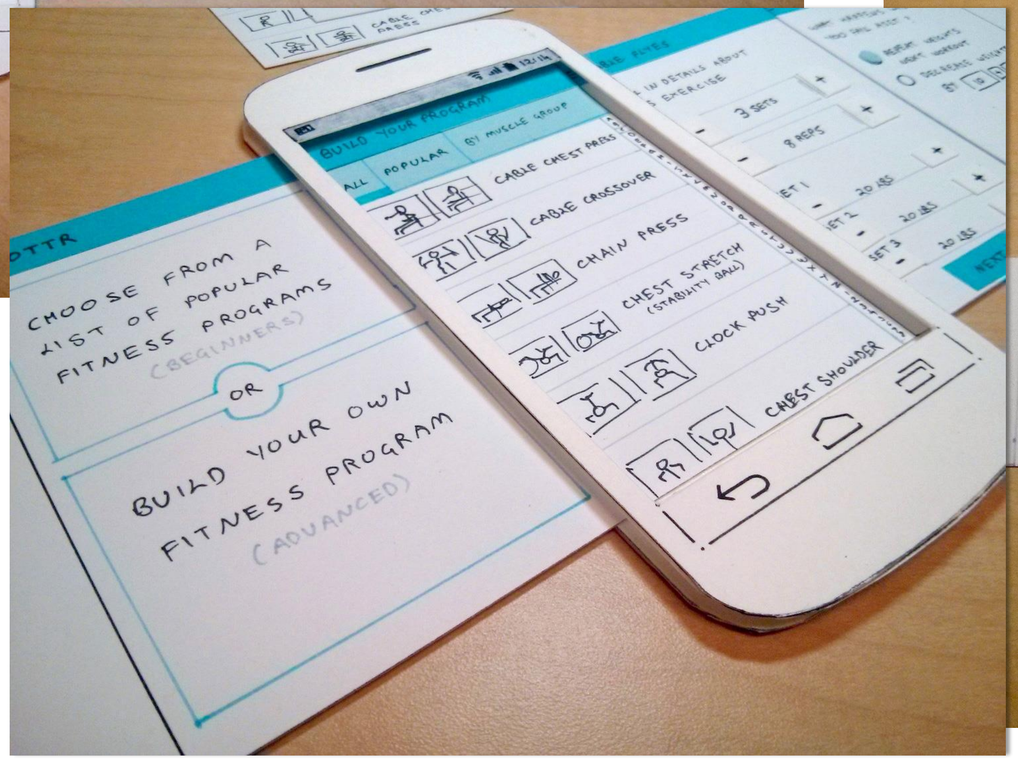
- Discuss paper prototyping for your project sketches
- Learn when and why to use interaction.
- Learn the basic interactive functions for visualizations.

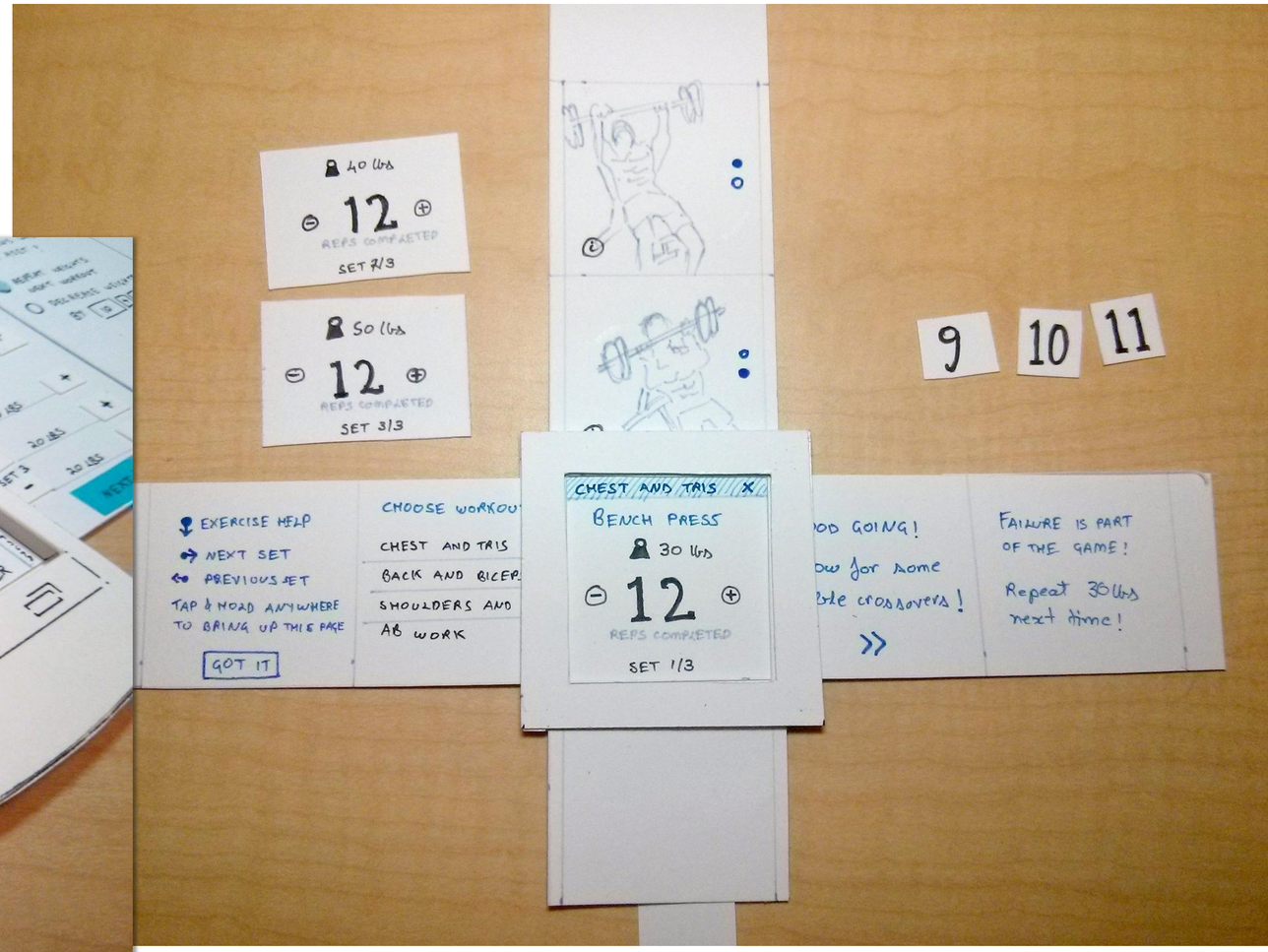
Paper Prototyping



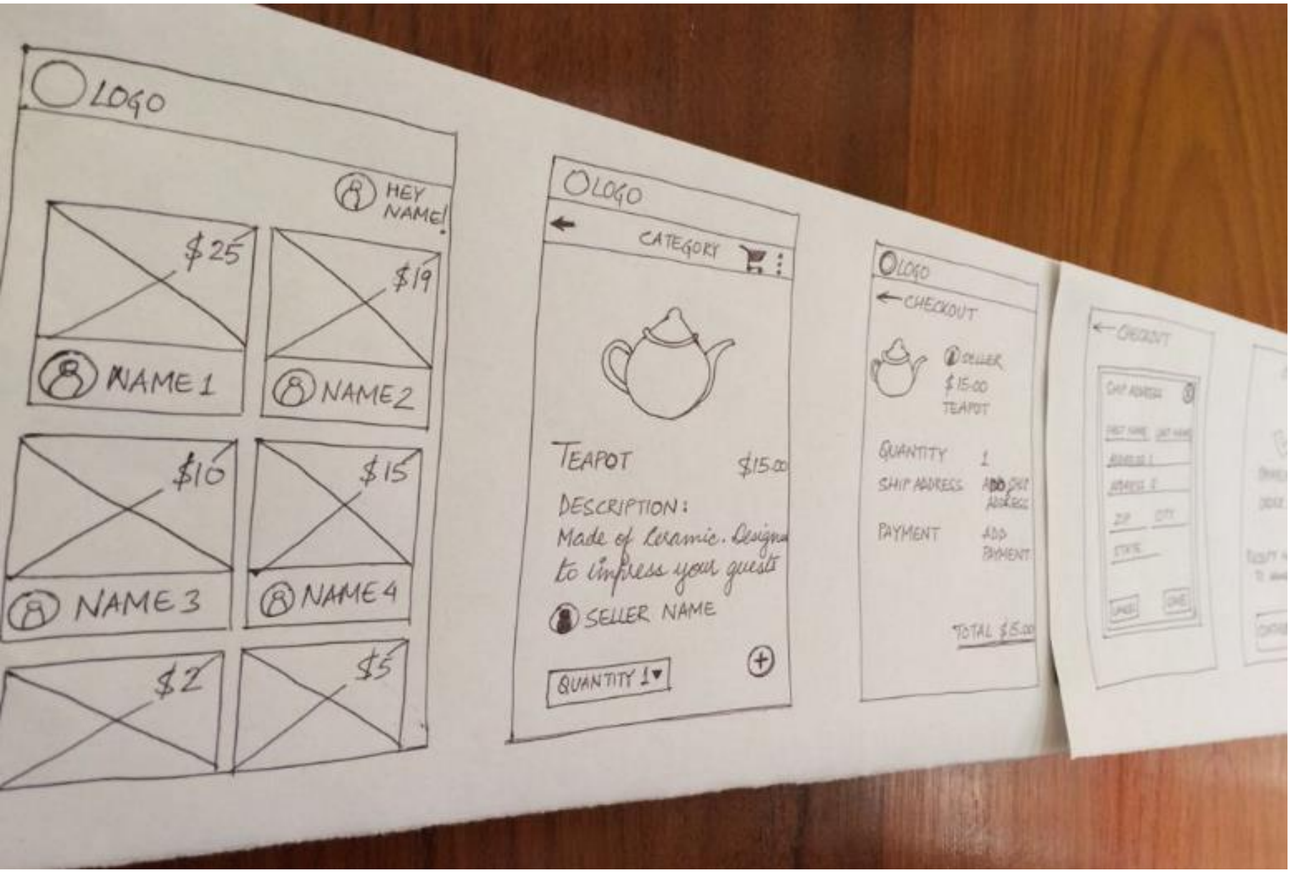
[Analitico, 2013](); [Rajkumar, 2017]()

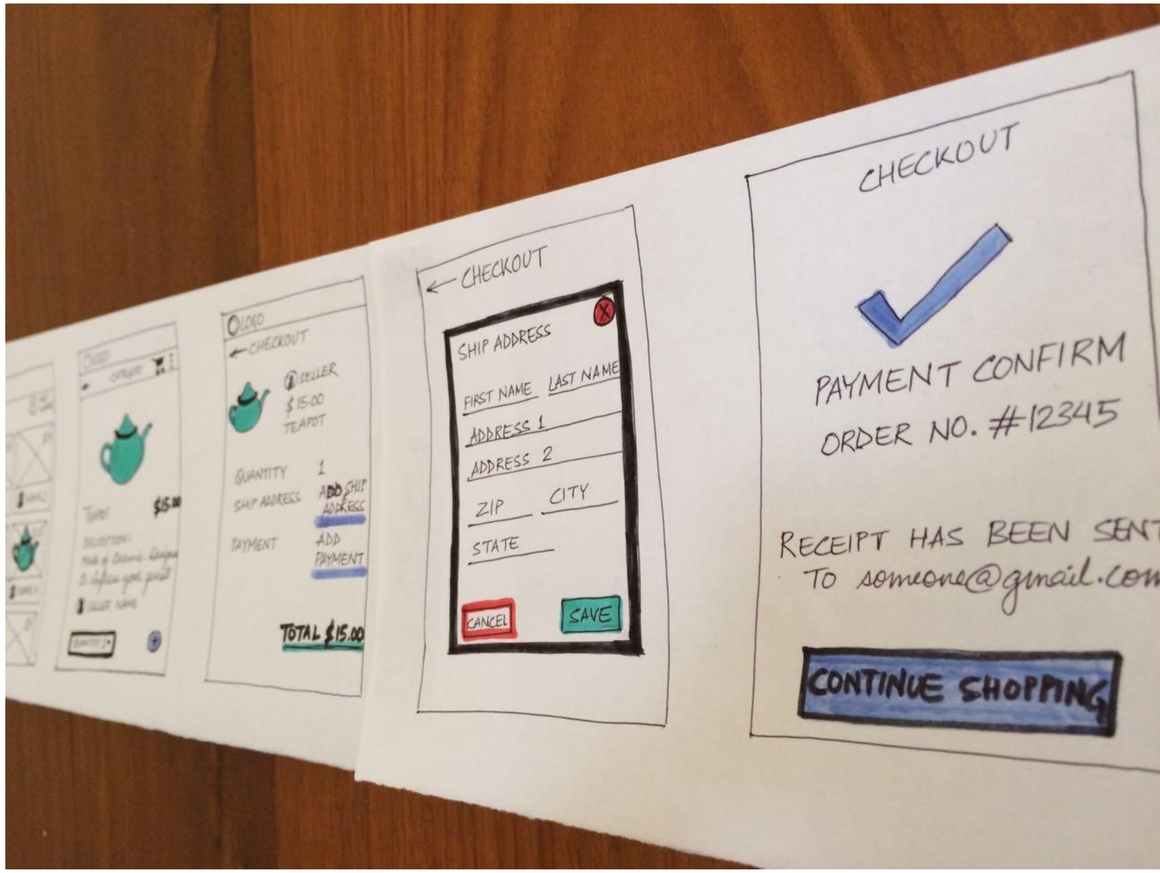
Paper Prototyping





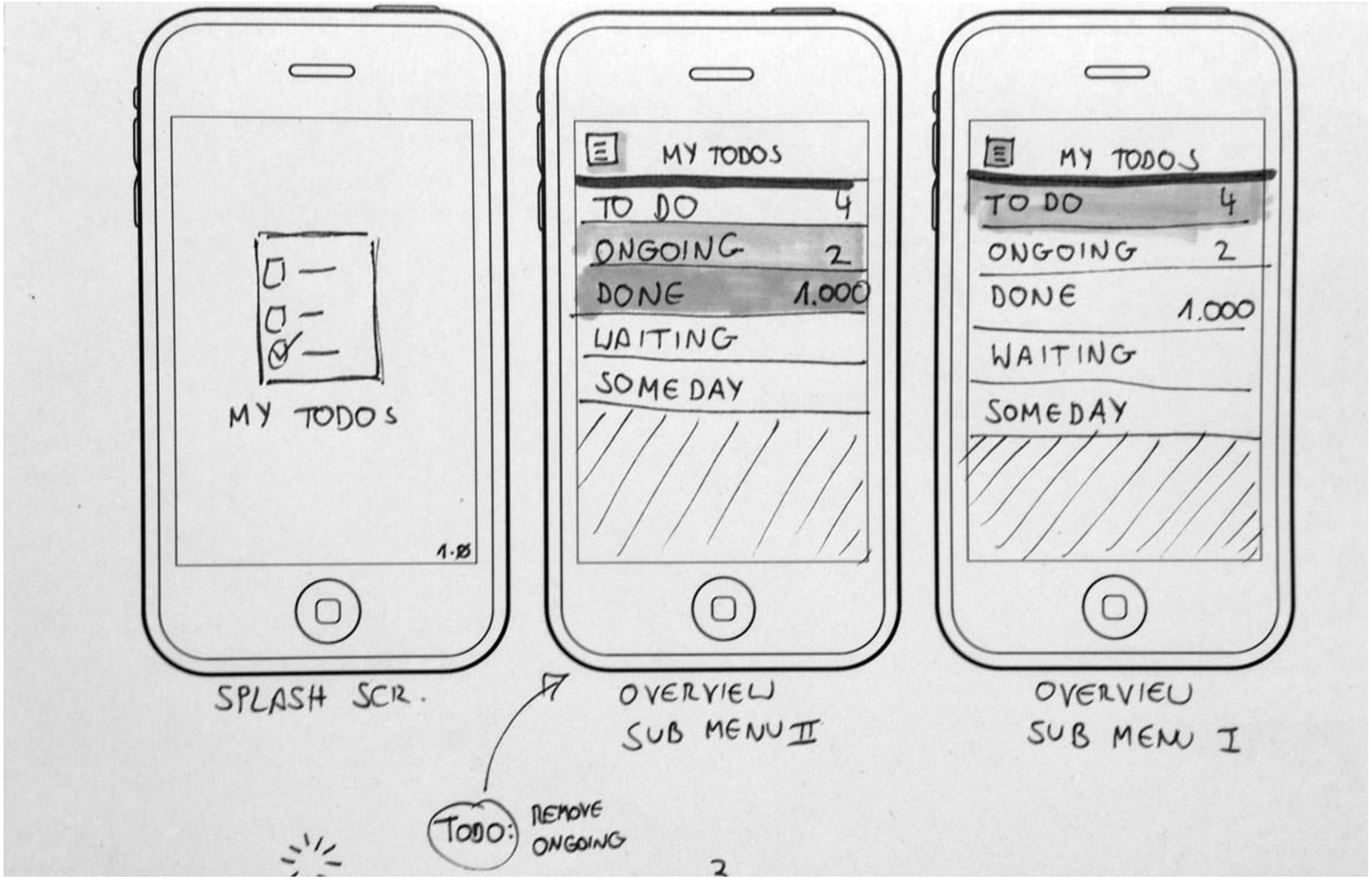
Low Fidelity to High Fidelity





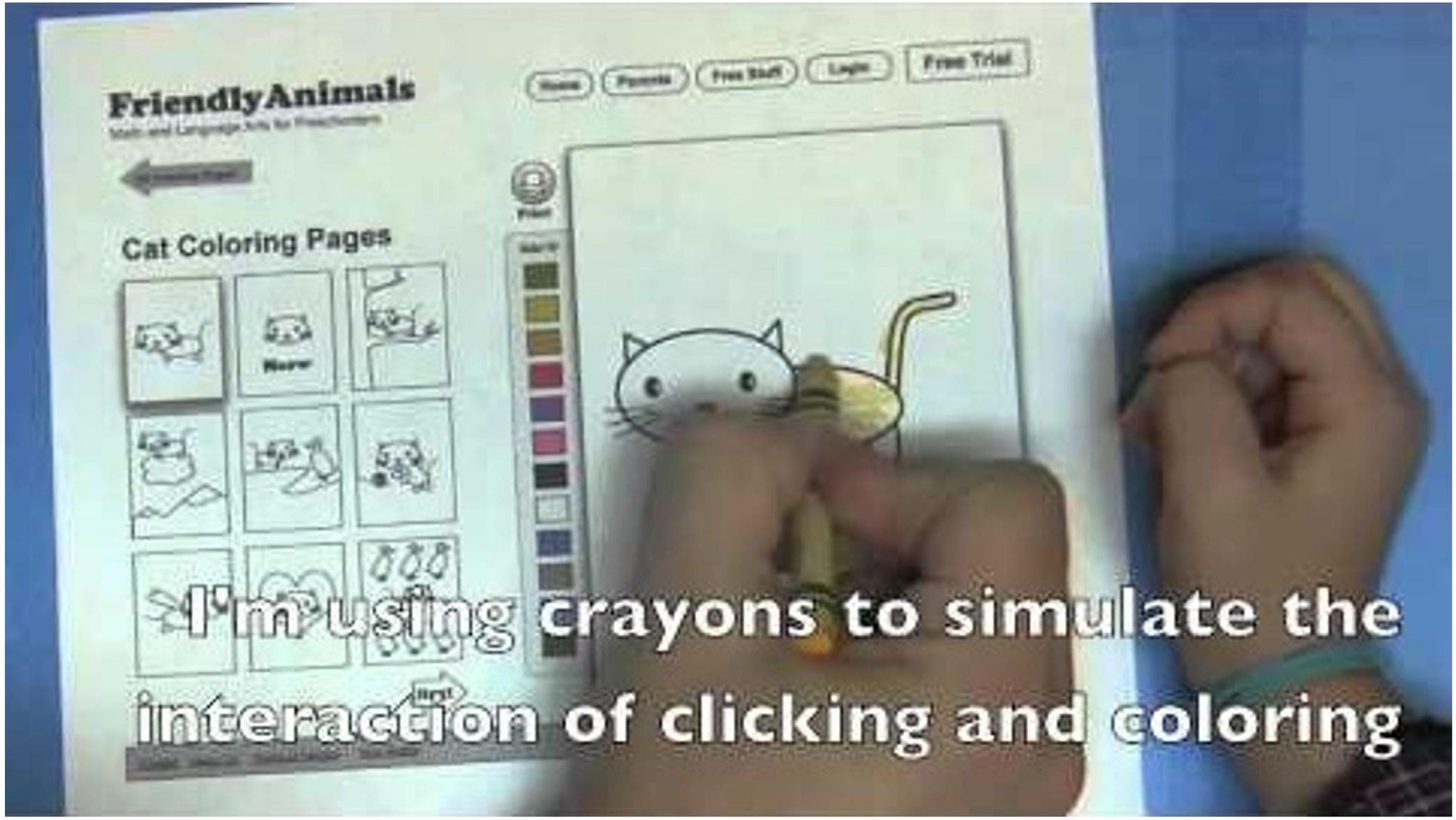
CanvasFlip, 2016

Sketching of Interactivity



Hennigs, 2013

Example Usability Test with a Paper Prototype



BlueDuckLabs, 2010


FriendlyAnimals
Cat Coloring Pages
I'm using crayons to simulate the
interaction of clicking and coloring

INTERACTION

Visualizing big data

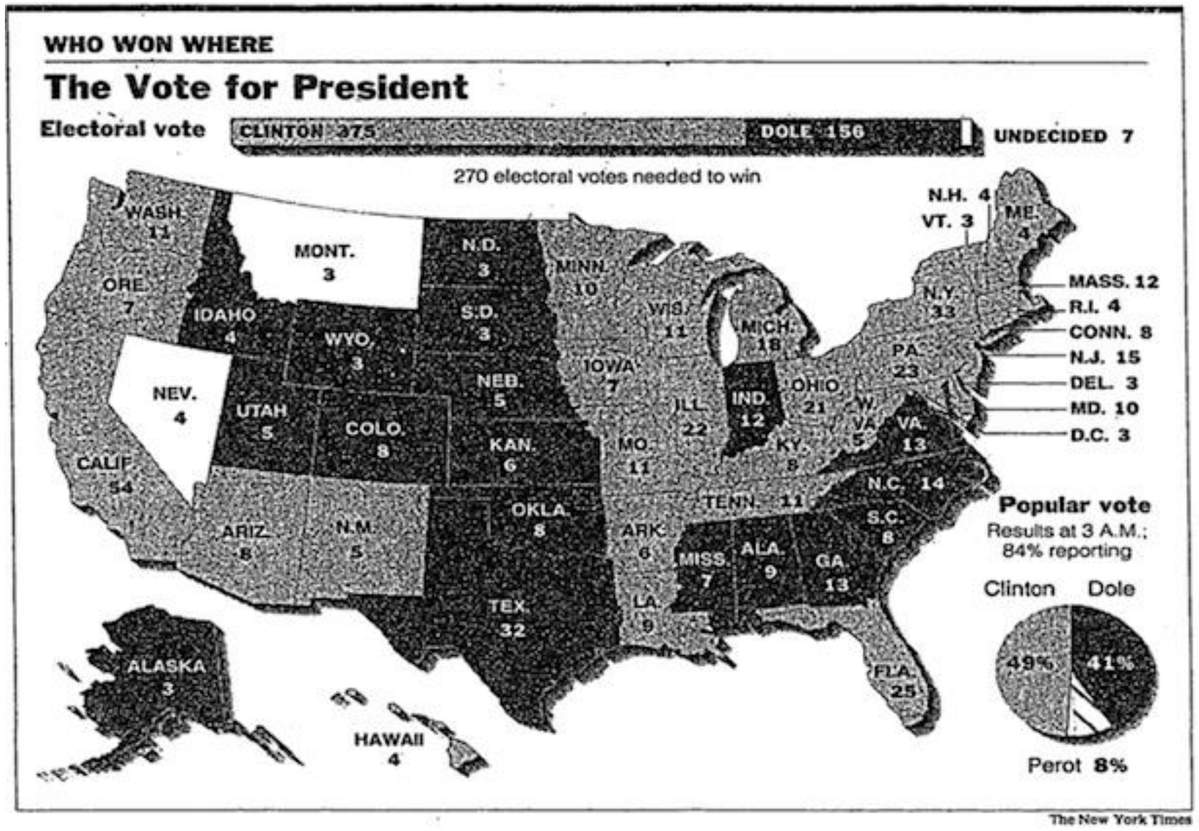
Several approaches for visualizing big data

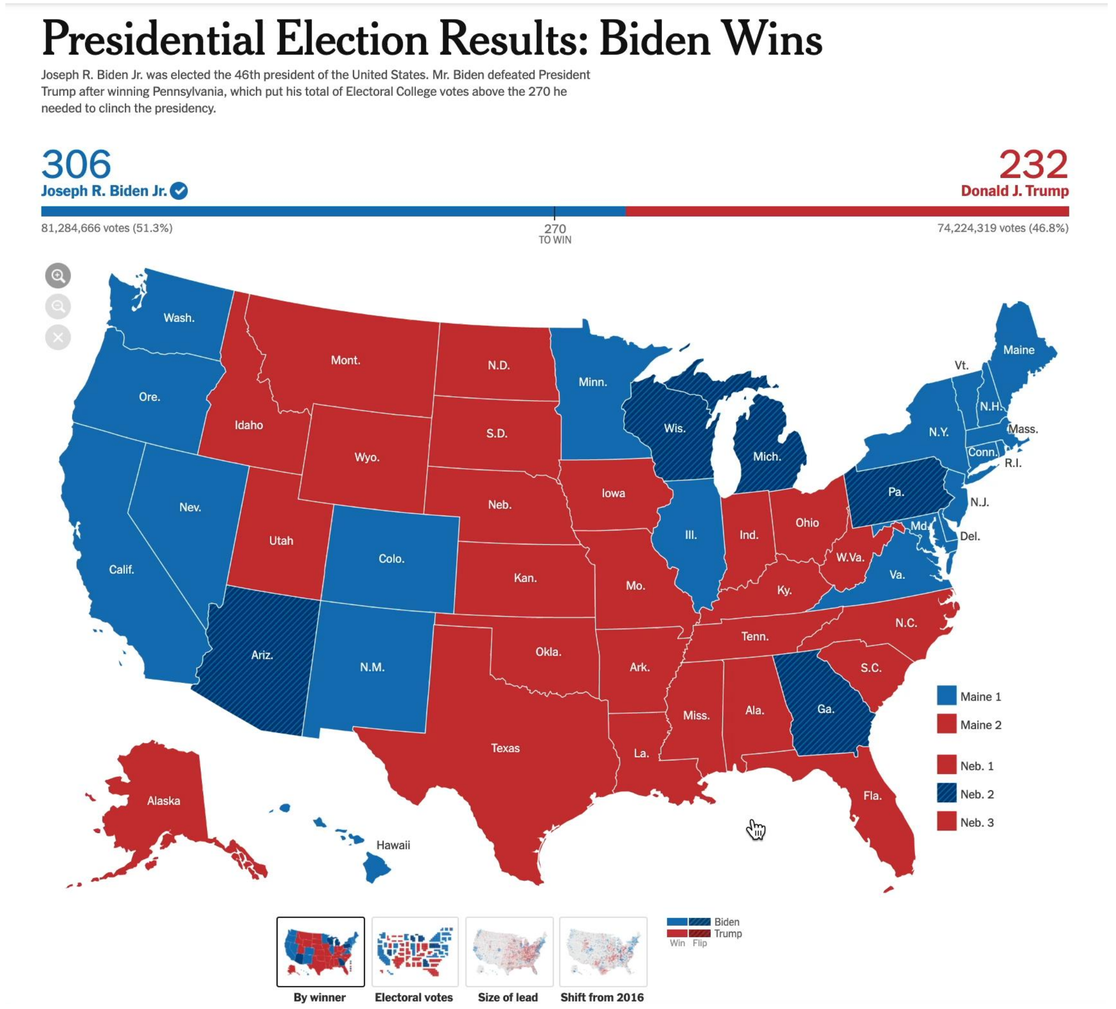
1. Dimensional Reduction—Reduce amount of attributes visualized
2. Interactions—Let user manipulate a single view
3. Faceting—Split data into multiple views
4. Aggregate and Filter—Reduce amount of data visualized
5. Focus+Context—Embed focused information

Interaction has benefits

- Enables visualization of large amounts of data
- Amplifies user cognition (supports sensemaking)
- Increases engagement (vis becomes personal to user)
- Increases deep learning and learning transfer

Interaction to expose details at the user's pace





New York Times, 1996 [via Megan Garber, 2012]

[New York Times, 2020]

Interaction has drawbacks

- Requires human time and attention
- Increase perceptual and exploration costs (van Wijk 2005)
- Interaction costs (Lam 2008)
- Multiple user studies find no increase in performance in specific situations (Ragan et al. 2012, Theis et al. 2016, Mosca et al., 2021)

Weigh the tradeoffs when designing!

Benefits

Costs

How?

Encode

Arrange

- Express
- Separate
- Order
- Align
- Use

Map

from categorical and ordered attributes

- Color
  - *Hue*
  - *Saturation*
  - *Luminance*
- Size, Angle, Curvature, ...
- Shape
- Motion
  Direction, Rate, Frequency, ...

Manipulate

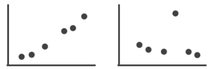
Change

Select

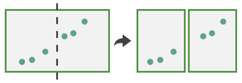
Navigate

Facet

Juxtapose



Partition



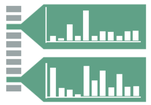
Superimpose

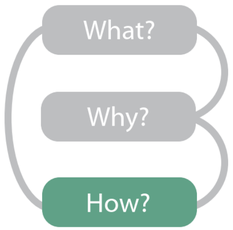
Reduce

Filter

Aggregate

Embed

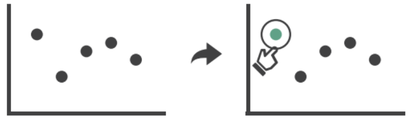




Manipulate

Change over Time

Select



Navigate

Item Reduction

- *Zoom*
  Geometric or *Semantic*

- *Pan/Translate*

- *Constrained*

Attribute Reduction

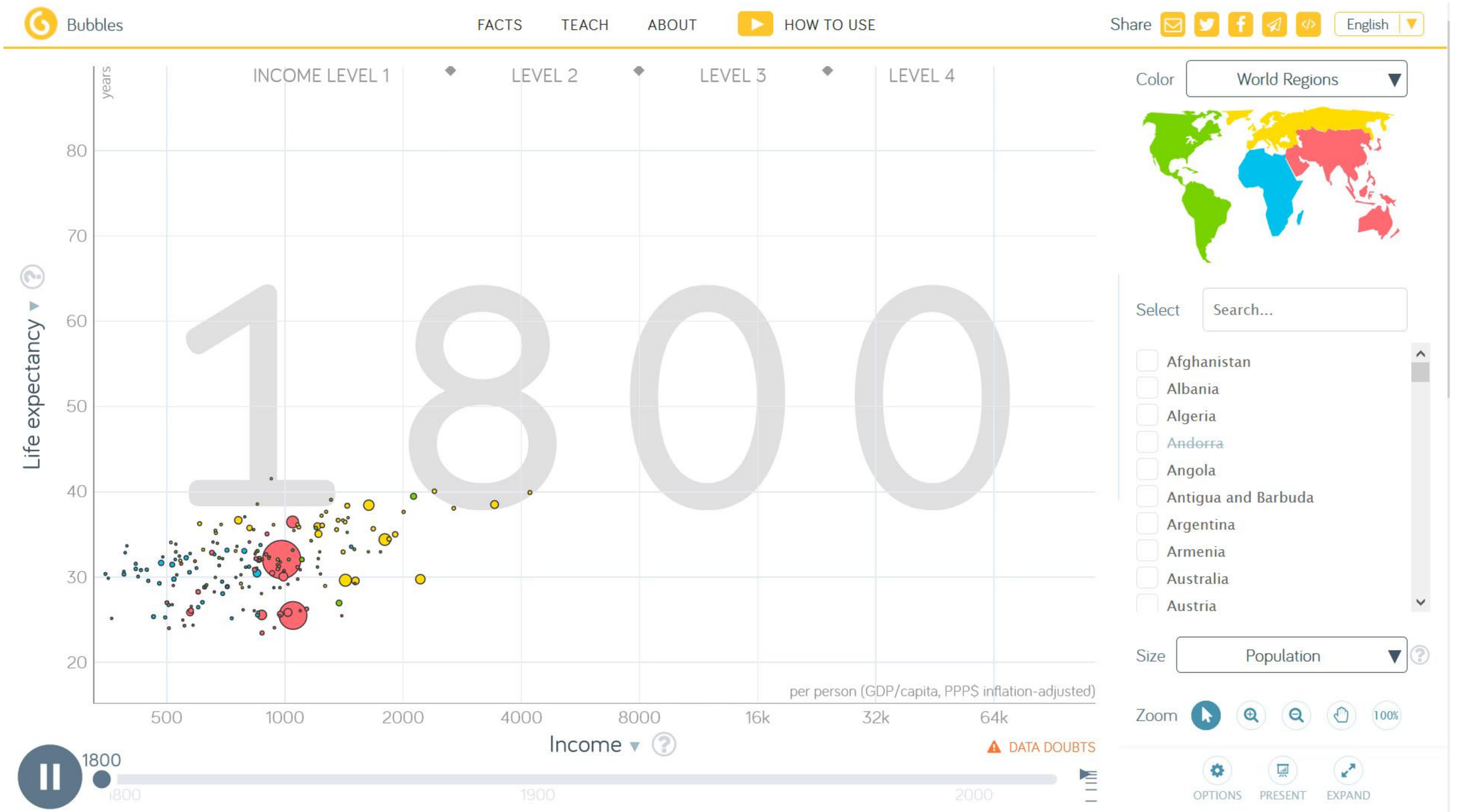
- *Slice*

- *Cut*

- *Project*

Change over Time

Showing changing data



Gapminder, 2018

Change over Time

Showing changing encodings

flexible transitions

Mike Bostock, 2011

Change over Time

Explaining algorithms

D3 General **Enter**, **Update**, **Exit** Pattern

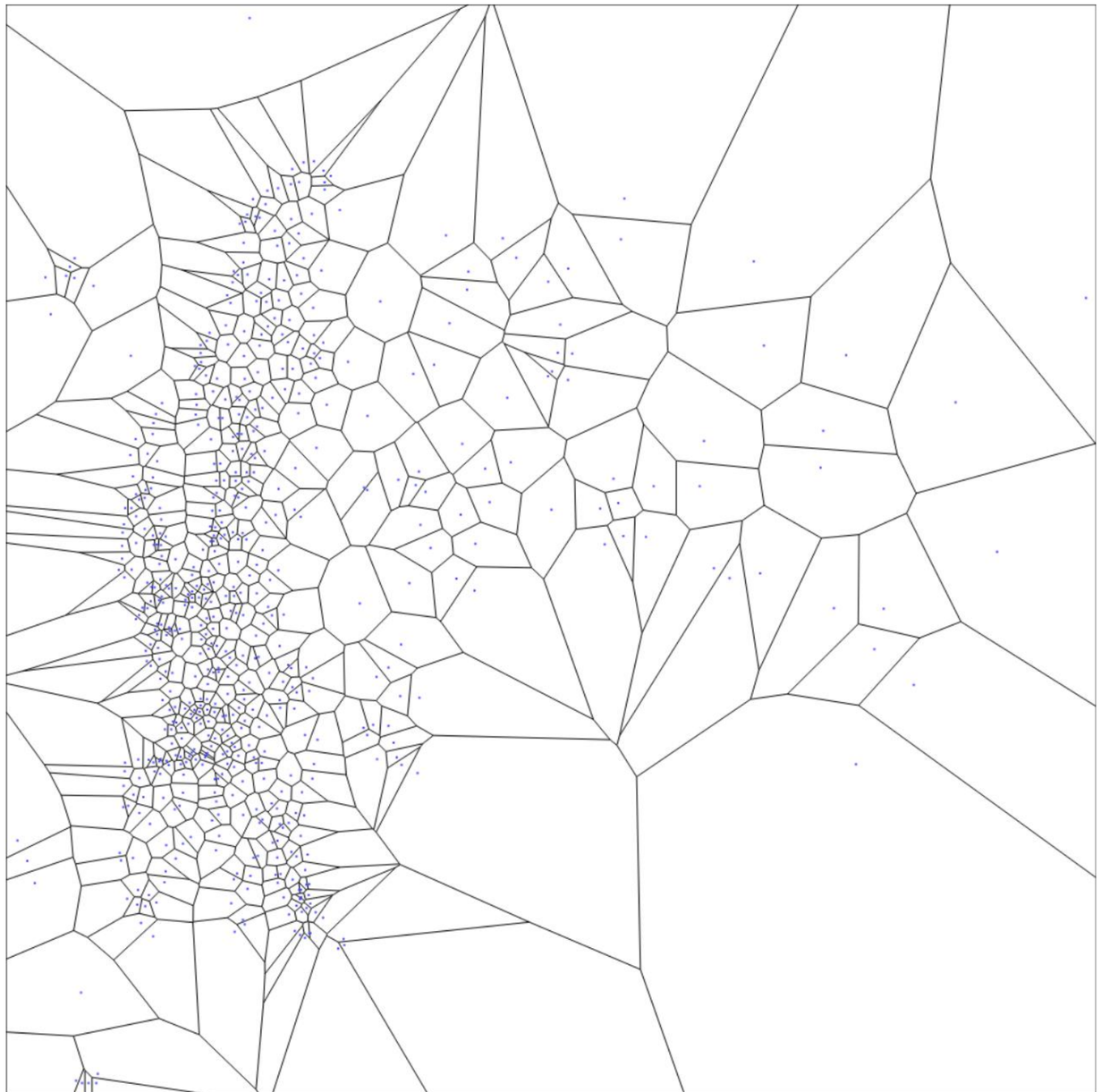
abcdefghijklmnopqrstuvwxyz

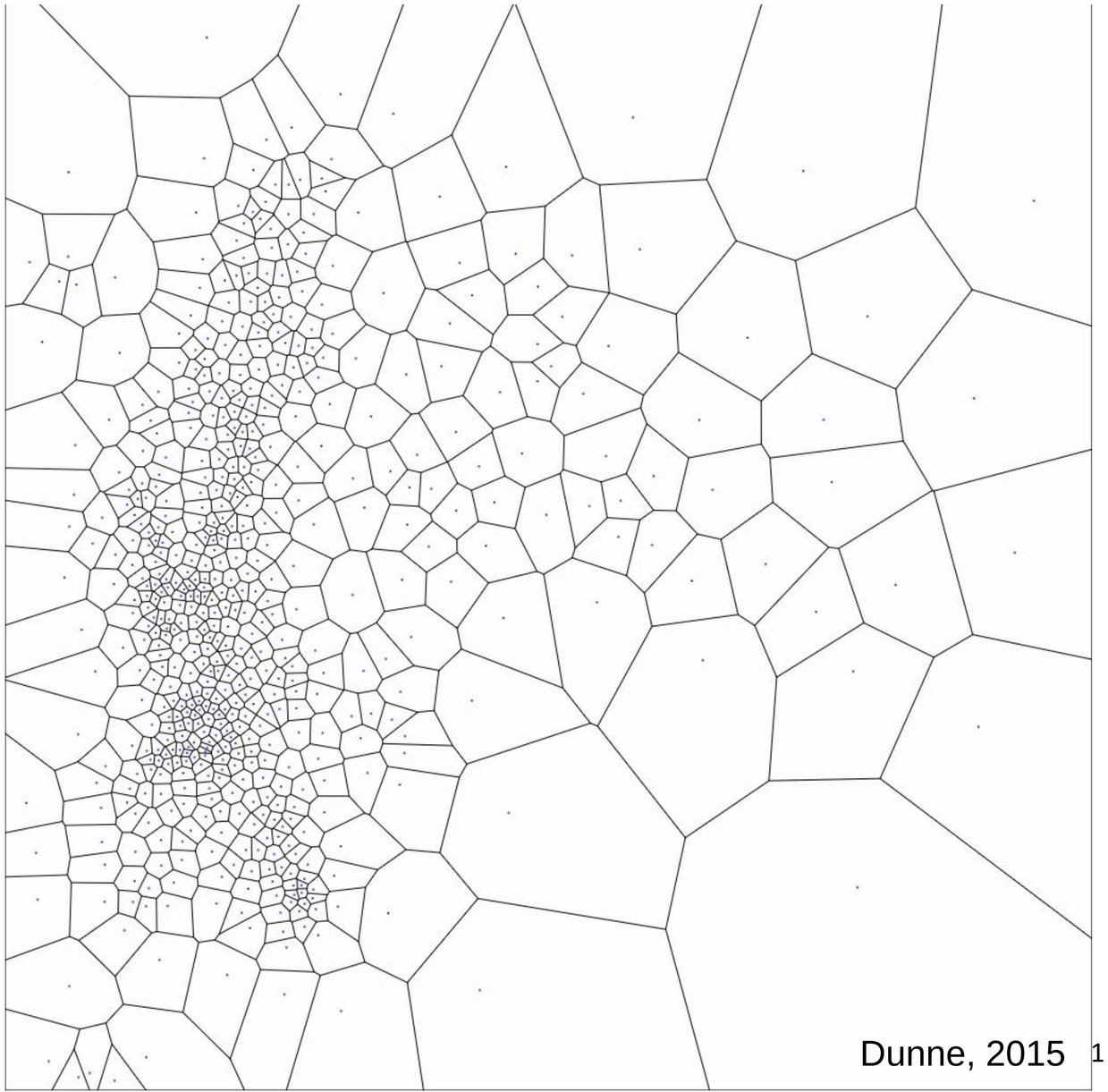
Mike Bostock, 2016

(can use *selection.join* to simplify)

Change over Time

Explaining algorithms: CVT





Dunne, 2015

Manipulate

Change over Time

Select

Navigate

Item Reduction

- *Zoom*
  Geometric or *Semantic*

- *Pan/Translate*

- *Constrained*

Attribute Reduction

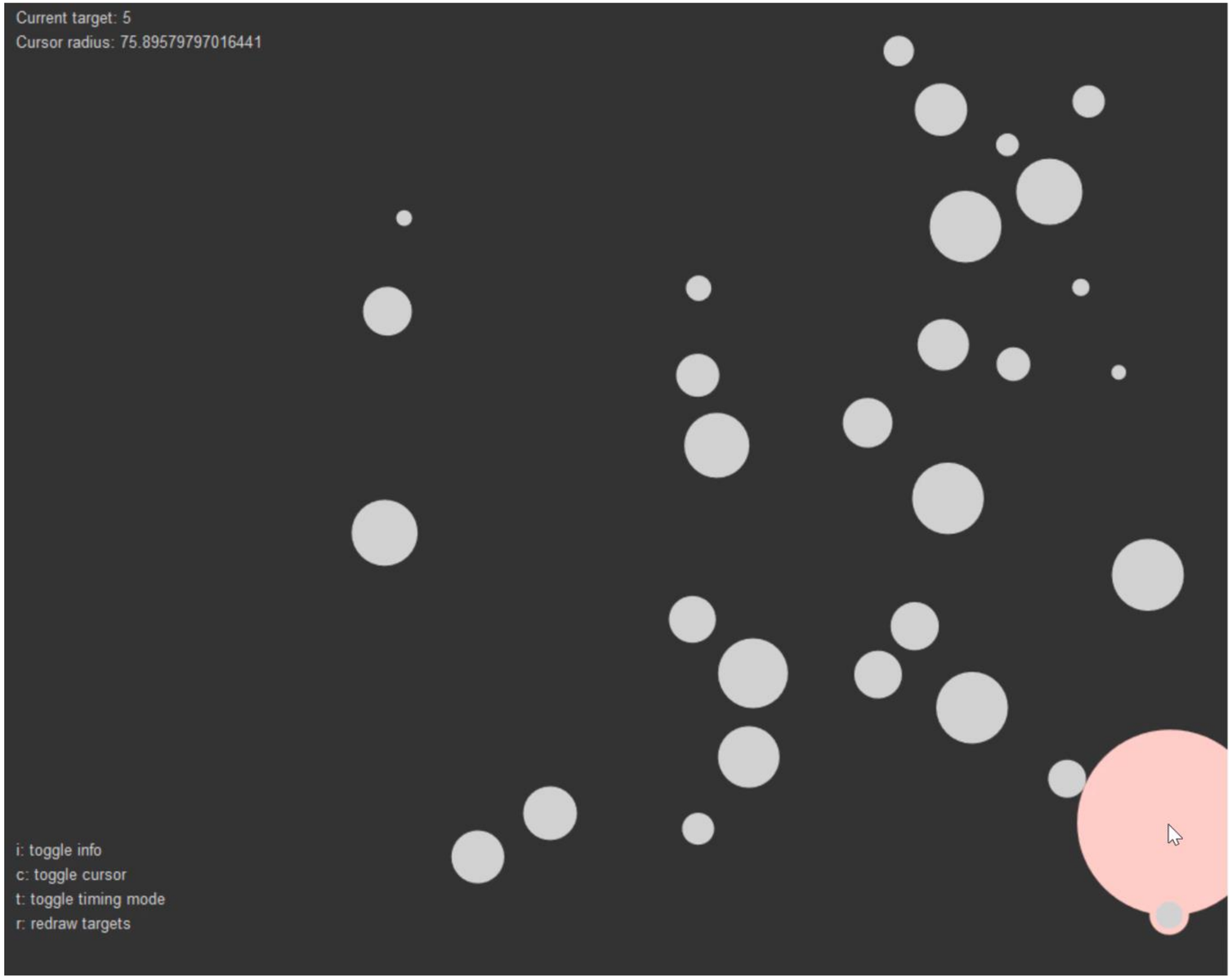
- *Slice*

- *Cut*

- *Project*

Select

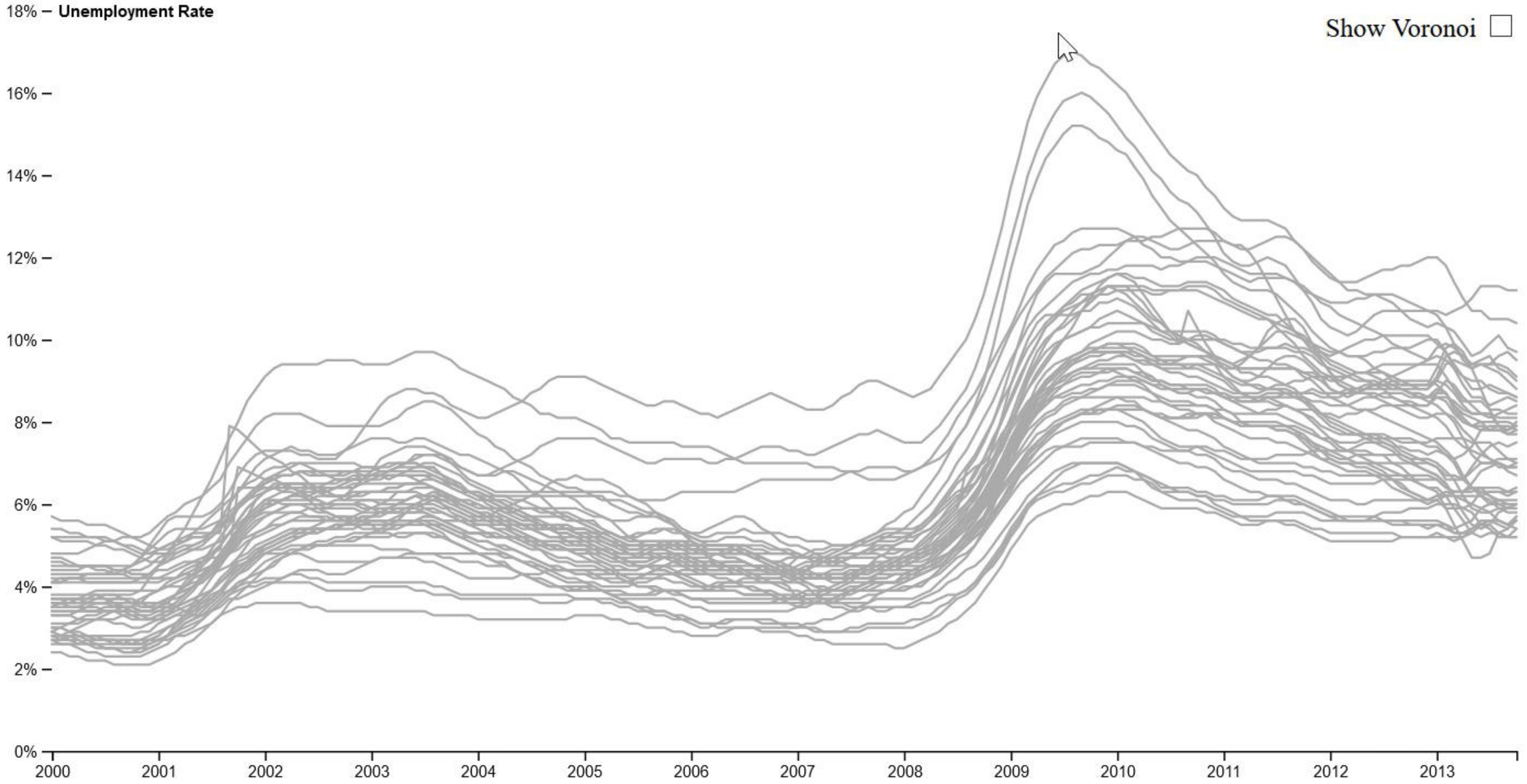
Easier picking via Bubble Cursors



Grossman and Balakrishnan, 2005; Anand Kulkarni, 2010

Select

Easier picking via Voronoi Cursors

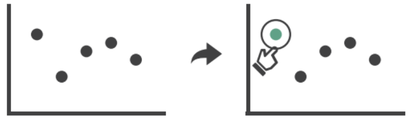


Mike Bostock, 2019

Manipulate

Change over Time

Select



Navigate

→ Item Reduction

→ *Zoom*

Geometric or *Semantic*

→ *Pan/Translate*

→ *Constrained*

→ Attribute Reduction

→ *Slice*

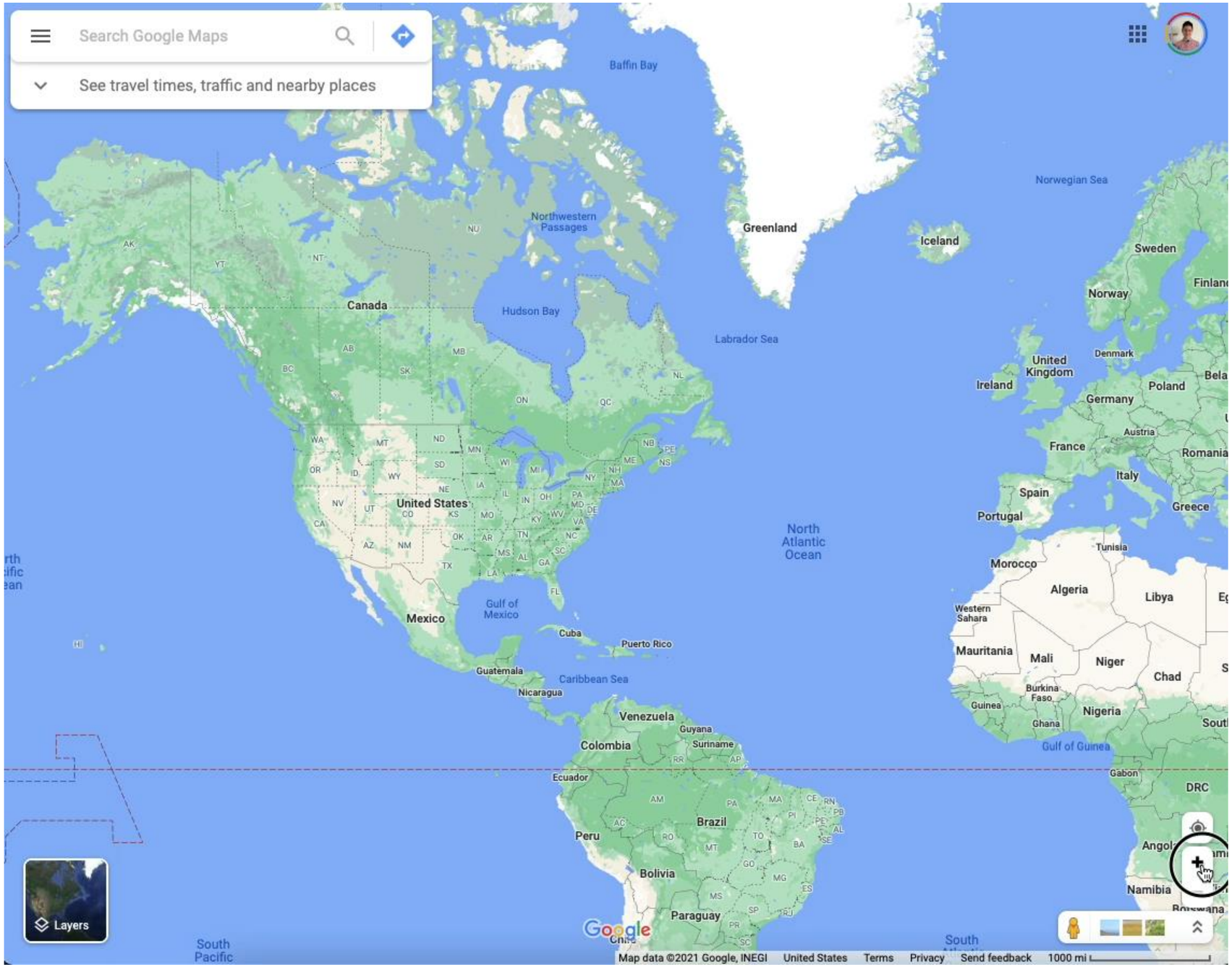
→ *Cut*

→ *Project*

Navigate

➔ Item Reduction

➔ *Zoom*
Geometric or *Semantic*

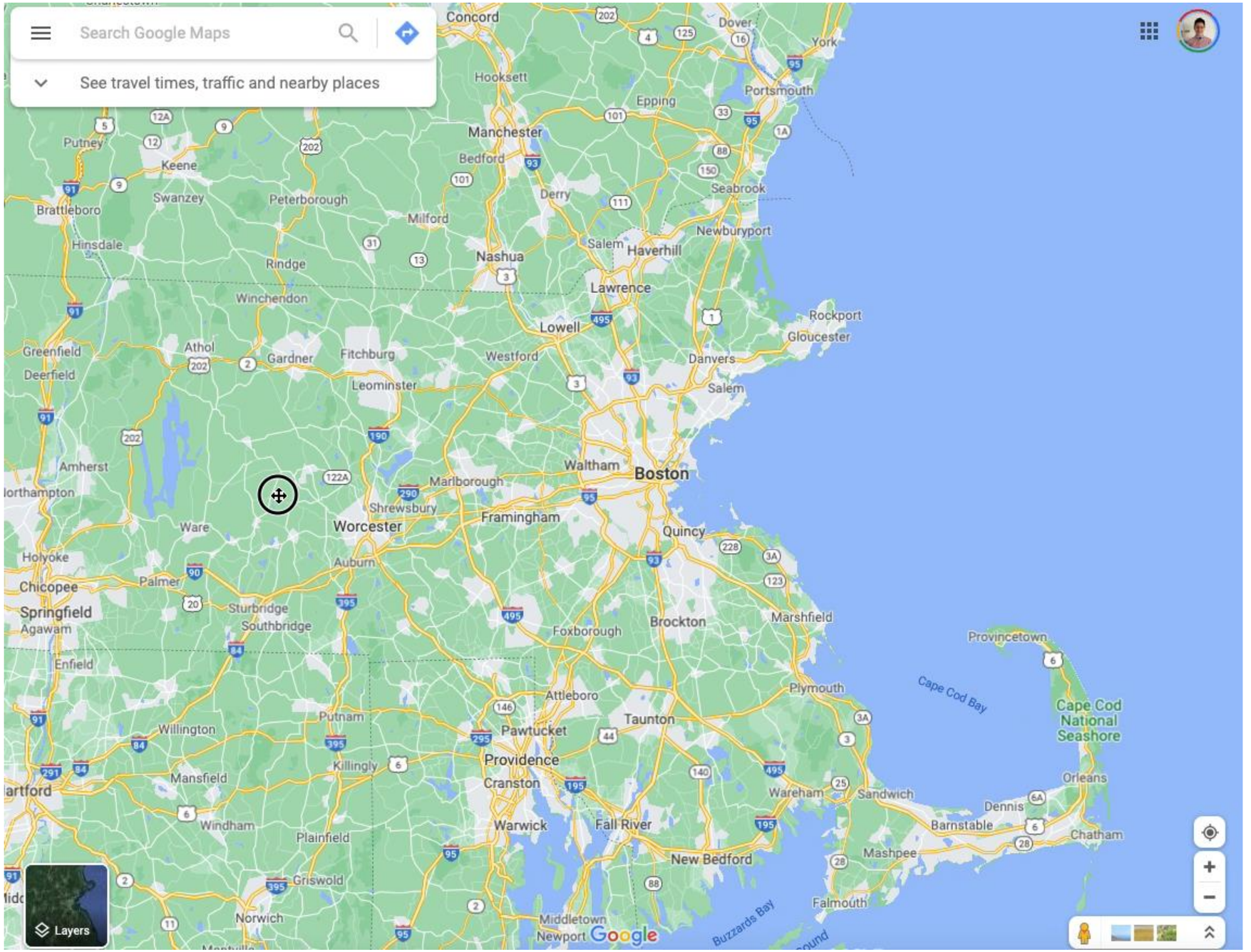


Ab Mosca, Google Maps, 2021

Navigate

➔ Item Reduction

➔ *Pan/Translate*

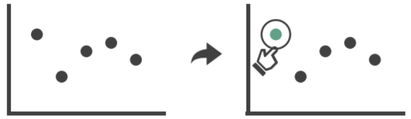


Ab Mosca, Google Maps, 2021

Manipulate

Change over Time

Select



Navigate

Item Reduction

- *Zoom*
  Geometric or *Semantic*

- *Pan/Translate*

- *Constrained*

Attribute Reduction

- *Slice*

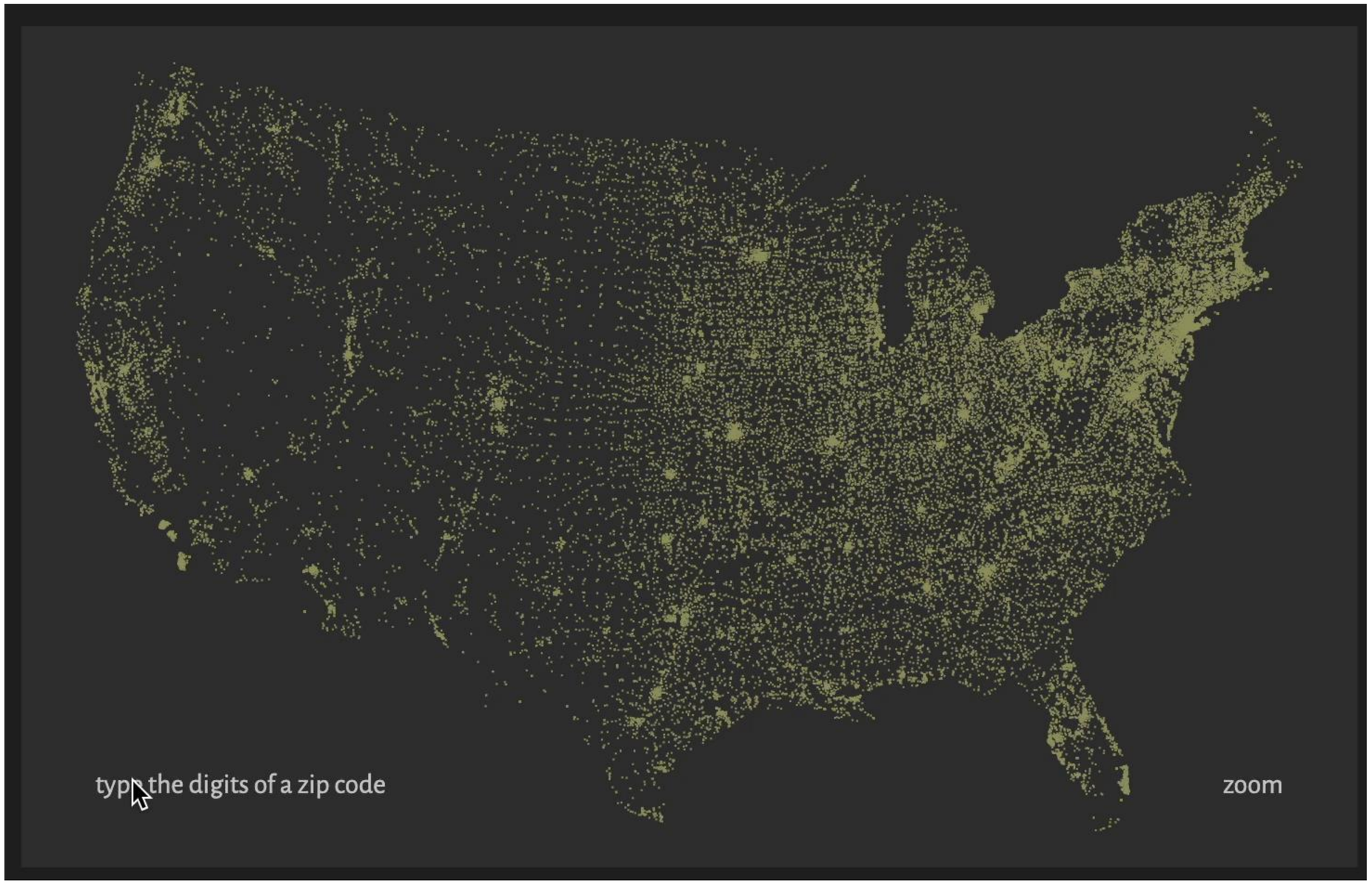
- *Cut*

- *Project*

Navigate

➔ Attribute Reduction

➔ *Slice*

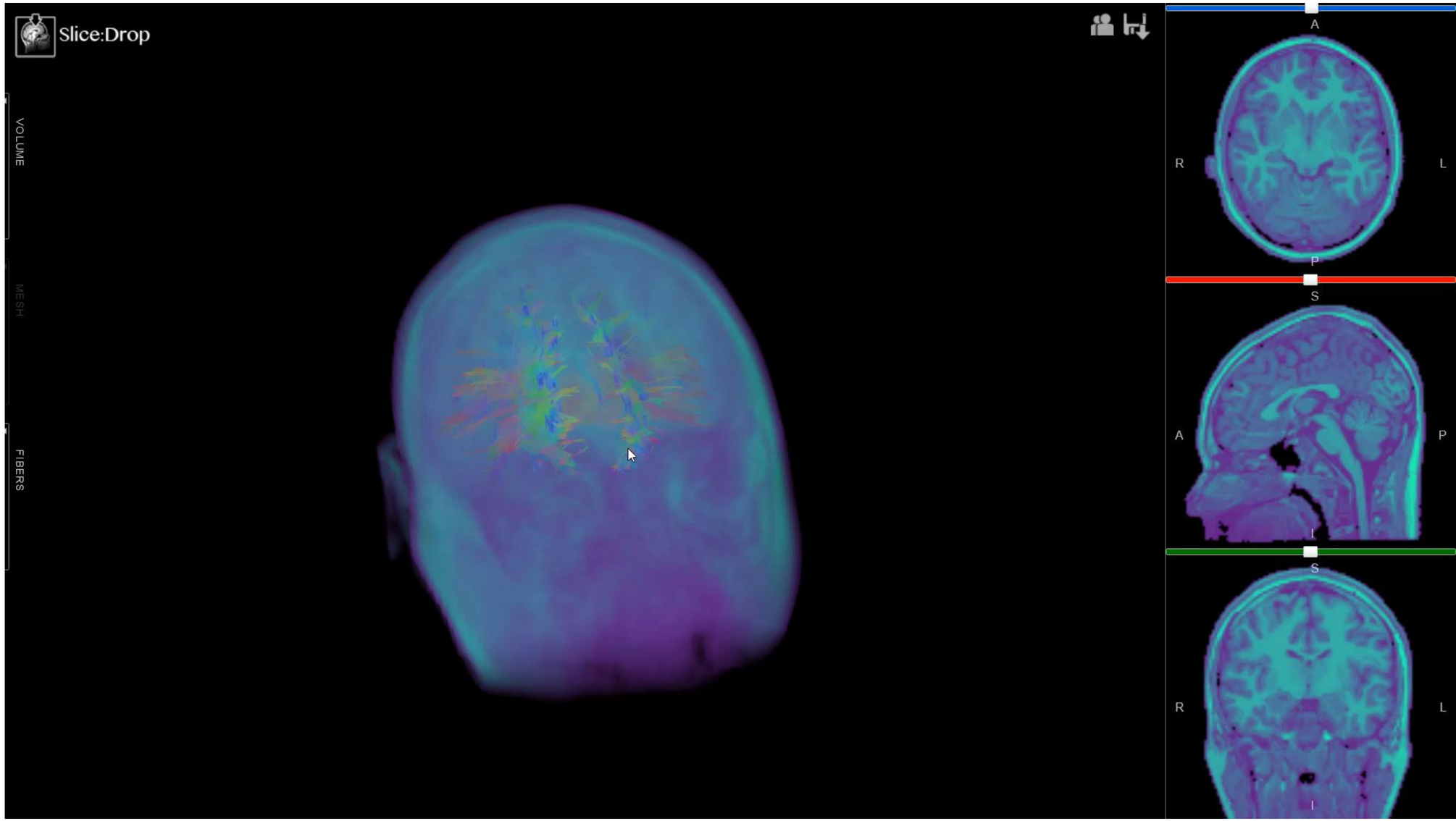


Ben Fry, 2014

Navigate

➔ Attribute Reduction

➔ *Cut*

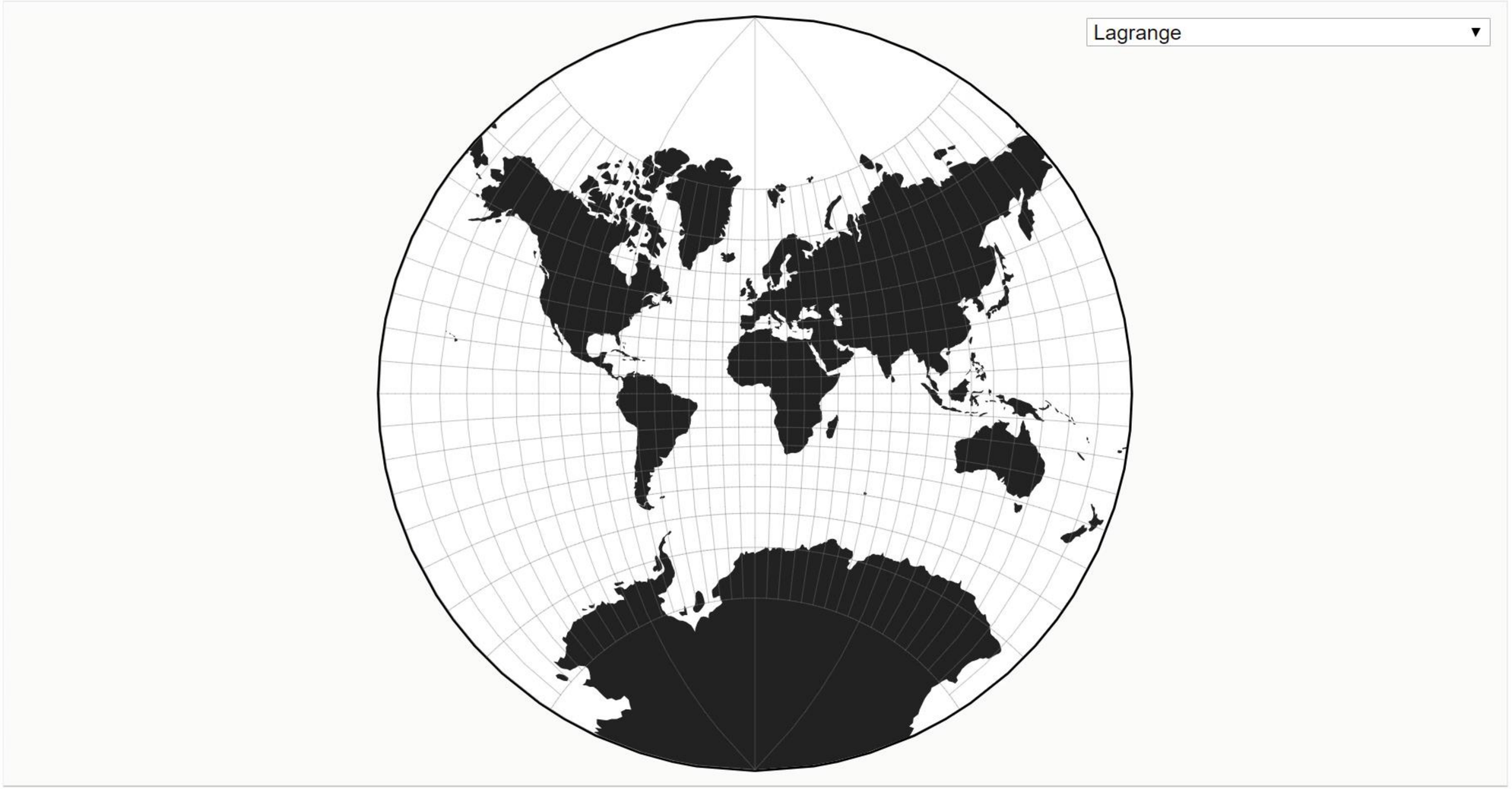


Navigate

➔ Attribute Reduction

➔ *Project*

Projection Transitions



Bostock, 2020

32

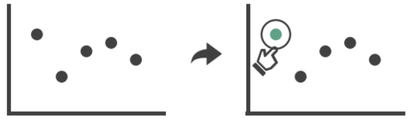
- **Navigate**
  - ➔ Attribute Reduction
    - ➔ *Project*

Pandey et al. (inc. Dunne, Borkin), 2019

Manipulate

Change over Time

Select



Navigate

→ Item Reduction

→ *Zoom*
Geometric or *Semantic*

→ *Pan/Translate*

→ *Constrained*

→ Attribute Reduction

→ *Slice*

→ *Cut*

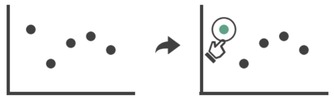
→ *Project*

Other interaction taxonomies exist

Manipulate

- **Change over Time**

- **Select**



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

    - *Pan/Translate*

    - *Constrained*

  - Attribute Reduction
    - *Slice*

    - *Cut*

    - *Project*

VS.

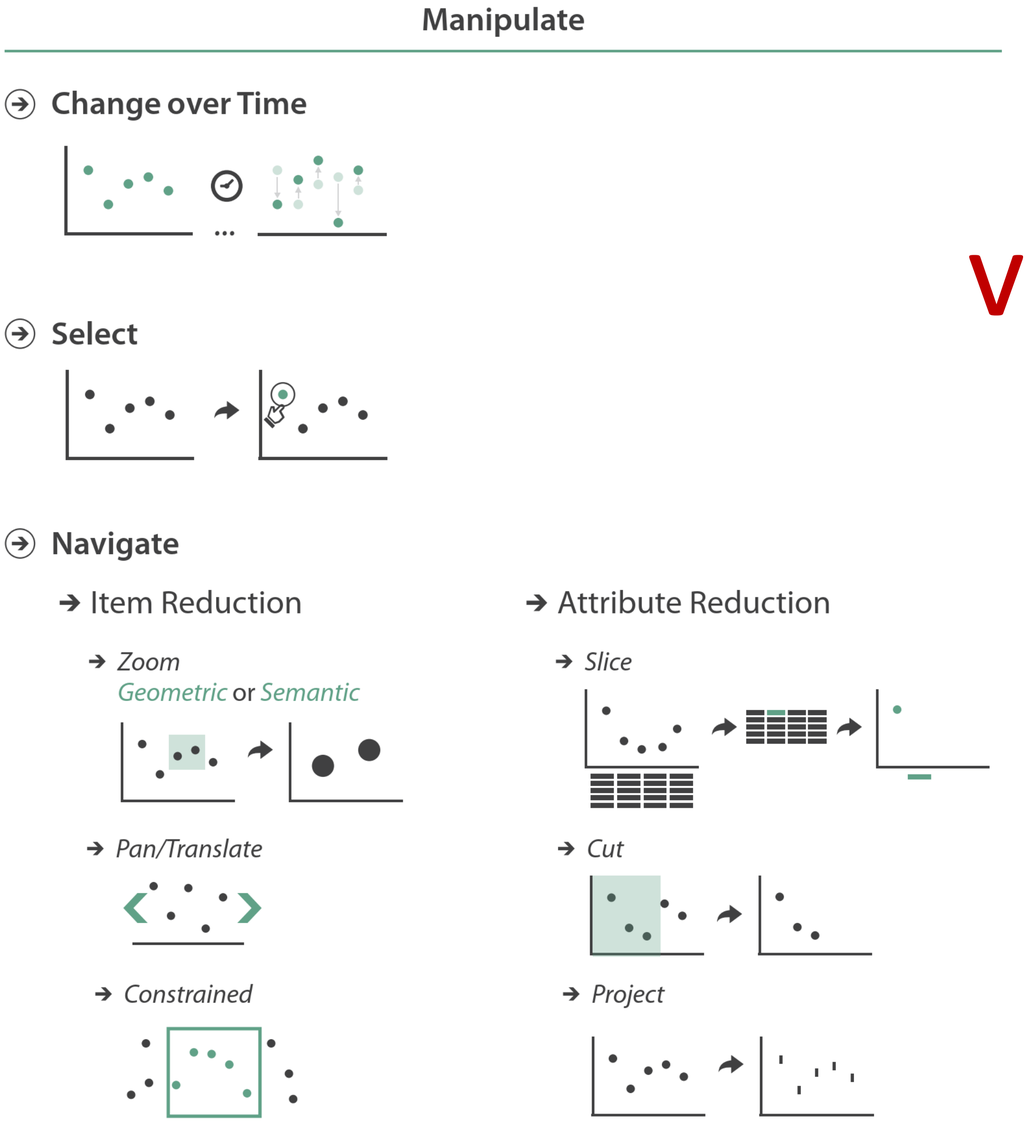
Toward a Deeper Understanding of the Role of Interaction in Information Visualization

Ji Soo Yi, Youn ah Kang, John T. Stasko, *Member, IEEE*, and Julie A. Jacko

- *Select*: mark something as interesting
- *Explore*: show me something else
- *Reconfigure*: show me a different arrangement
- *Encode*: show me a different representation
- *Abstract/Elaborate*: show me more or less detail
- *Filter*: show me something conditionally
- *Connect*: show me related items

Yi et al., 2007

Other interaction taxonomies exist



VS.

Toward a Deeper Understanding of the Role of Interaction in Information Visualization

Ji Soo Yi, Youn ah Kang, John T. Stasko, *Member, IEEE*, and Julie A. Jacko

- *Select*: mark something as interesting
- *Explore*: show me something else
- *Reconfigure*: show me a different arrangement
- *Encode*: show me a different representation
- *Abstract/Elaborate*: show me more or less detail
- *Filter*: show me something conditionally
- *Connect*: show me related items

Compare and contrast. Can you think of situations one is more useful than the other?

Yi et al., 2007

In-Class Exercise: Slicing

In-Class Exercise: Slicing

15m

Slice:Drop

INSTRUCTIONS:

- Go to *http://slicedrop.com/*
- Click on the first example dataset in the top-right gallery “A 14 year old healthy male brain.”
- Explore the different views of the data using the hidden toolbars along the left side of the image:
- VOLUME: Explore the 2D and 3D view options.
- VOLUME: Experiment with the brightness/contrast (“Window level”) and data range (“Threshold”) sliders. Also try to change the colors.
- FIBERS: Experiment with the fiber threshold (i.e. data range).
- While in the 2D view, explore the slicing sliders. Also try dragging inside the small visualizations in this panel.

How?

Encode

Arrange

- Express
- Separate
- Order
- Align
- Use

Map

from categorical and ordered attributes

- Color
  - *Hue*
  - *Saturation*
  - *Luminance*
- Size, Angle, Curvature, ...
- Shape
- Motion

Direction, Rate, Frequency, ...

Manipulate

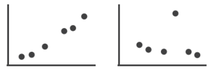
Change

Select

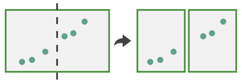
Navigate

Facet

Juxtapose



Partition



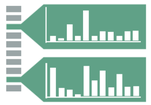
Superimpose

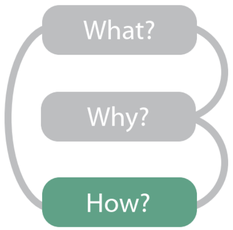
Reduce

Filter

Aggregate

Embed

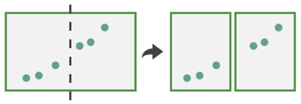




Facet

Juxtapose

Partition



Superimpose

- Facet = to split
- In visualization, we can facet to reduce complexity in several ways
- Faceting lets us use vision rather than memory retrieval

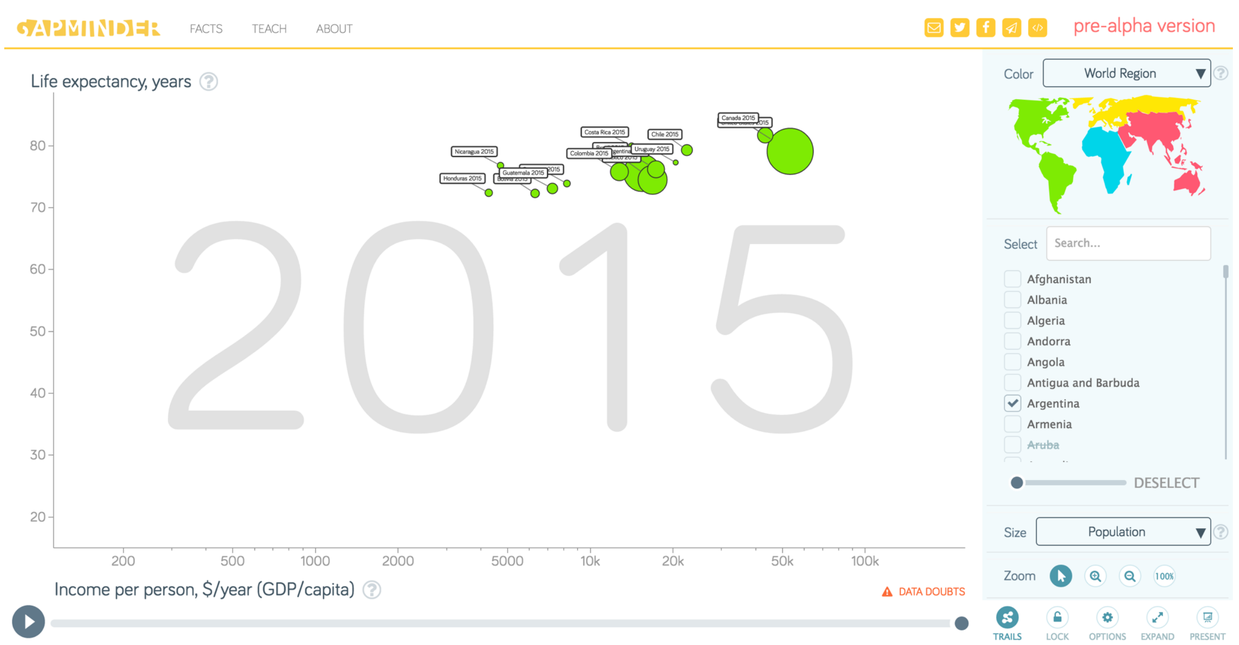
Juxtapose

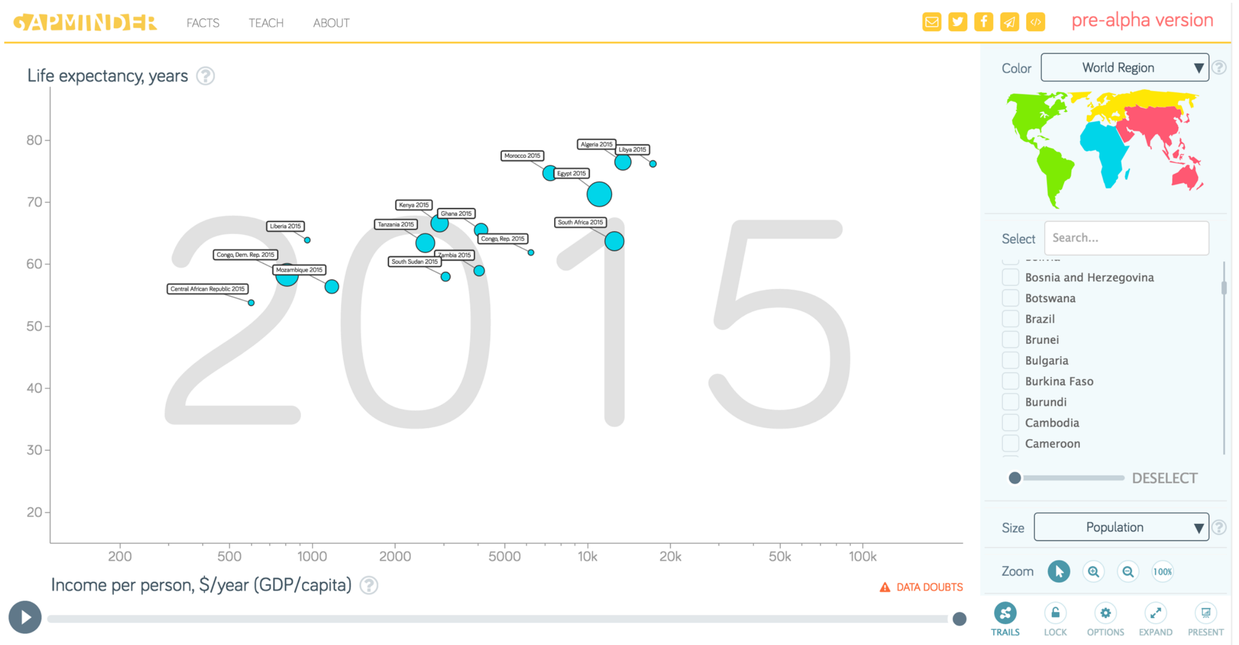
Pro:

→**Easy to compare**

Con:

→ **Takes up more space on the screen**





Superimpose

Pro:

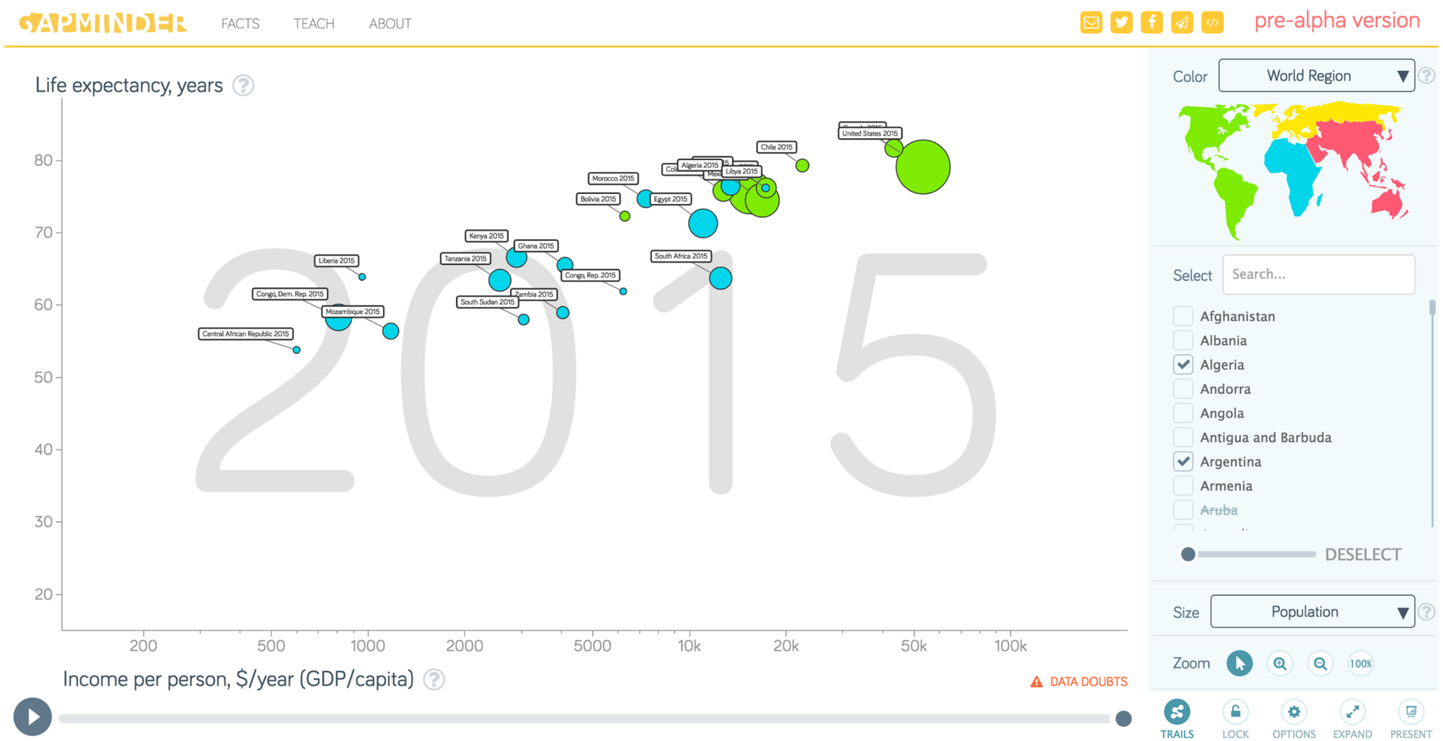
→Requires less screen space

→Easy to compare between groups

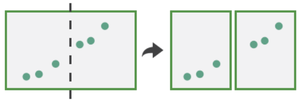
Con:

→Limits encodings options

→Can get messy



Partition

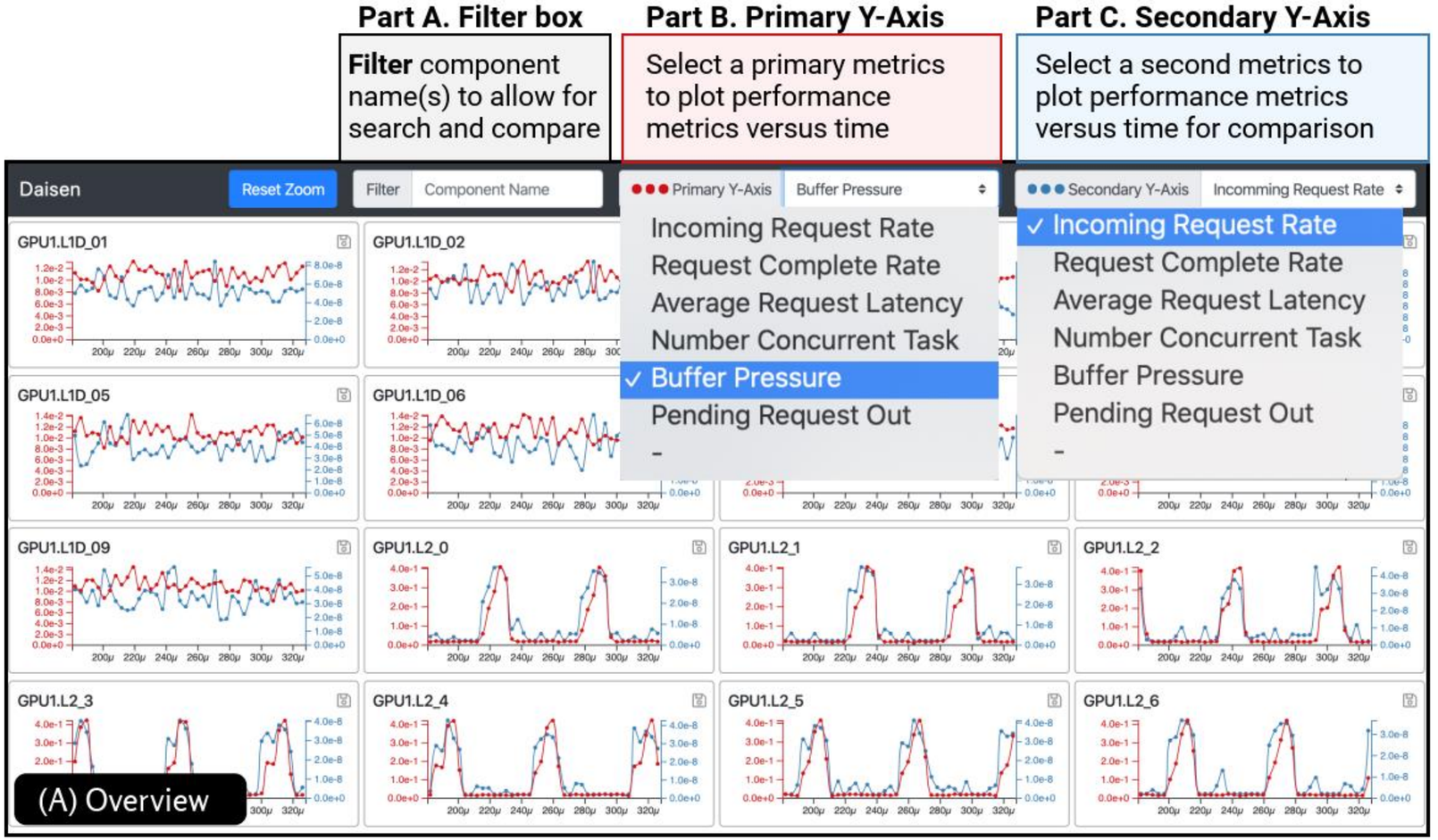


Pro:

→ **Easy to compare within groups**

Con:

→ **Harder to compare between groups**



Several ways to coordinate facets

- Share Encoding: Same/Different
  - *Linked Highlighting*

- Share Data: All/Subset/None

- Share Navigation

		Data		
		All	Subset	None
Encoding	Same	Redundant	Overview/ Detail	Small Multiples
	Different	Multiform	Multiform, Overview/ Detail	No Linkage

How?

Encode

Arrange

- Express
- Separate
- Order
- Align
- Use

Map

from categorical and ordered attributes

- Color
  - *Hue*
  - *Saturation*
  - *Luminance*
- Size, Angle, Curvature, ...
- Shape
- Motion

Direction, Rate, Frequency, ...

Manipulate

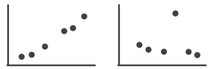
Change

Select

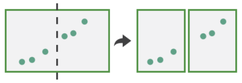
Navigate

Facet

Juxtapose



Partition



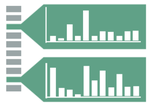
Superimpose

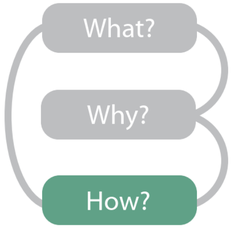
Reduce

Filter

Aggregate

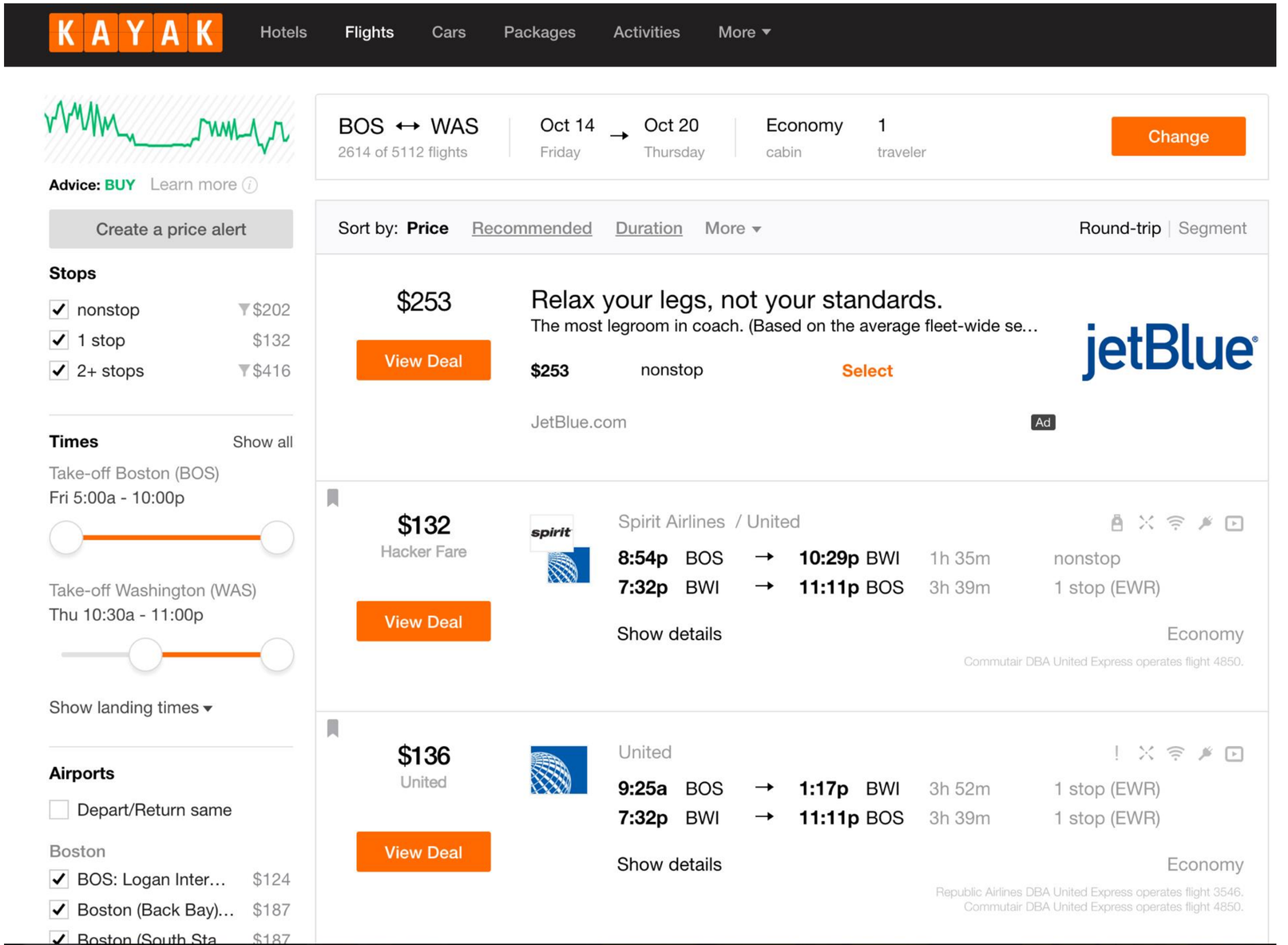
Embed





Interaction Showcase

Dynamic queries



[Kayak, 2020]

Scented Widgets

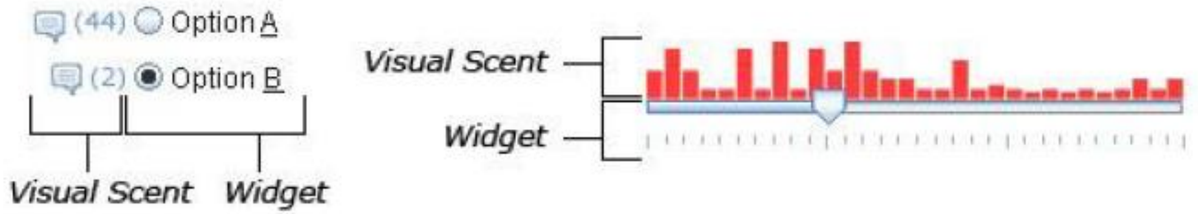


Figure 1. Widgets with visual information scent cues. Left: Radio buttons with comment counts. **Right**: Histogram slider with data totals.

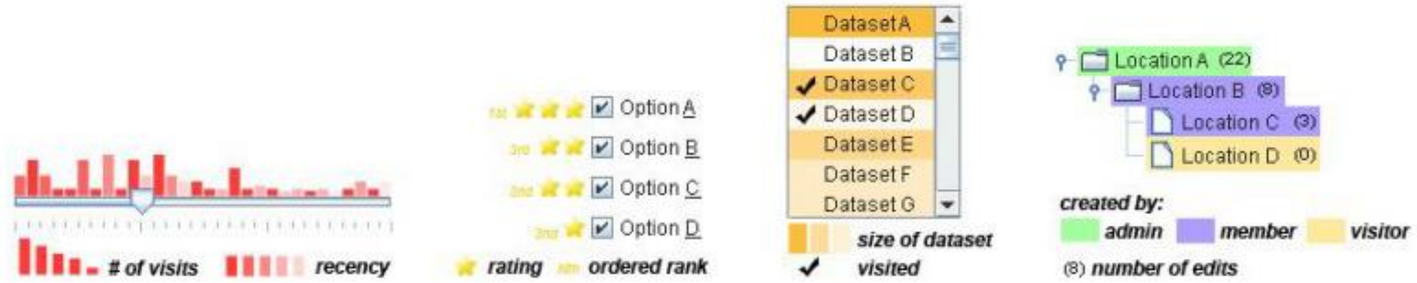
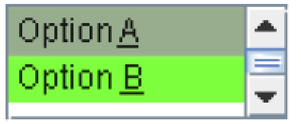
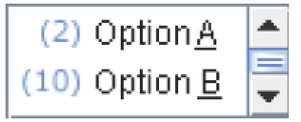
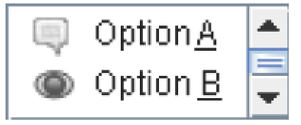
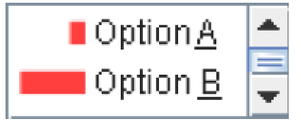
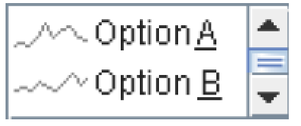


Figure 2. Examples of several scent encodings. From left to right: 1. A slider with visit totals encoded as a bar chart with recency encoded as opacity. 2. Checkboxes with star rankings encoded using icons and rank values displayed as text. 3. A list box with dataset sizes encoded using opacity and a visited/not visited value encoded using an icon. 4. A tree with author categories encoded using hue and edit totals encoded as text.

Willet et al., 2007

Scented Widgets

Table 1. Scent encodings supported by scented widgets

Name	Description	Example
Hue	Varies the hue of the widget (or of a visualization embedded in it)	
Saturation	Varies the saturation of the widget (or of a visualization embedded in it)	
Opacity	Varies the saturation of the widget (or of a visualization embedded in it)	
Text	Inserts one or more small text figures into the widget	
Icon	Inserts one or more small icons into the widget.	
Bar Chart	Inserts one or more small bar chart visualizations into the widget	
Line Chart	Inserts one or more small line chart visualizations into the widget	

Willet et al., 2007

Interactive Legends

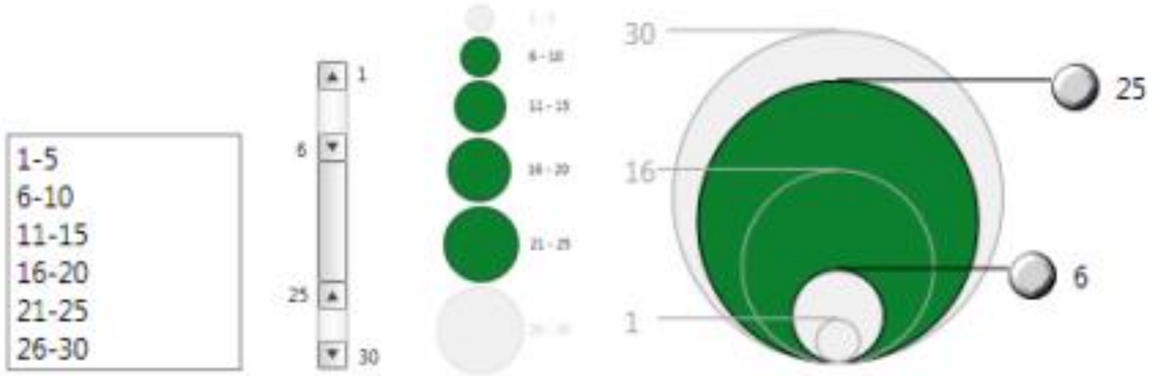
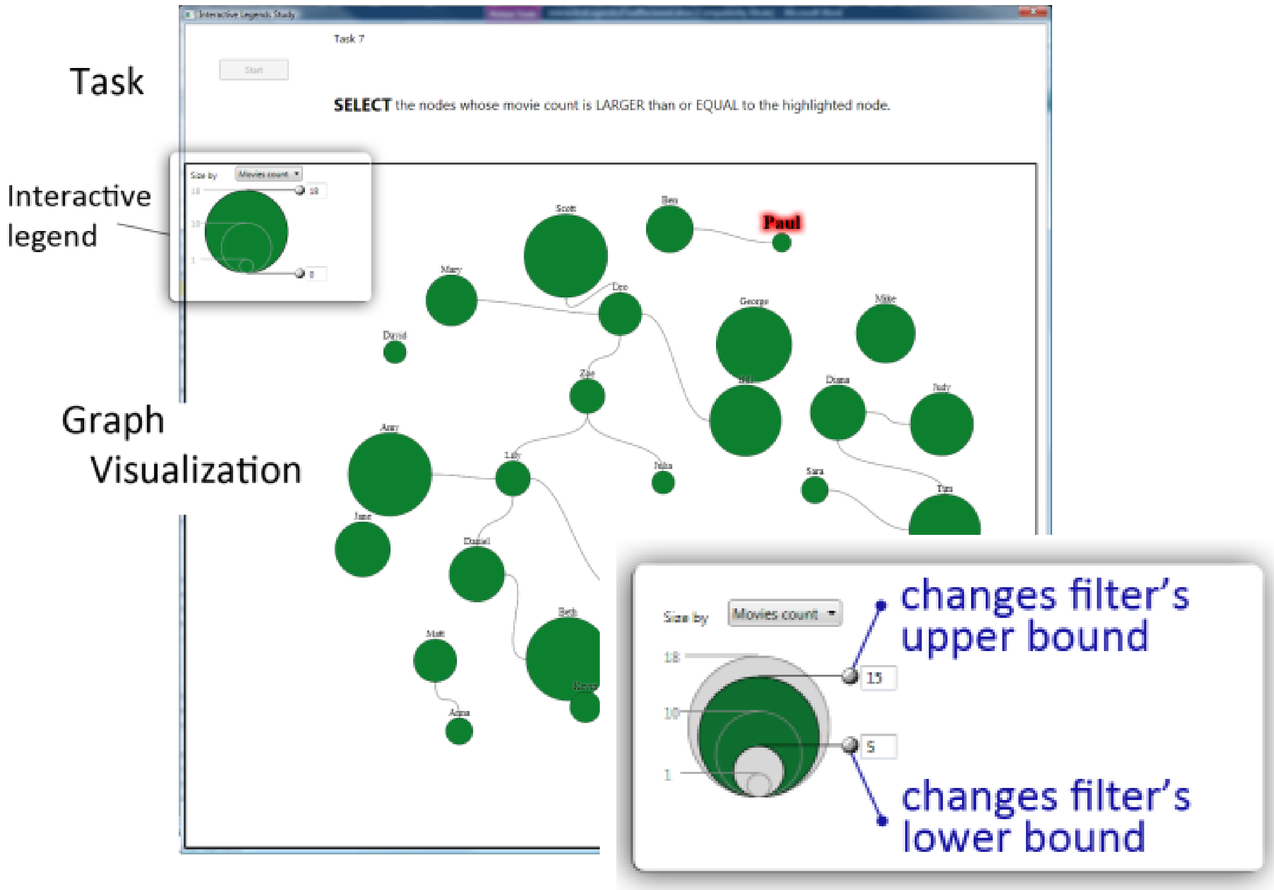


Figure 1: *Standard widgets (left), interactive legends (right)*

Riche et al., 2010

Interactive Legends



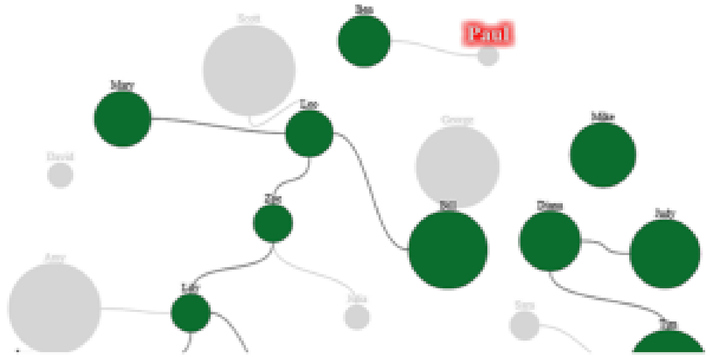
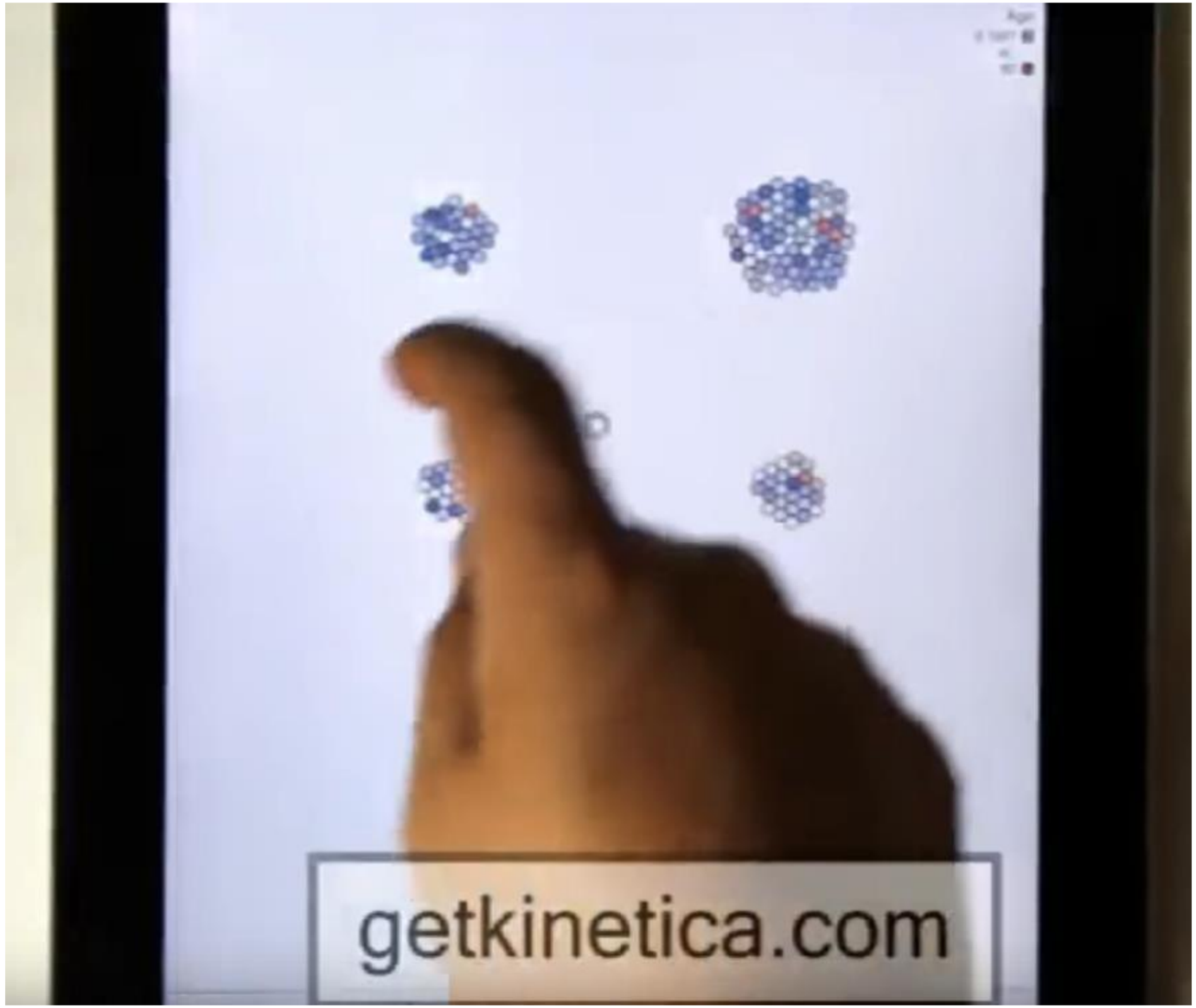


Figure 5: *Interactive legend for controling the size. Handles are provided to filter interactively the visualization.*

[Riche et al., 2010]

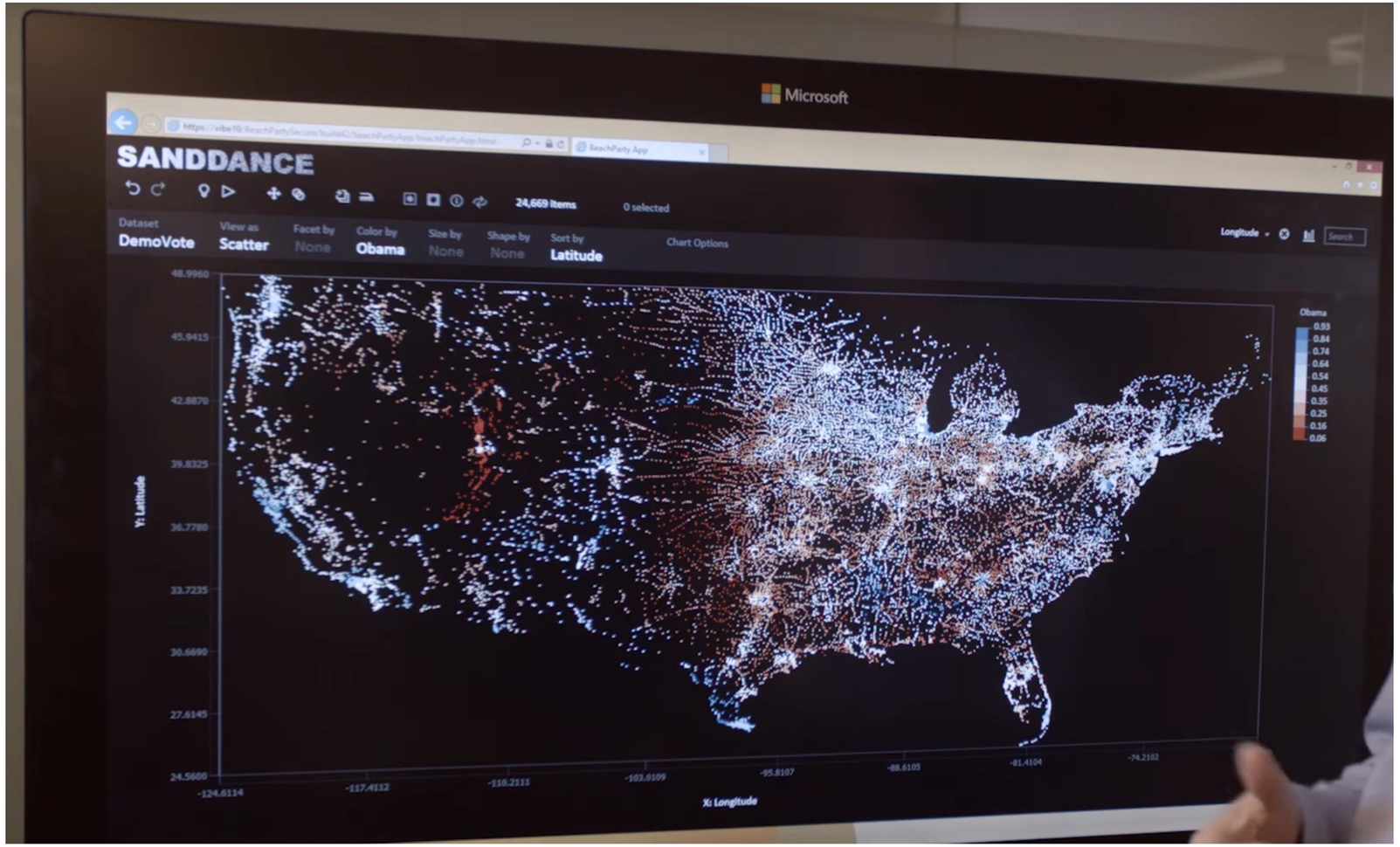
Kinetica



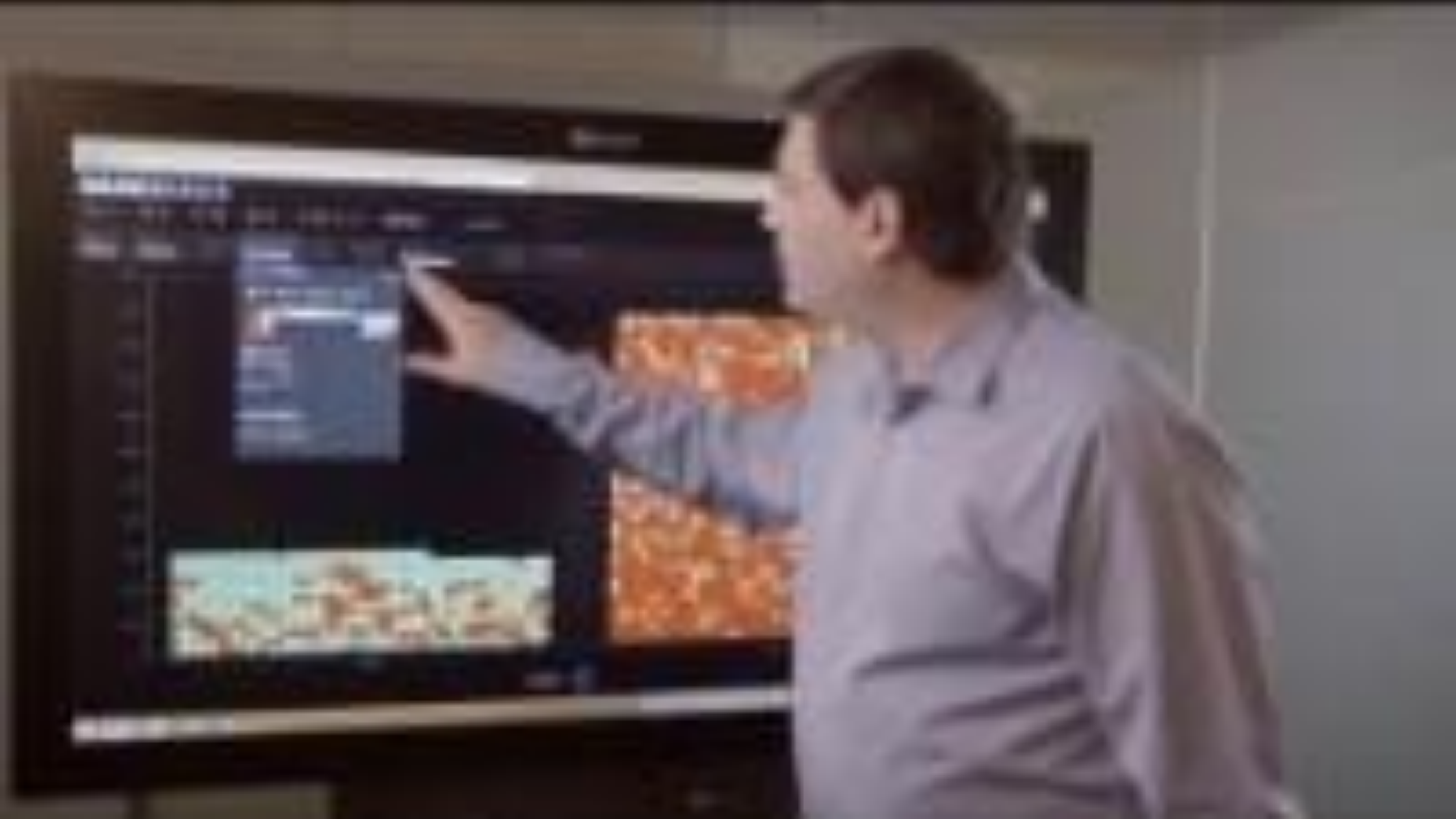
Rzeszotarski and Kittur


Kinetica helps users explore multivariate
data through physics-based interactions.

Sand Dance



[Drucker and Fernandez, 2015]



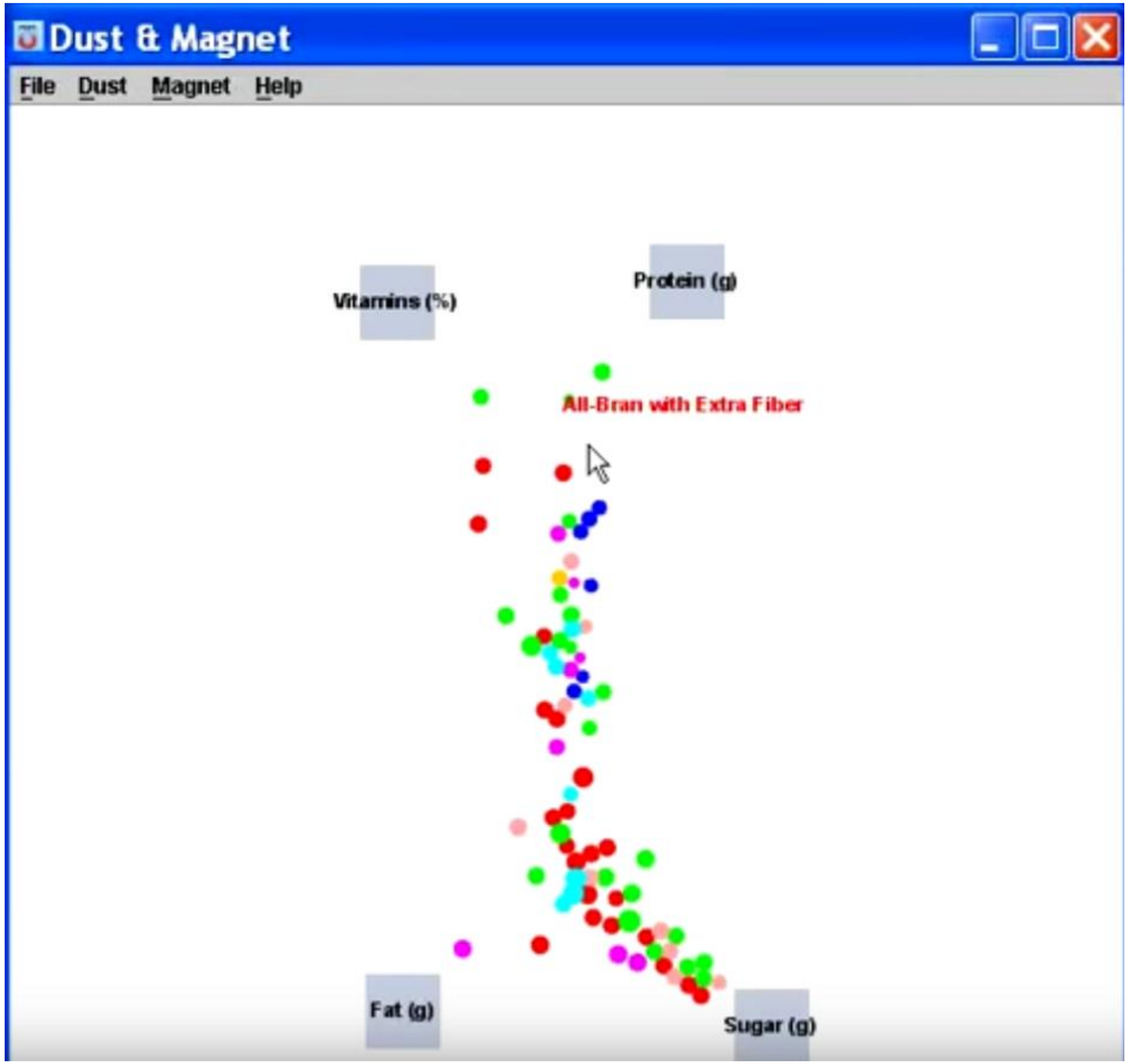
➔ Attribute Reduction

➔ *Slice*

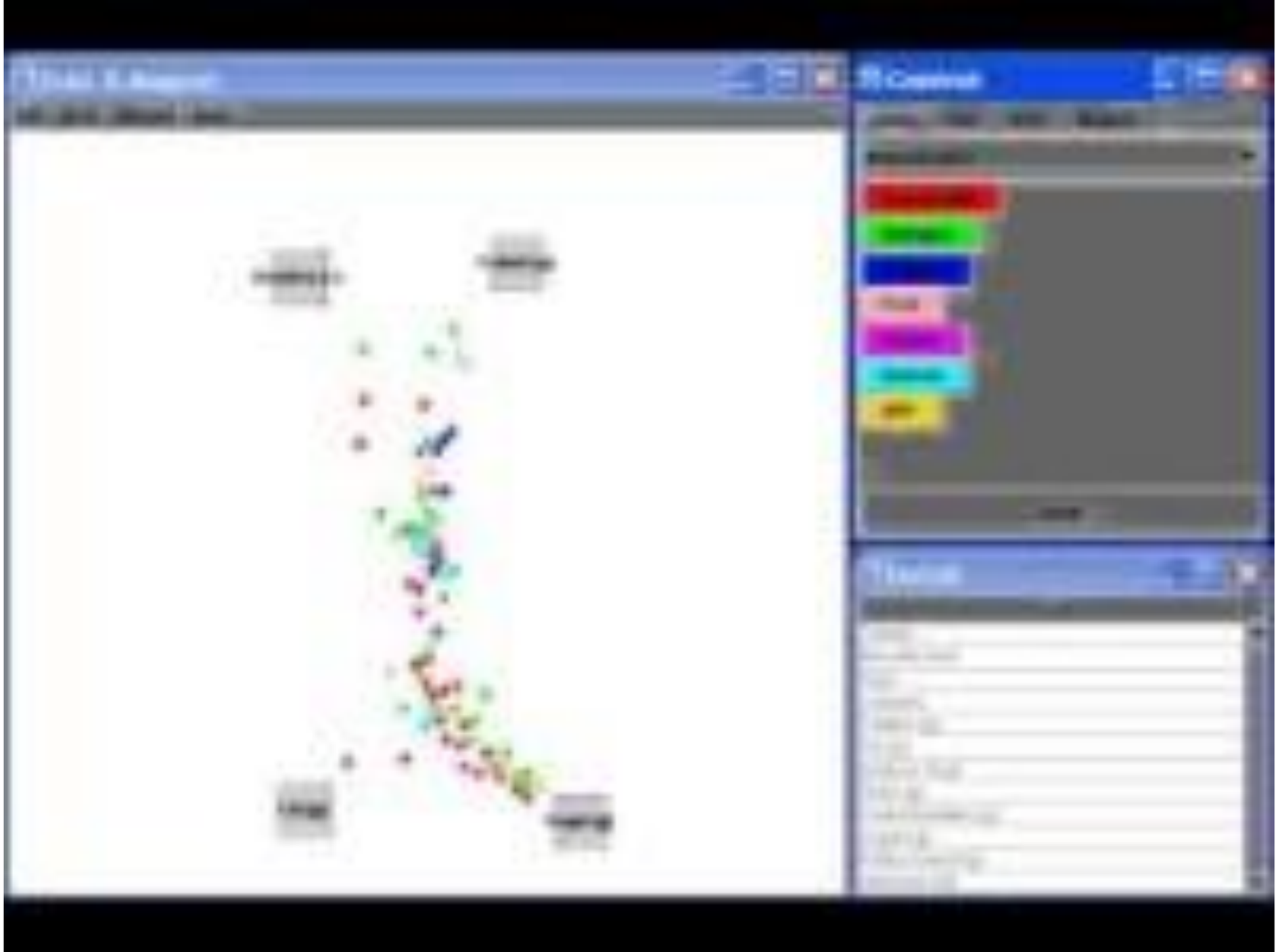
➔ *Cut*

➔ *Project*

Dust & Magnet



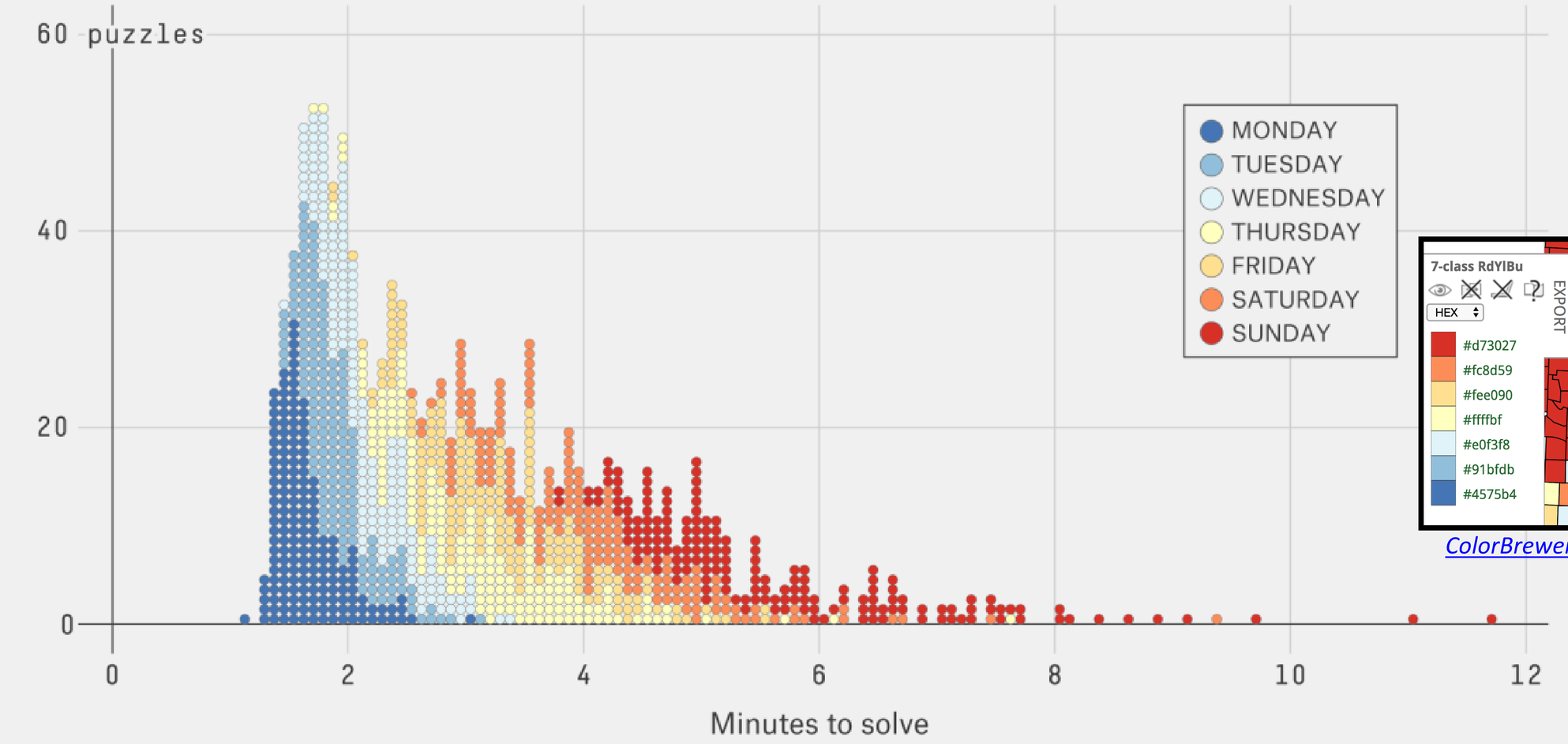
Dai et al., 2005



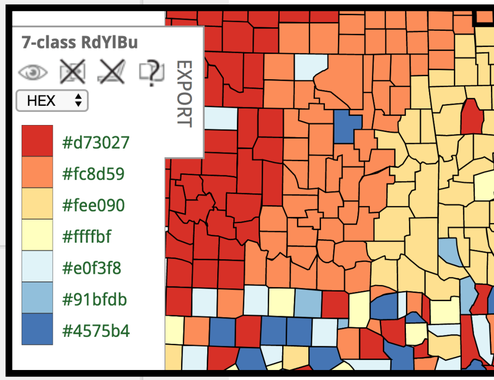
Hall of Fame or Hall of Shame

The Puzzling Speed Of Dan Feyer

Solve times for the past 1,208 New York Times crossword puzzles, by day of the week

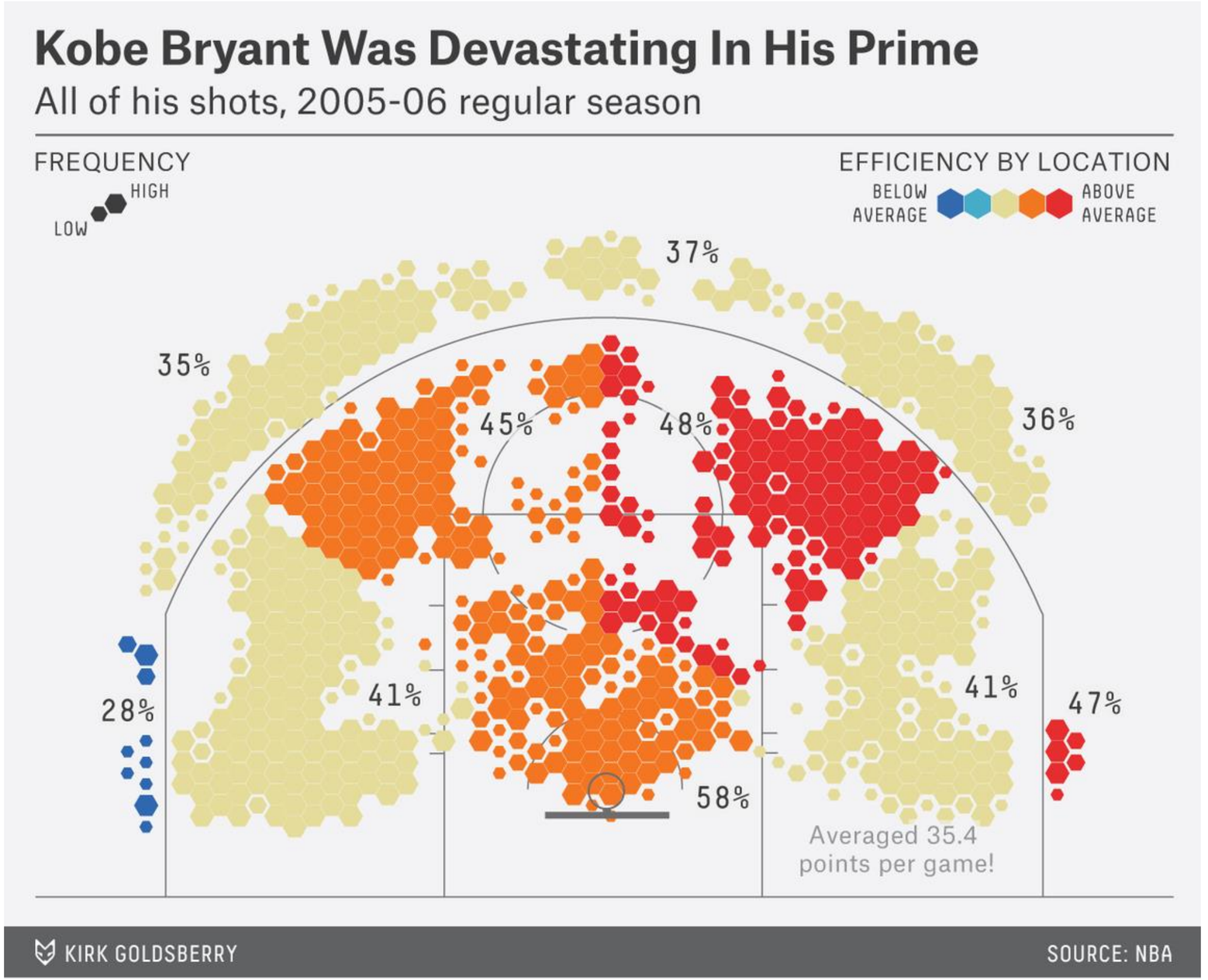


FIVETHIRTYEIGHT



ColorBrewer 'RdYlBu' scale, 2013

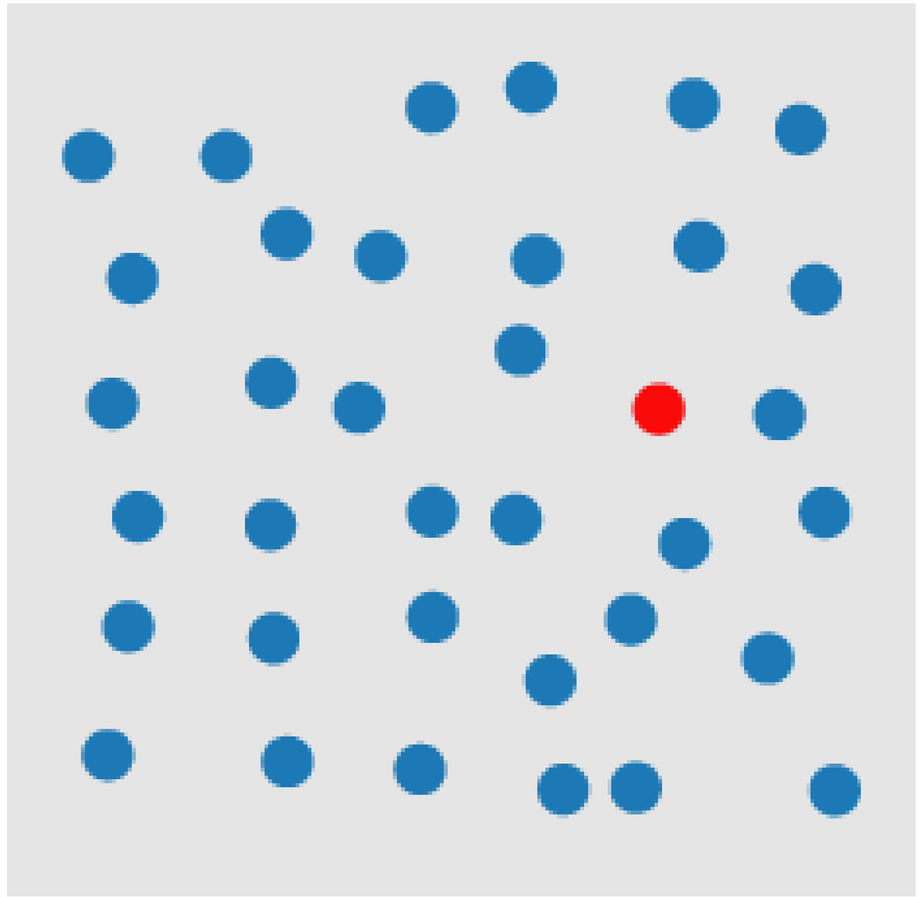
FiveThirtyEight, 2015

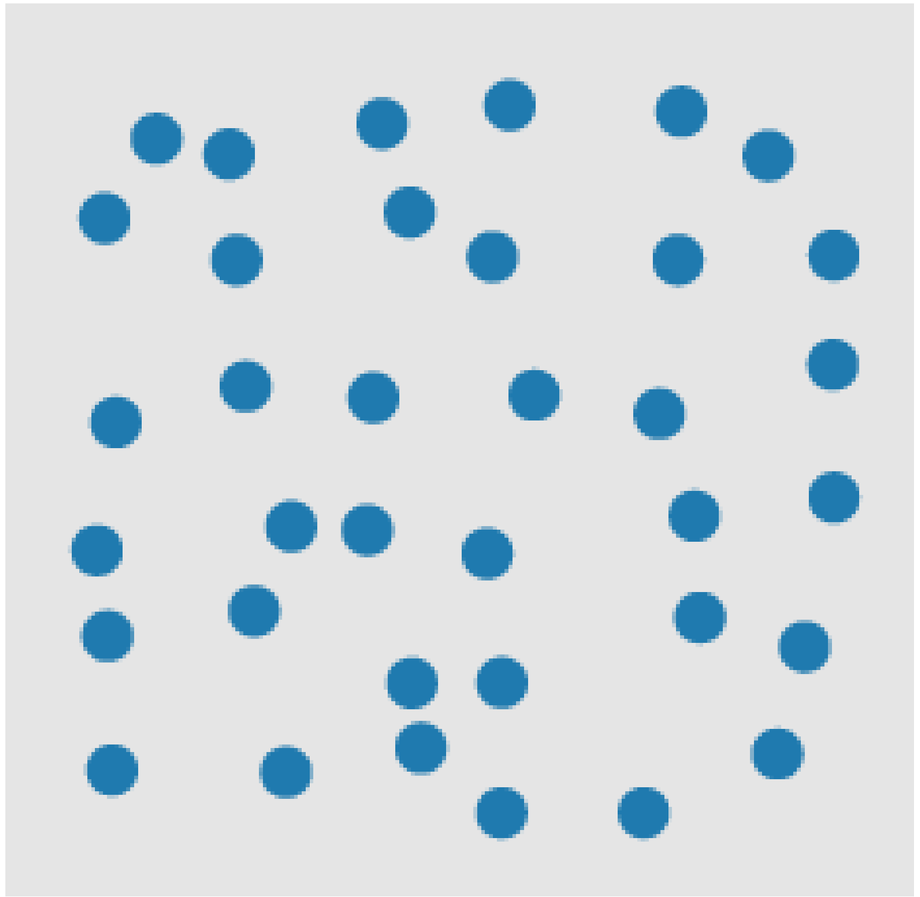


FiveThirtyEight, 2015

Pop-out Effects

POP-OUT EFFECTS





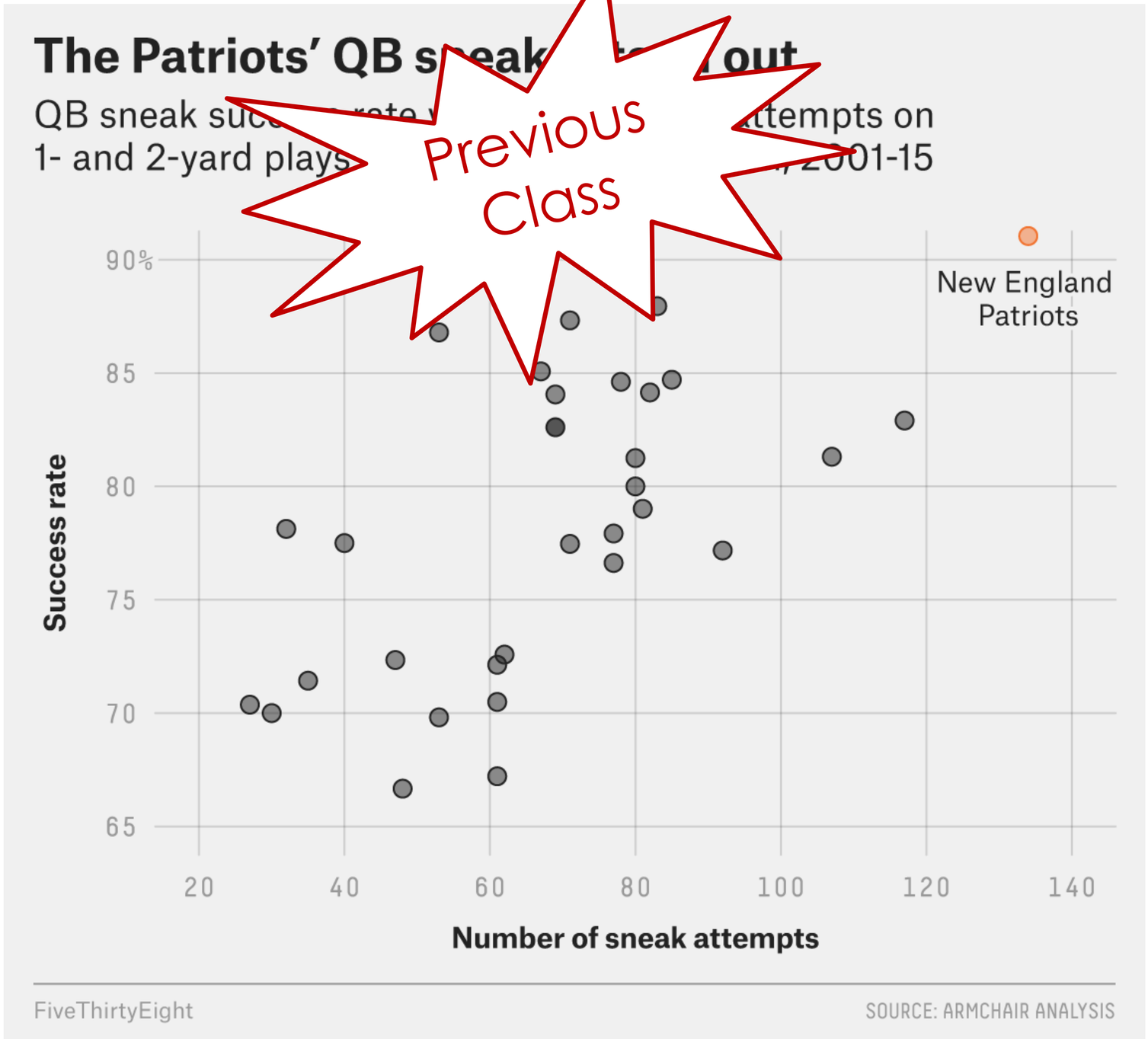
COLOR

Healey, 2012

A quarterback sneak is a play in American football and Canadian football in which the quarterback, upon taking the center snap, dives ahead while the offensive line surges forward. It is usually only used in very short yardage situations.

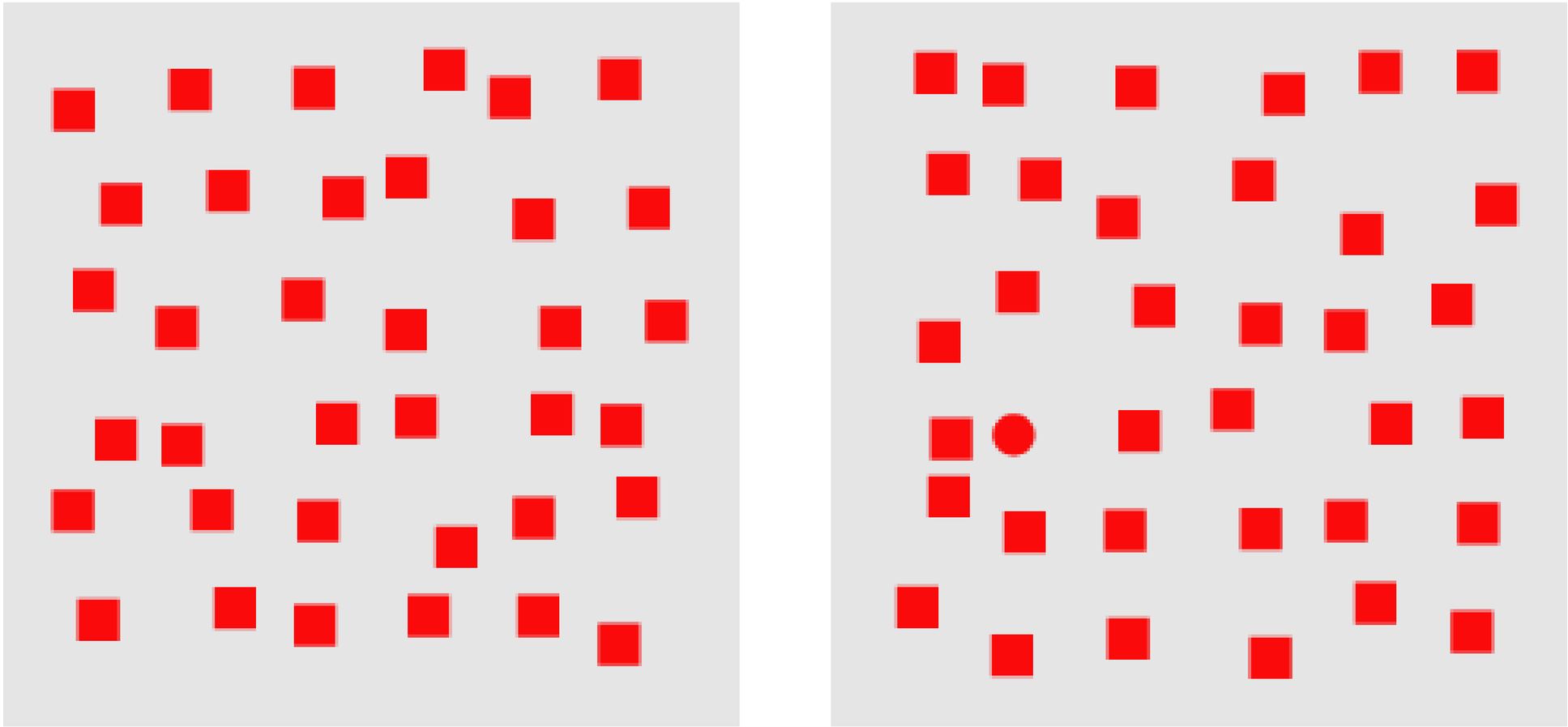
https://en.wikipedia.org/wiki/Quarterback_sneak

Which pop-out effects are used in this example visualization?



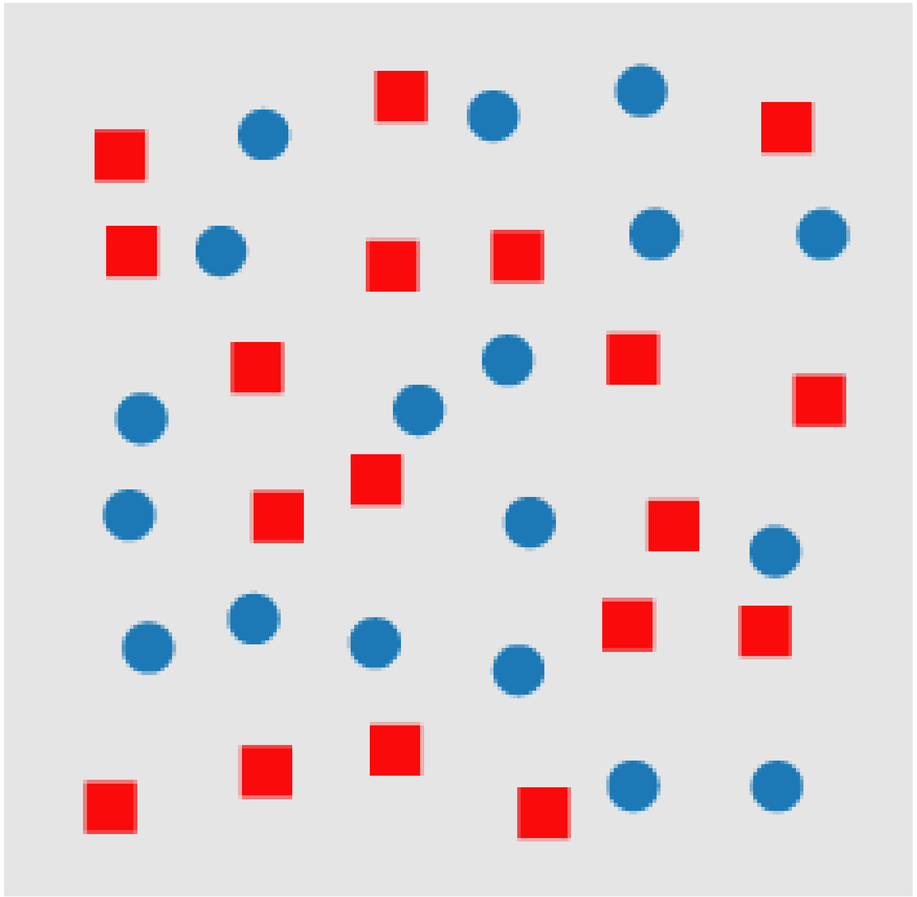
Davis & Lopez, 2017

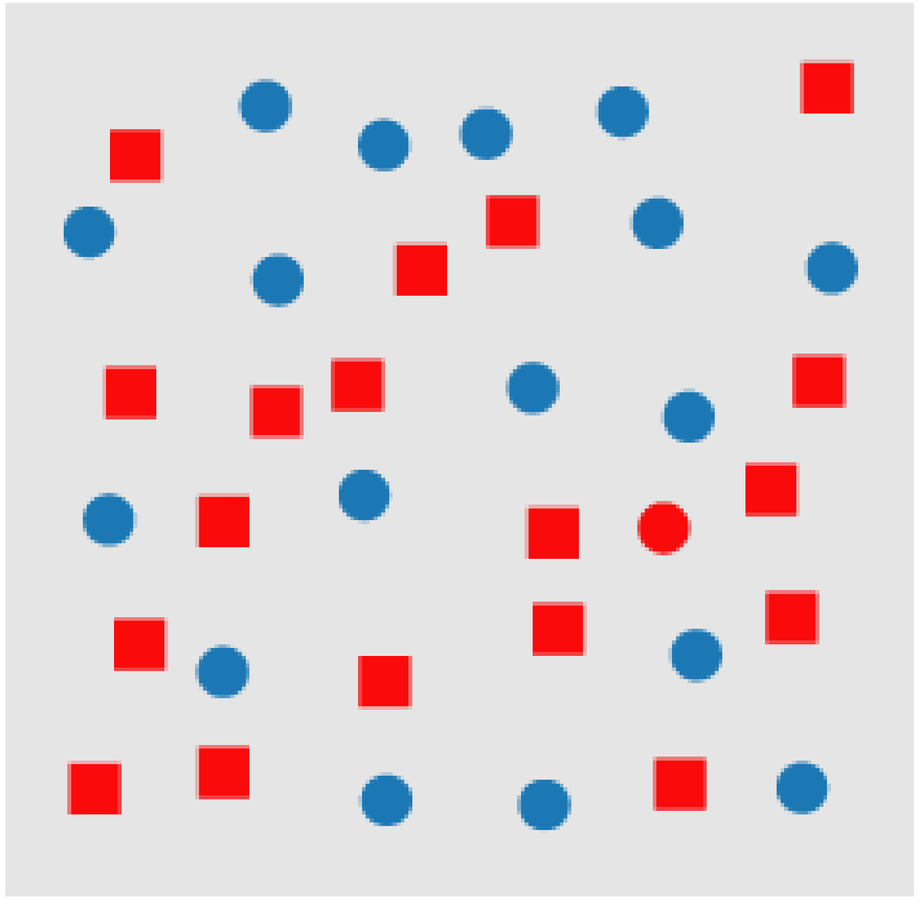
POP-OUT EFFECTS



SHAPE

POP-OUT EFFECTS

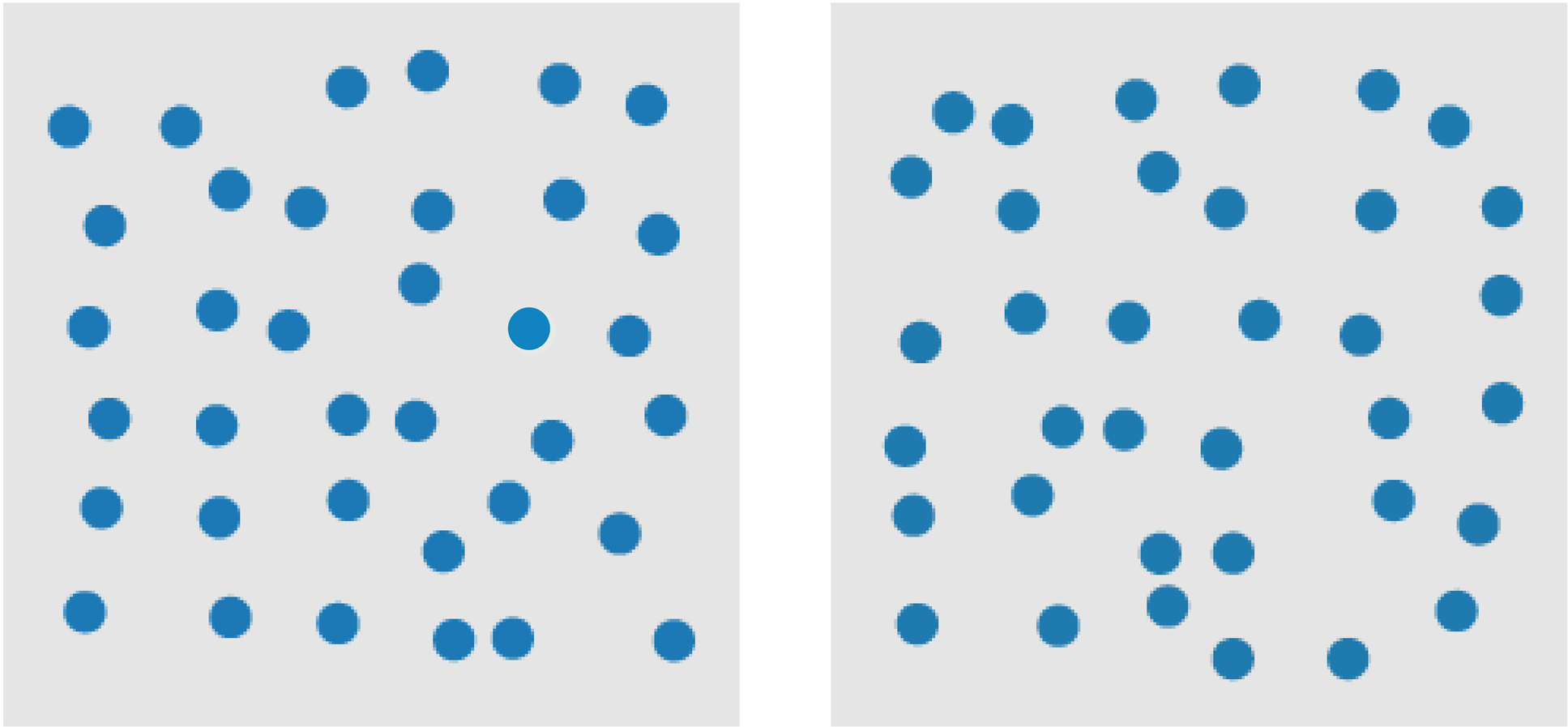




"CONJUNCTION" (HARDER TO FIND RED CIRCLE!)

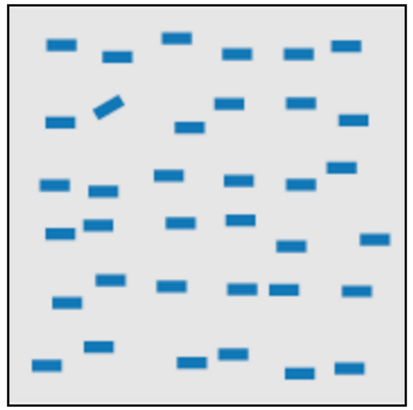
Healey, 2012

POP-OUT EFFECTS

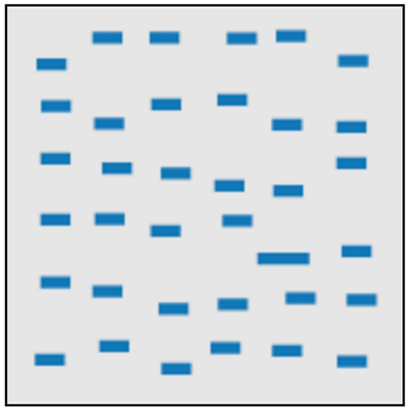


MOTION

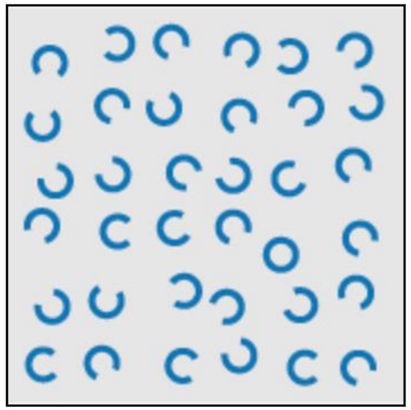
Pop-Out Effects



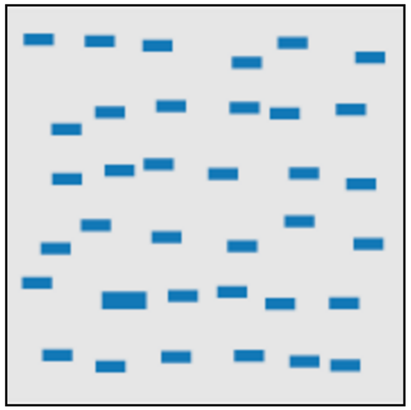
line (blob) orientation
Julész & Bergen 83; Sagi & Julész 85a, Wolfe et al. 92; Weigle et al. 2000



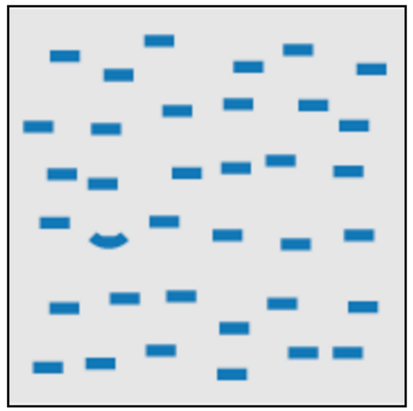
length, width
Sagi & Julész 85b; Treisman & Gormican 88



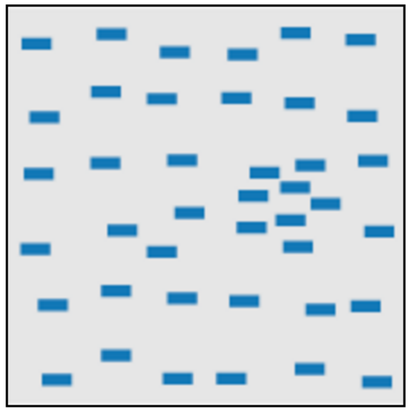
closure
Julész & Bergen 83



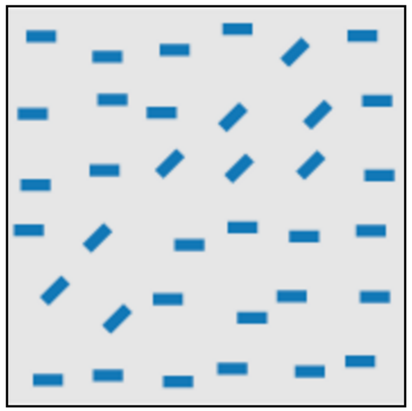
size
Treisman & Gelade 80; Healey & Enns 98; Healey & Enns 99



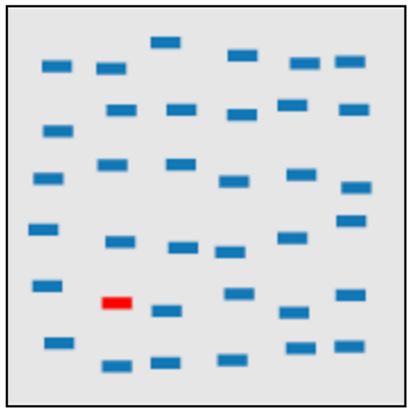
curvature
Treisman & Gormican 88



density, contrast
Healey & Enns 98; Healey & Enns 99

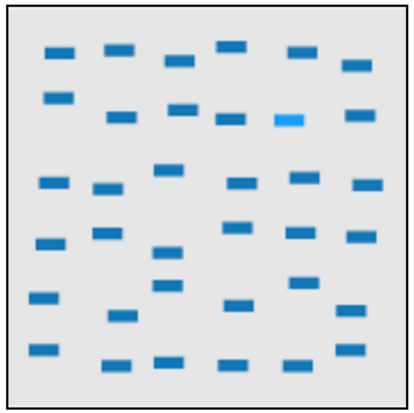


number, estimation
Sagi & Julész 85b; Healey et al. 93; Trick & Pylyshyn 94

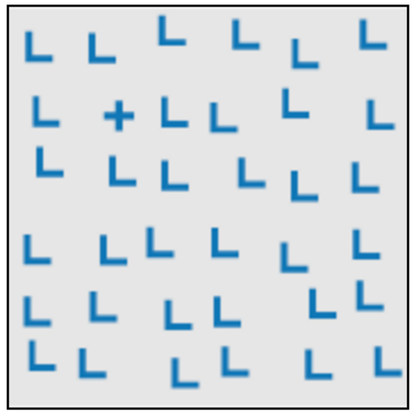


colour (hue)
Nagy & Sanchez 90; Nagy et al. 90; D'Zmura 91; Kawai et al. 95; Bauer et al. 96; Healey 96; Bauer et al. 98; Healey & Enns 99

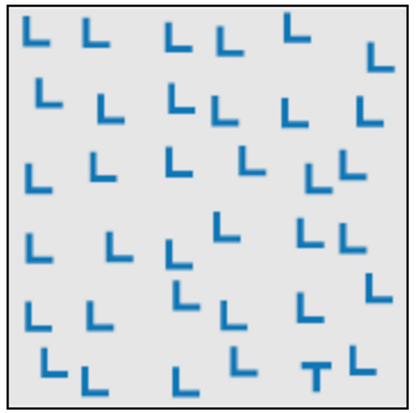
POP-OUT EFFECTS



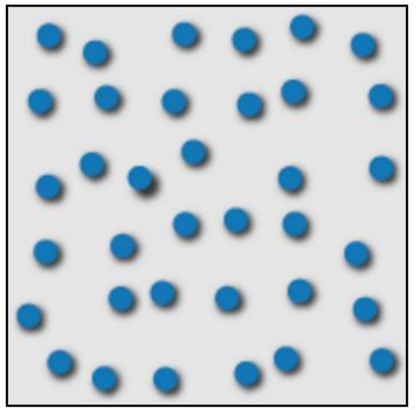
intensity, binocular lustre
Beck et al. 83; Treisman & Gormican 88; Wolfe & Franzel 88



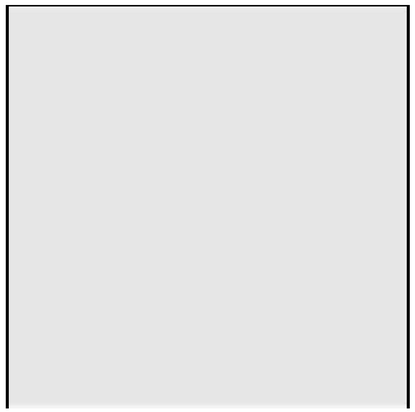
intersection
Julész & Bergen 83



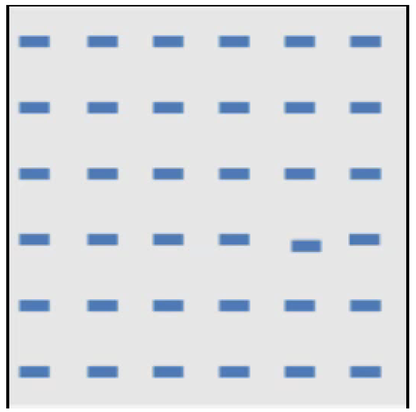
terminators
Julész & Bergen 83



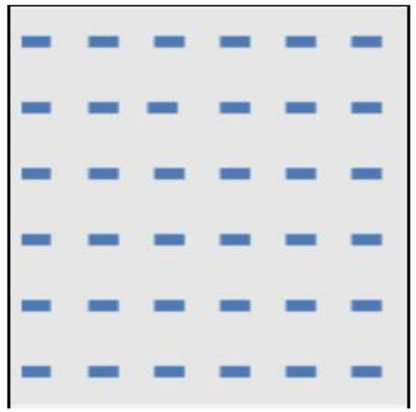
3D depth cues
Enns 90b; Nakayama & Silverman 86



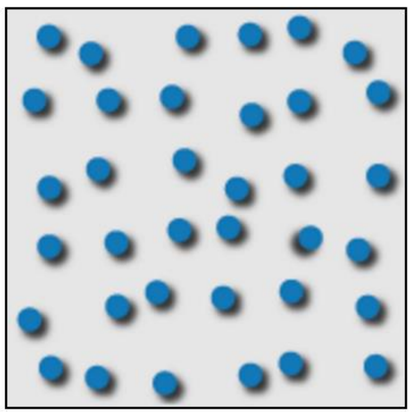
flicker
Gebb et a. 55; Mowbray & Gebhard 55; Brown 65; Julész 71; Huber & Healey 2005



direction of motion
Nakayama & Silverman 86; Driver & McLeod 92; Huber & Healey 2005



velocity of motion
Tynan & Sekuler 82; Nakayama & Silverman 86; Driver & McLeod 92; Hohnsbein & Mateeff 98; Huber & Healey 2005



lighting direction
Enns 90a

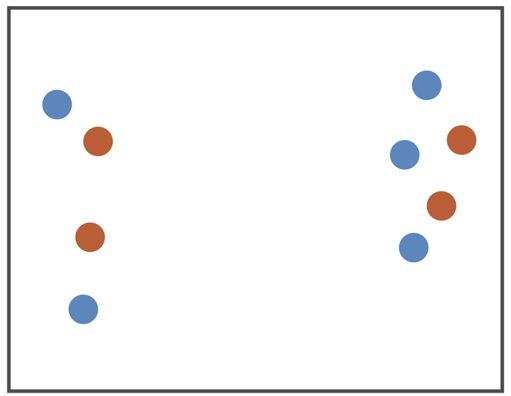
Use these “popout” effects to help design effective visualizations!

(E.g., draw viewer’s attention to main points, effective redundant encodings, etc.)

Discriminability and Separability

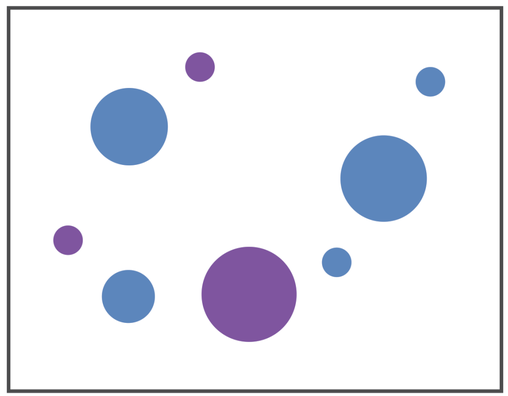
The question of discriminability is: if you encode data using a particular visual channel, are the differences between items perceptible to the human as intended?

Position
+ Hue (Color)



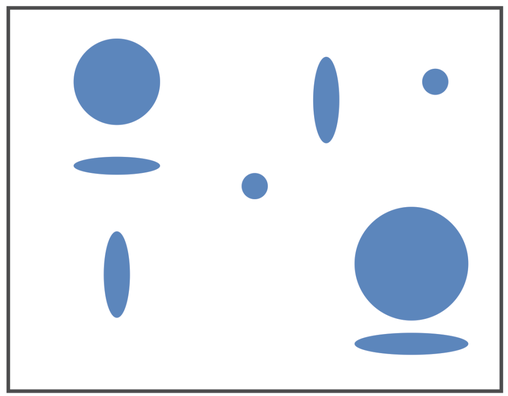
Fully separable

Size
+ Hue (Color)



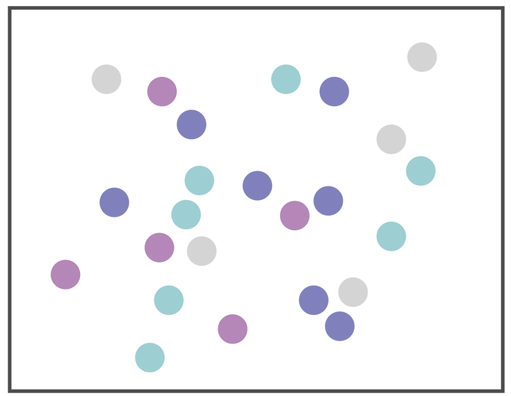
Some interference

Width
+ Height



Some/significant interference

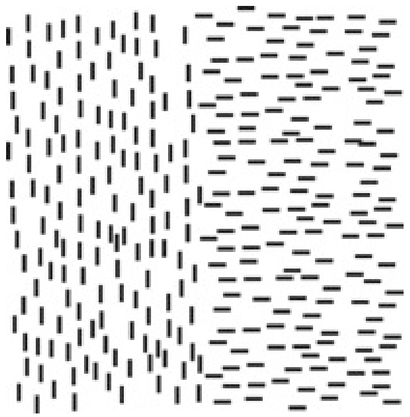
Red
+ Green

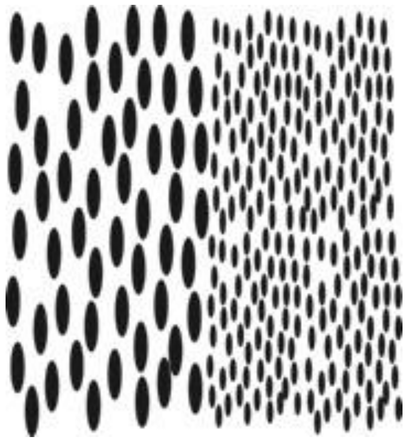


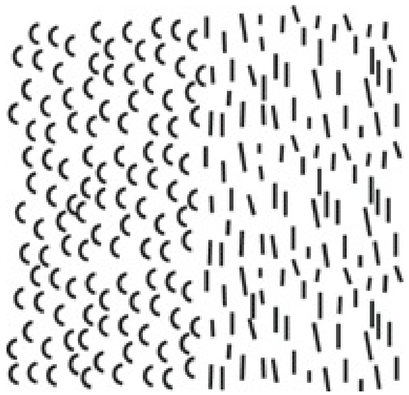
Major interference

Textures

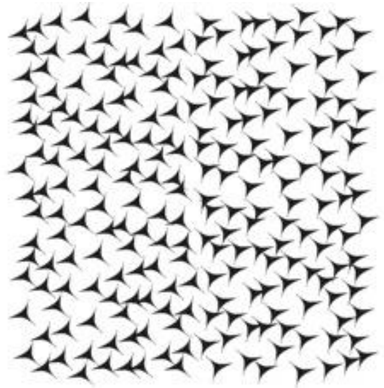
easy

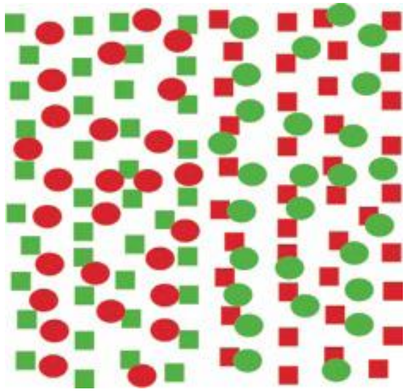


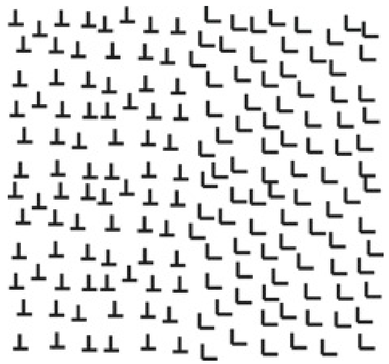




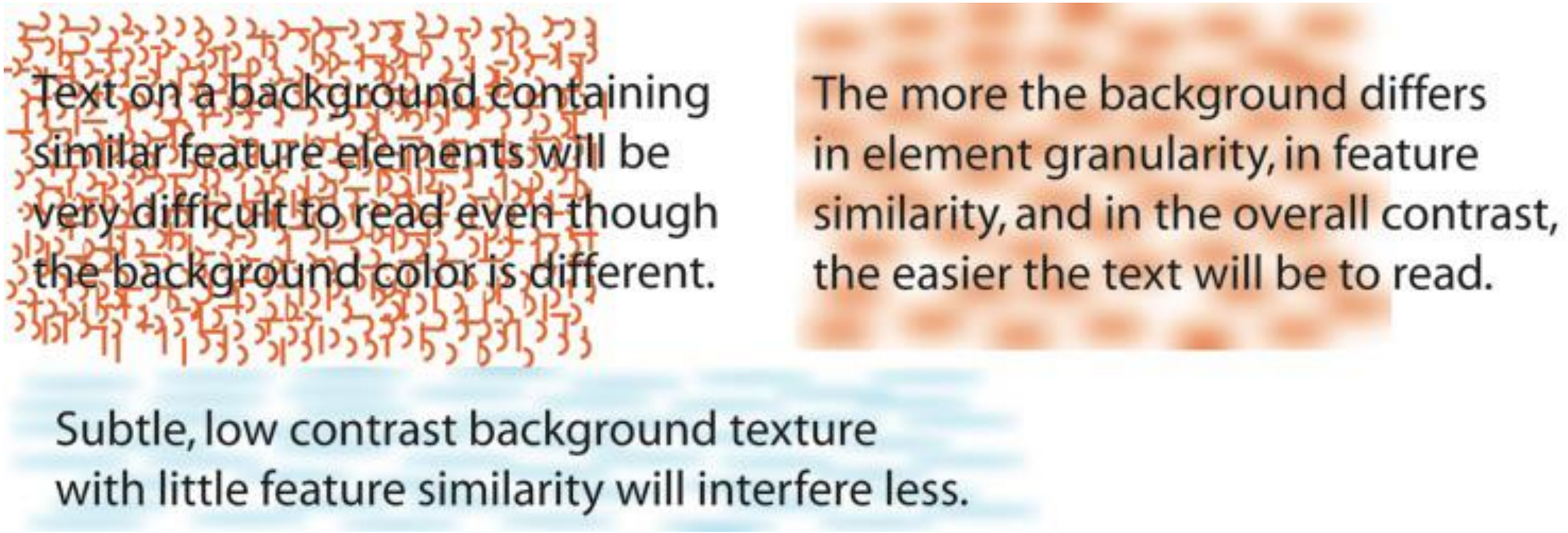
hard







Textures: Interference



For Next Time

neu-ds-4200-s22.github.io/schedule

Look at the upcoming assignments and deadlines

- Textbook, Readings, & Reading Quizzes—Variable days
- In-Class Activities—If due, they are due 11:59pm the same day as class

Everyday Required Supplies:

- 5+ colors of pen/pencil
- White paper
- Laptop and charger

Use Canvas Discussions for general questions, email codydunne-and-tas@ccs.neu.edu for questions specific to you.

Week	Topics	Assignments
#1: Jan 17–21	What is visualization Design rules of thumb	A1—Setting up
#2: Jan 24–28	JS development, projects Marks & channels	A2—Encodings & xenographics
#3: Jan 31–Feb 04	Data types and tasks, Tableau D3 tutorial 1/2	P1—Pitches★
#4: Feb 07–11	In-class group formation D3 tutorial 2/2	A3—Tableau analysis P2—Proposal★
#5: Feb 14–18	Altair and JupyterLab Practice Design Study	A4—D3 basic charts
#6: Feb 21–25	Arrange Tables Color, pop-out, illusions	A5—Altair basic charts P3—Interview & tasks
#7: Feb 28–Mar 04	Interaction & animation In-class project meetings 1/2	A6—D3 event handling P4—Data and sketches
#8: Mar 07–11	Trees & networks In-class project meetings 1/2	P5—Final sketches & plan★
Mar 14–18	*Spring Break*	
#9: Mar 21–25	Project feedback & work Spatial, 3D, and scientific vis.	A7—D3 Brushing & linking 1 P6—Implementation 1
#10: Mar 28–Apr 01	Validation & evaluation Flex day	A8—Brushing & linking 2 P7—Implementation 2
#11: Apr 04–08	Project usability testing, how to give a talk Storytelling	
#12: Apr 11–15	Project presentations 1/2 Project presentations 2/2	P8—Presentations★⧗
#13: Apr 18–22	Flex day	P9—Presentation peer review
#14: Apr 25–29	Reflecting & project work	
May 02–06		P10—Video & Final Deliverables★⧗