

Visualizations are ambiguous figures



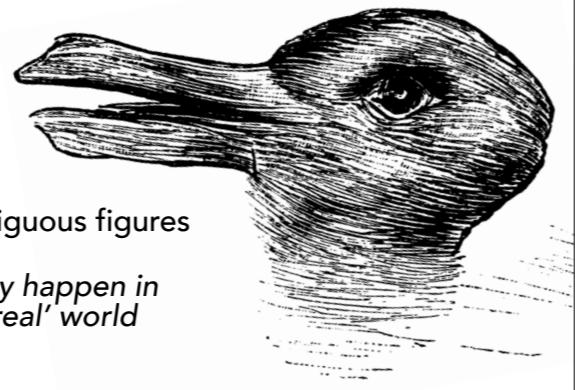
Steve Franconeri
Psychology, Kellogg,
& Design/Engineering
Northwestern University



@SteveFranconeri

Ambiguous figures

Rarely happen in the 'real' world



Hannah Murphy

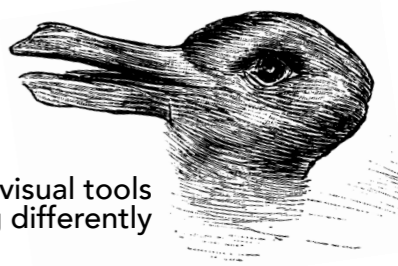
my mother was giggling at this and told me to "take a look at that adorable dachshund, he's sleeping", she was looking at a purse:



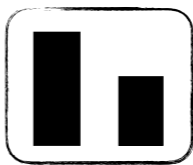
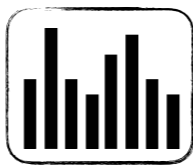
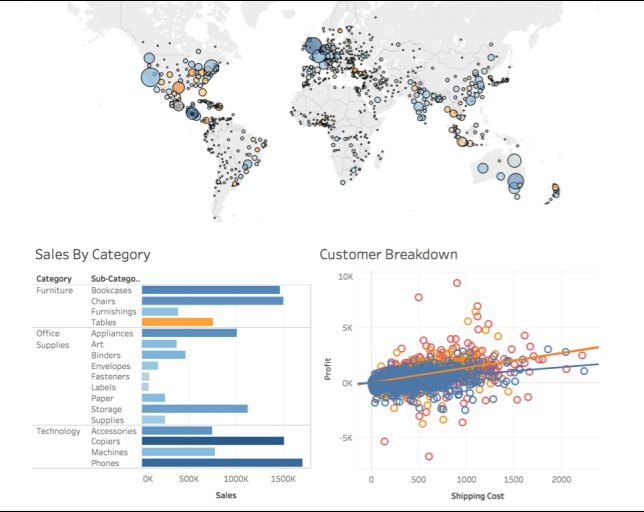
8:15 AM - 30 Jul 2017
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But in visualizations, multi-stable interpretation is **ubiquitous**

Visualizations are ambiguous figures



Three visual tools for seeing differently



FAST < 100ms

Shape recognition (Sloped roof)

FAST < 100ms

Histograms (Different sizes)

SLOW ~seconds

Comparisons (Left bigger; Right smaller; Right lighter...)

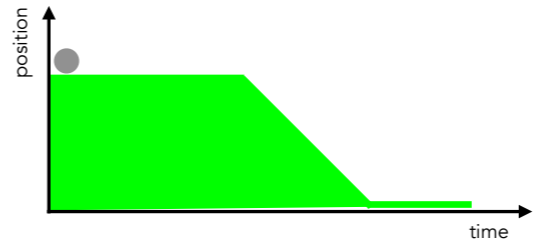
object recognition

the world

A B C

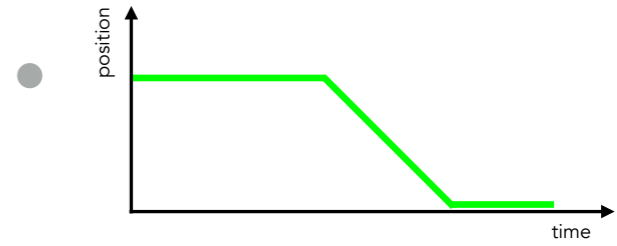
O □ △

L ⊥ ×



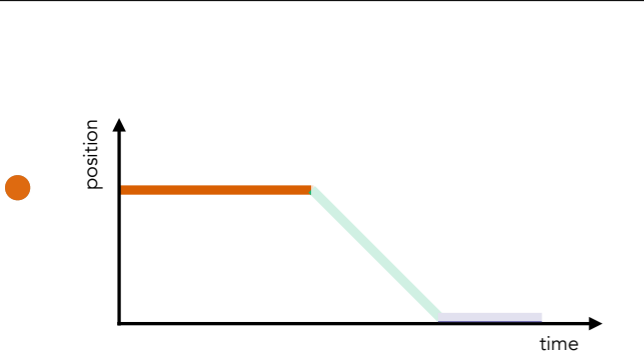
Here is a graph of an object's motion. Imagine some real situation depicted on the graph

Kozhevnikov, Hegarty, & Mayer, 2002



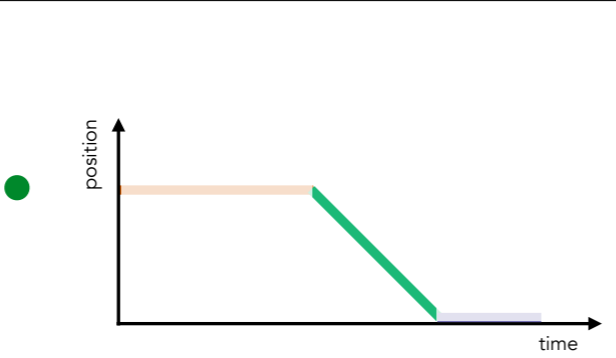
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Kozhevnikov, Hegarty, & Mayer, 2002



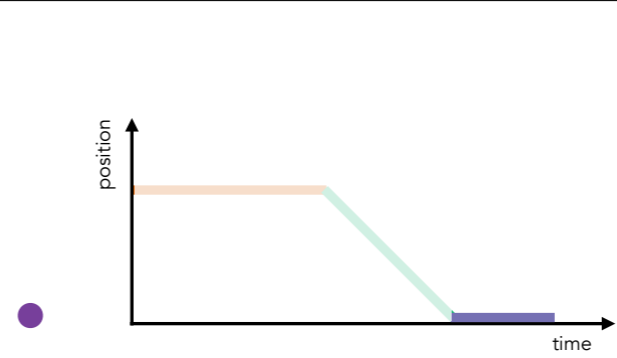
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Here is a graph of an object's motion. Imagine some real situation depicted on the graph

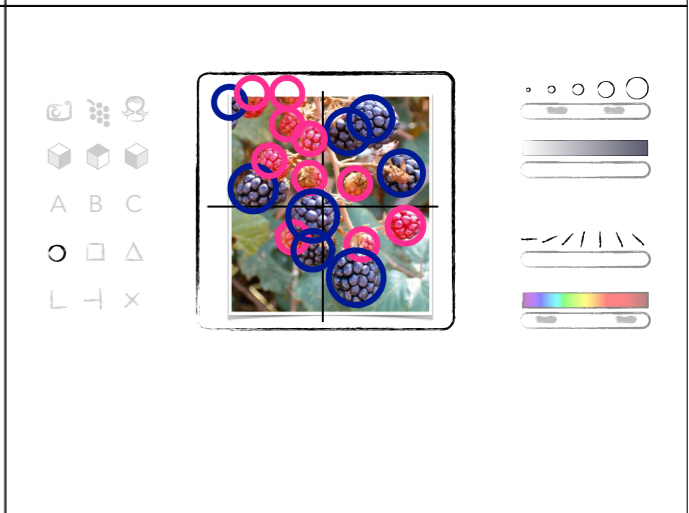
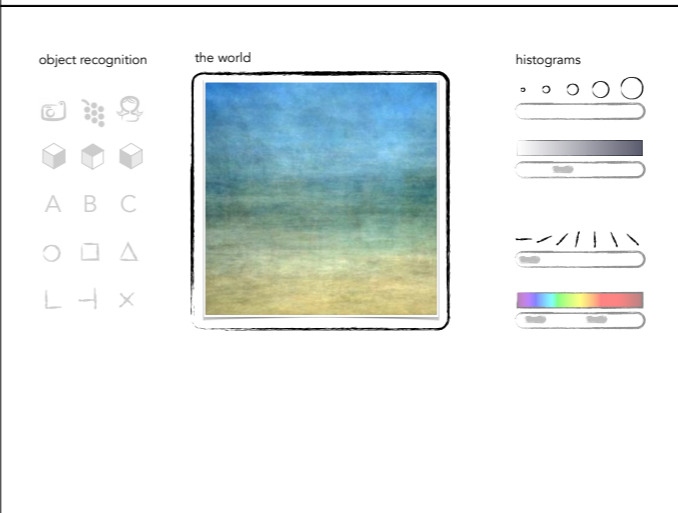
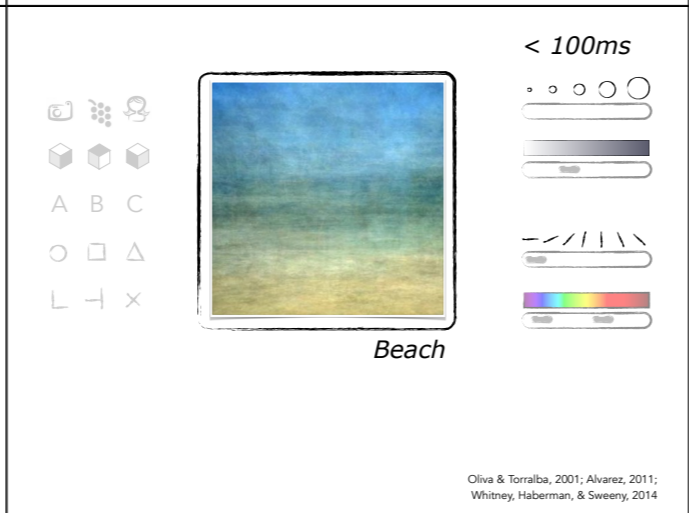
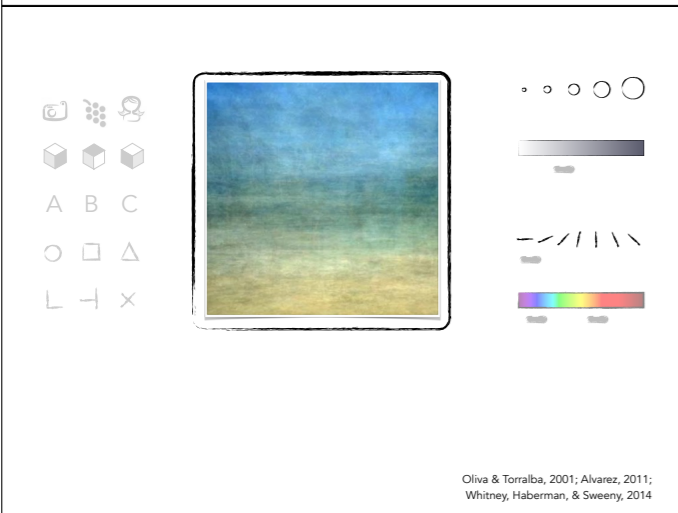
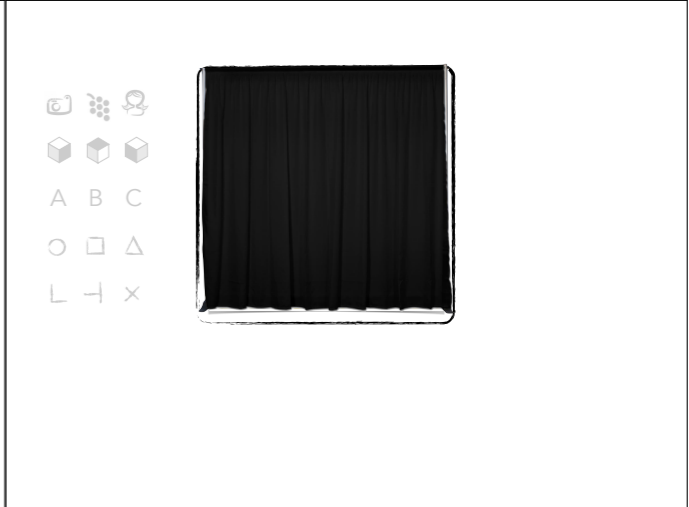
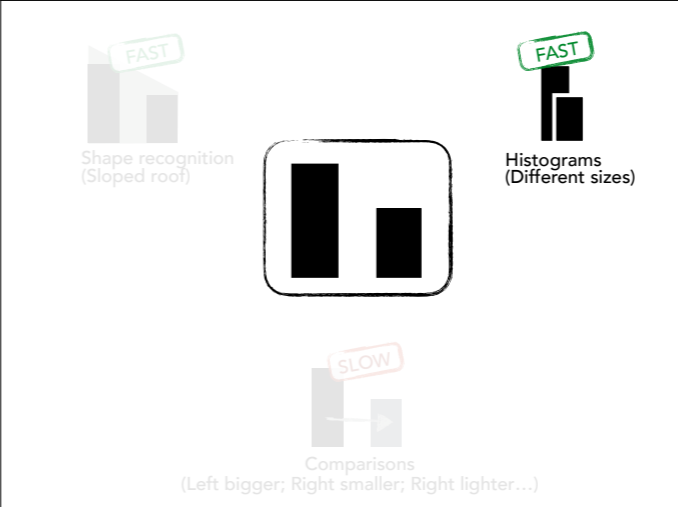
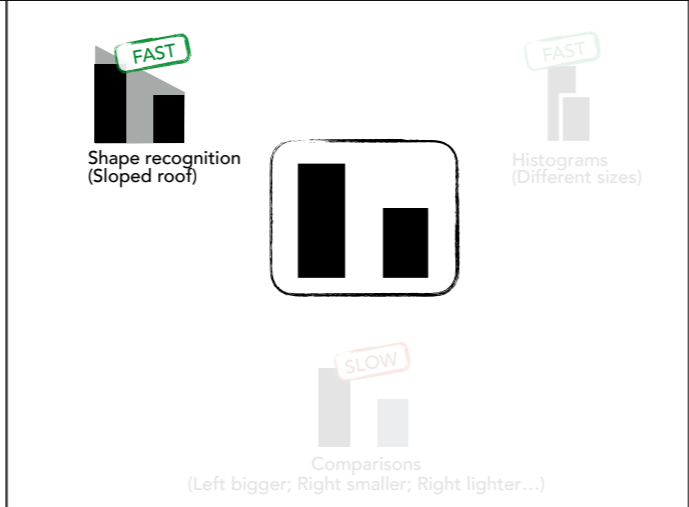
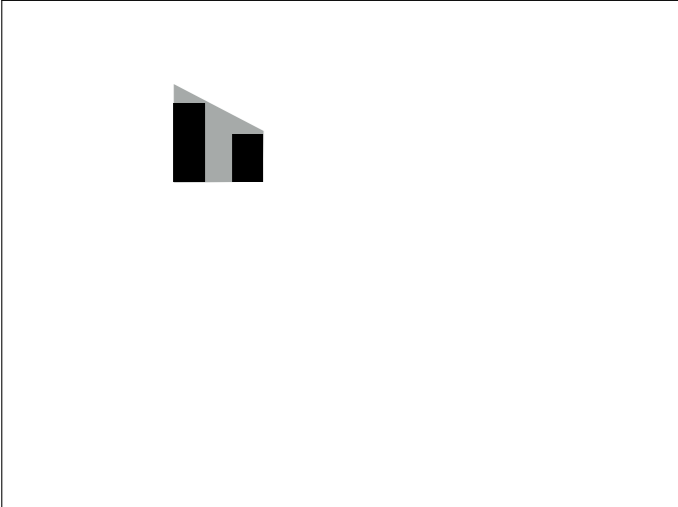
Kozhevnikov, Hegarty, & Mayer, 2002

object recognition < 100ms

A B C

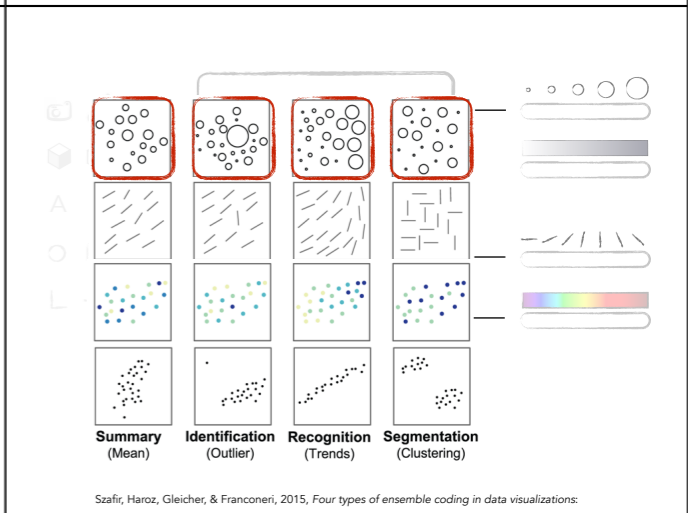
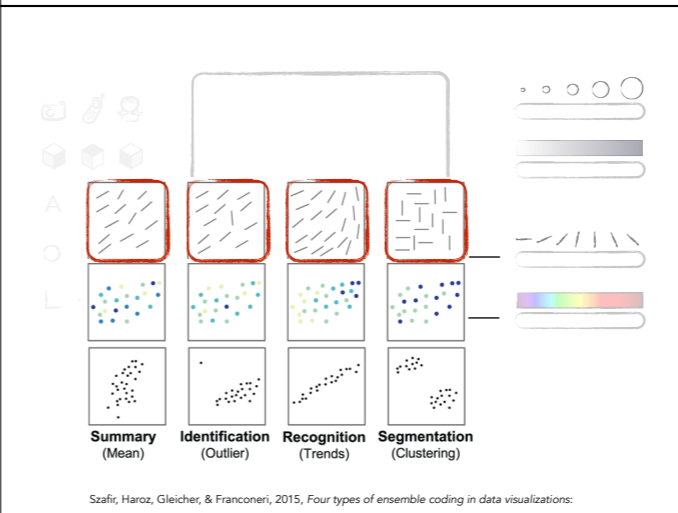
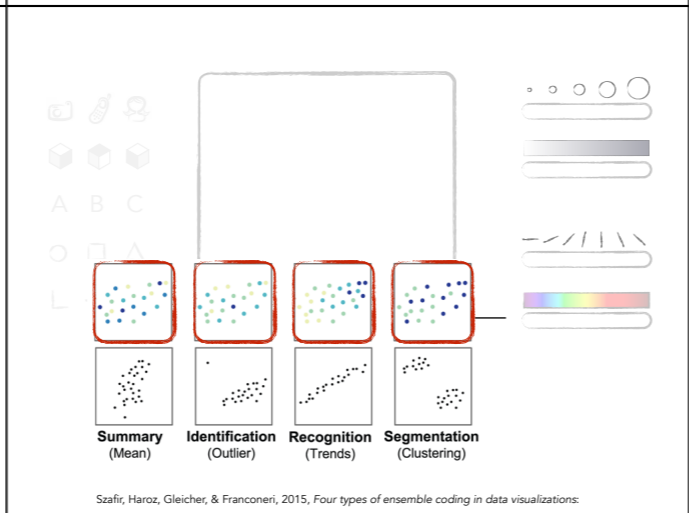
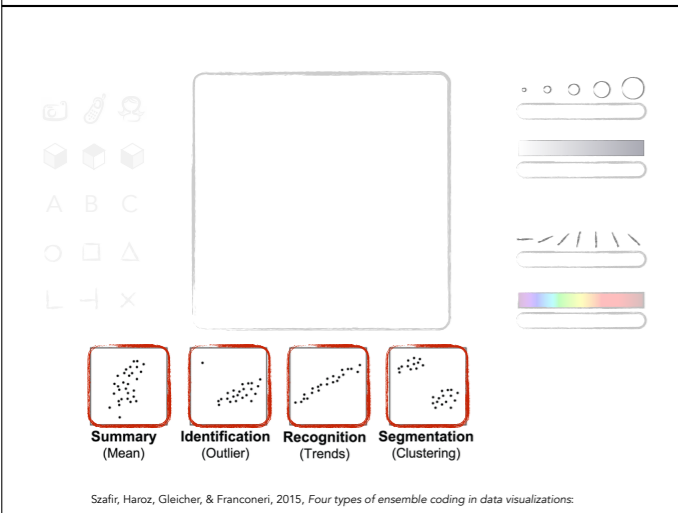
O □ △

L ⊥ ×



Oliva & Torralba, 2001; Alvarez, 2011; Whitney, Haberman, & Sweeny, 2014

Oliva & Torralba, 2001; Alvarez, 2011; Whitney, Haberman, & Sweeny, 2014

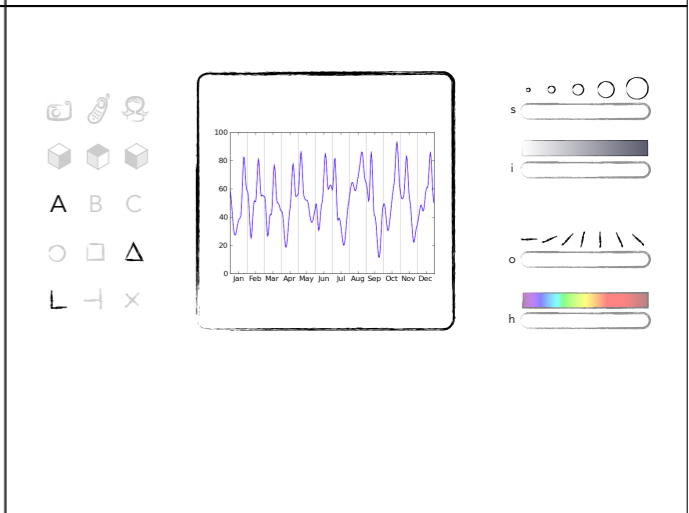
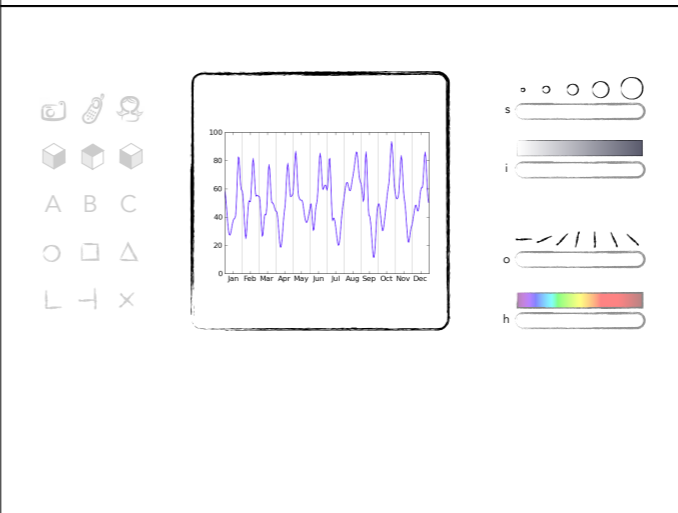
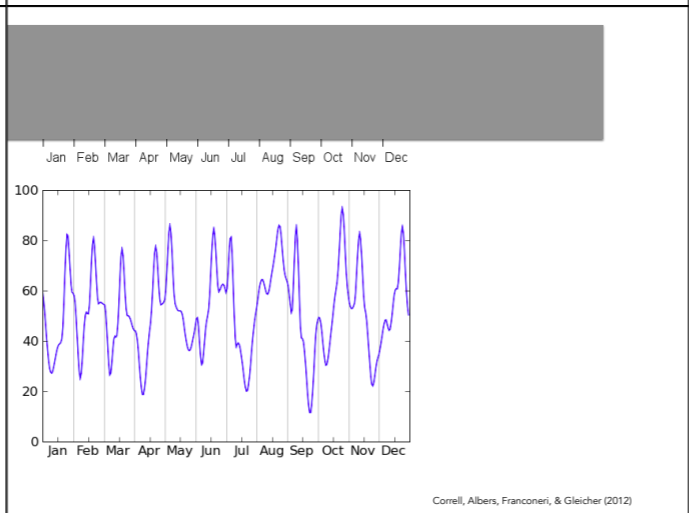
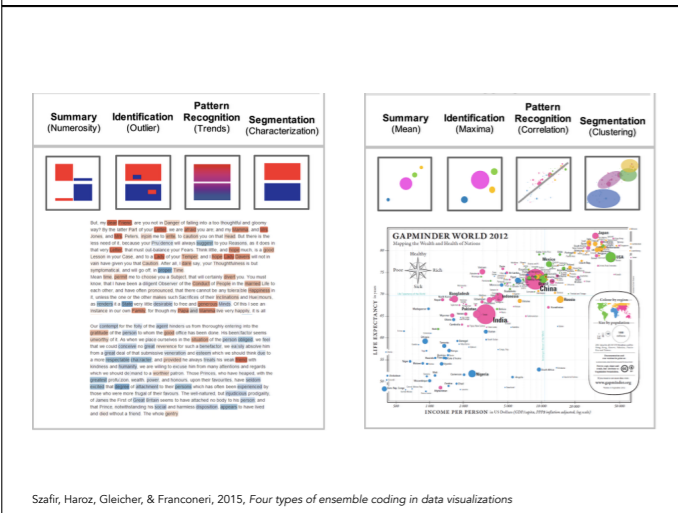


Szafir, Haroz, Gleicher, & Franconeri, 2015, Four types of ensemble coding in data visualizations

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Cornell, Albers, Franconeri, & Gleicher (2012)

FAST

Shape recognition (Sloped roof)

FAST

Histograms (Different sizes)

SLOW

Comparisons (Left bigger; Right smaller; Right lighter...)

FAST

Shape recognition (Sloped roof)

FAST

Histograms (Different sizes)

(??)

SLOW

Comparisons (Left bigger; Right smaller; Right lighter...)

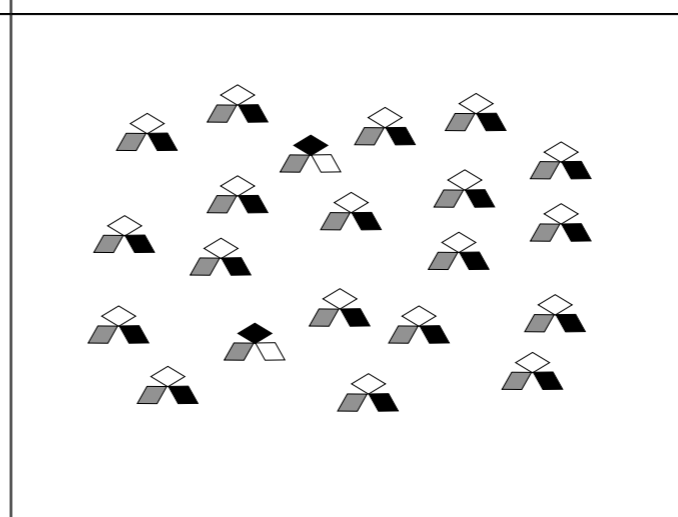
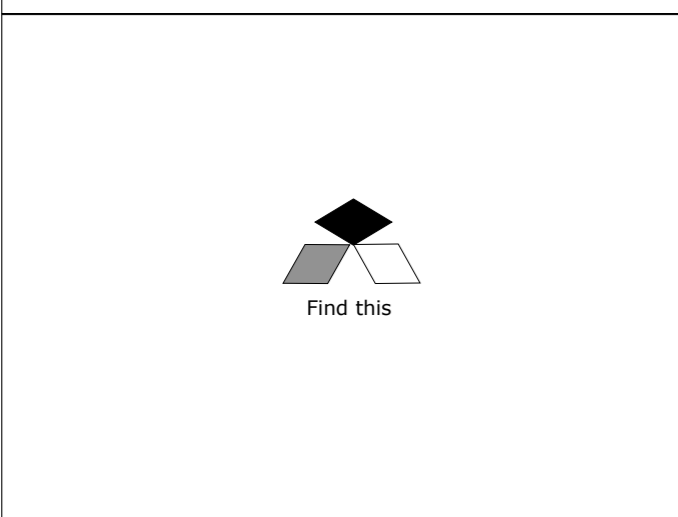
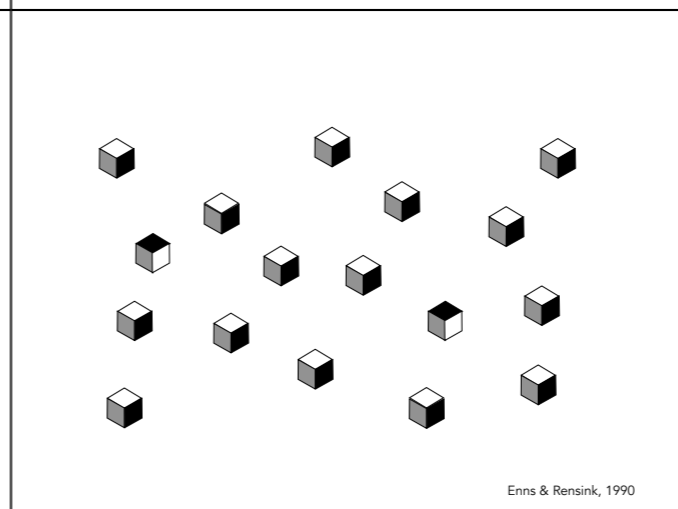
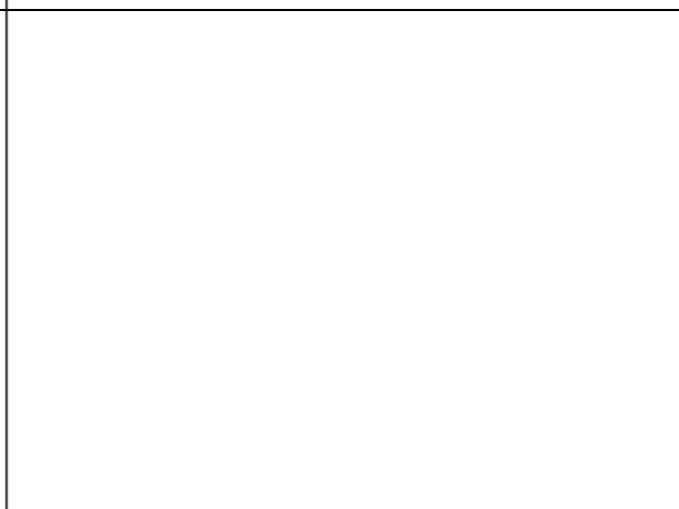
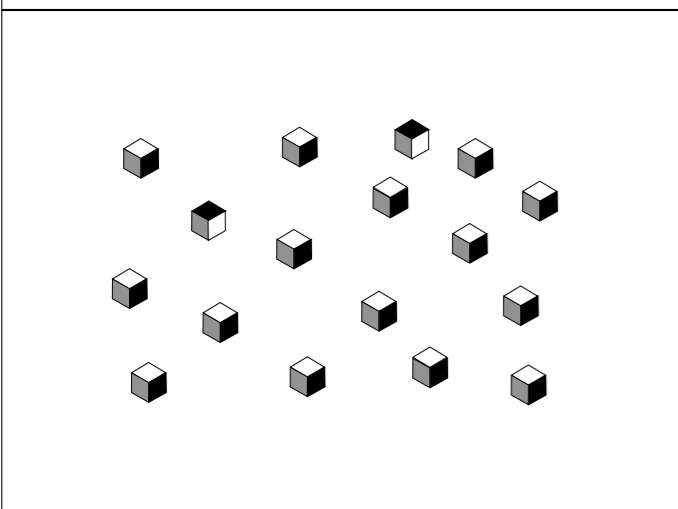
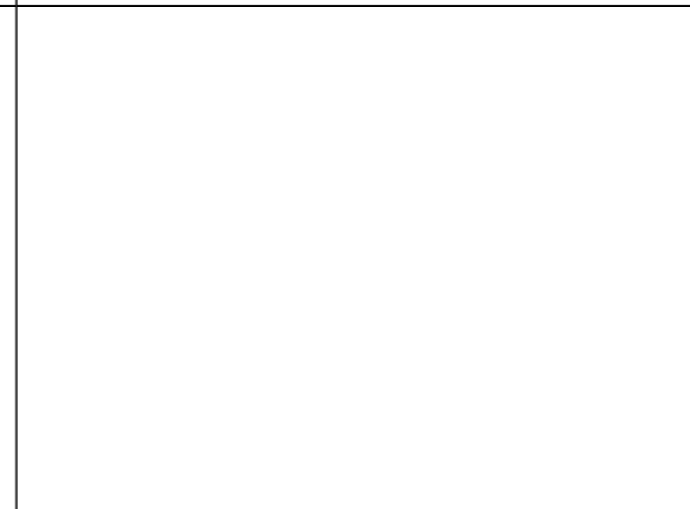
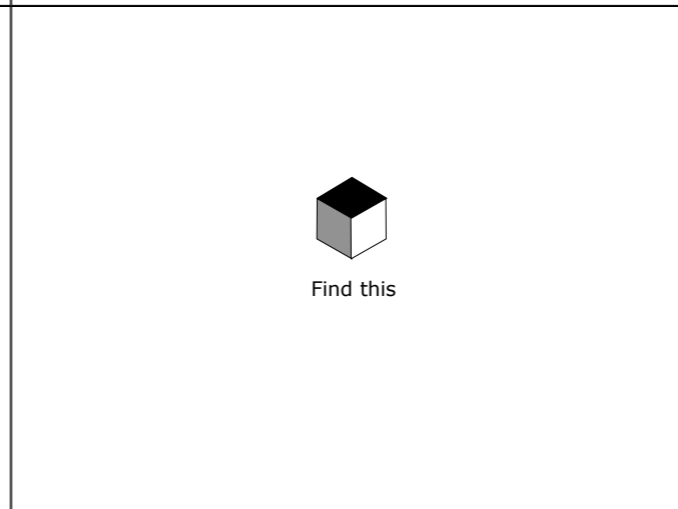
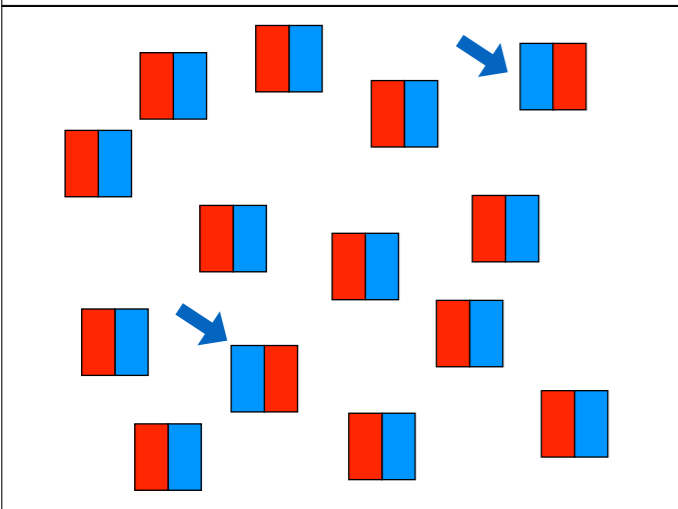
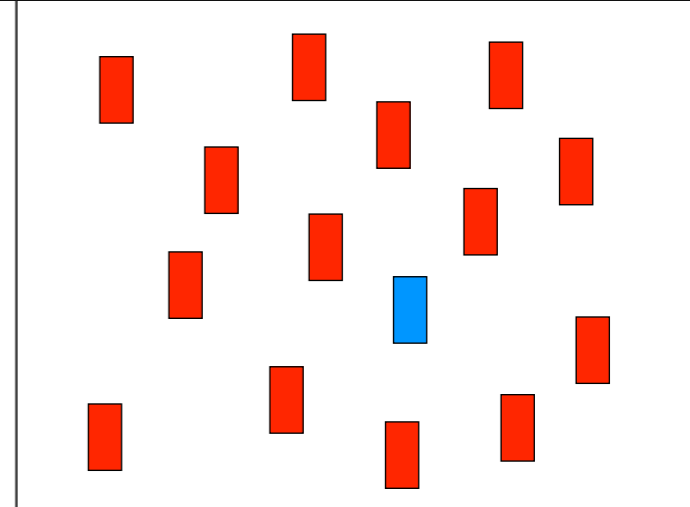
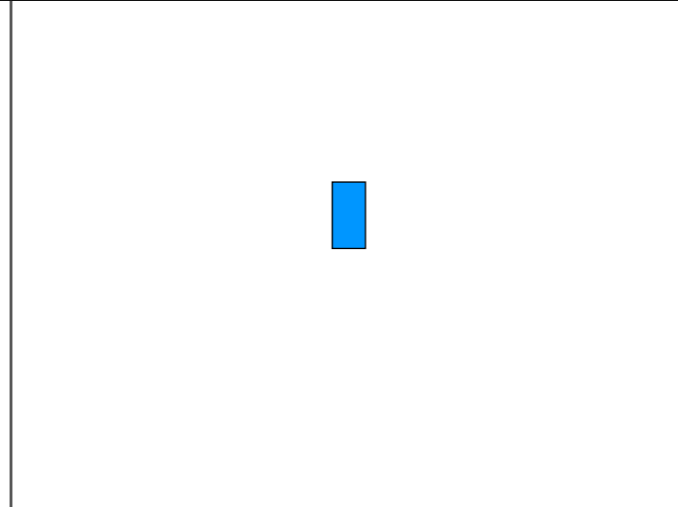
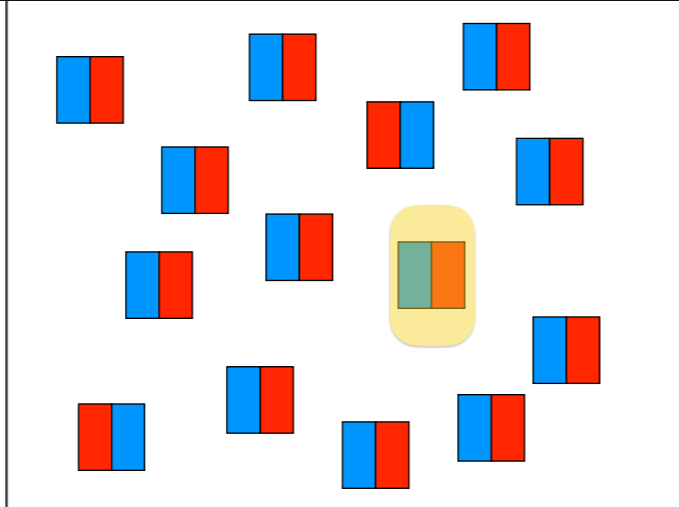
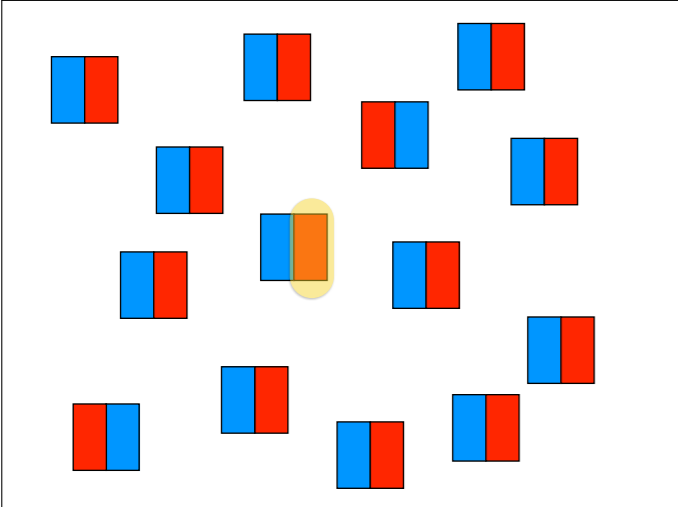
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 Holcombe, 2009, TICS
 Hummel, 2011, Connection Science
 Franconeri, et al., 2012, Cognition

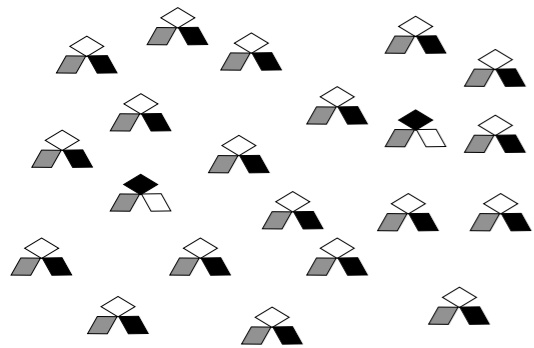
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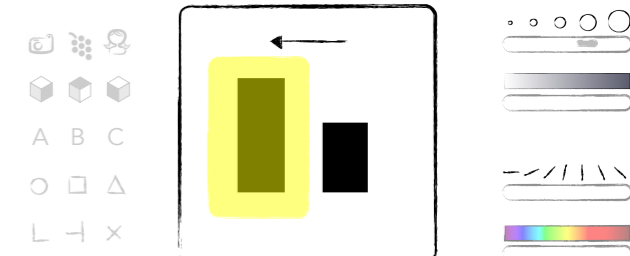
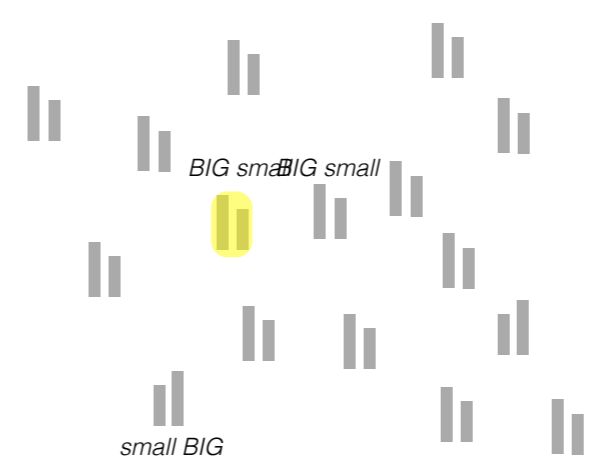
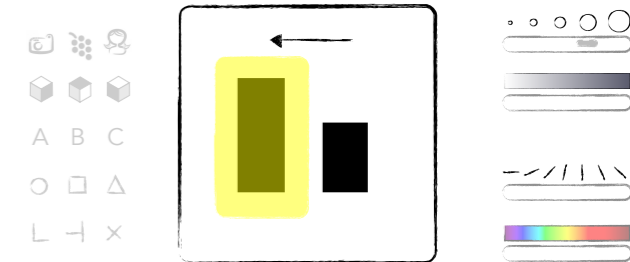
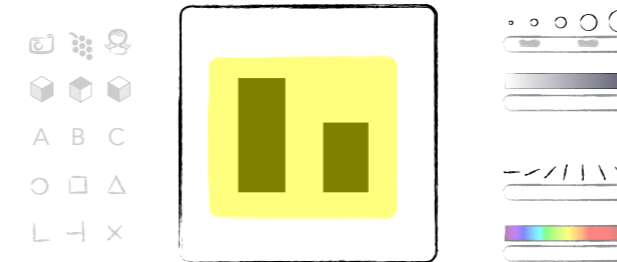
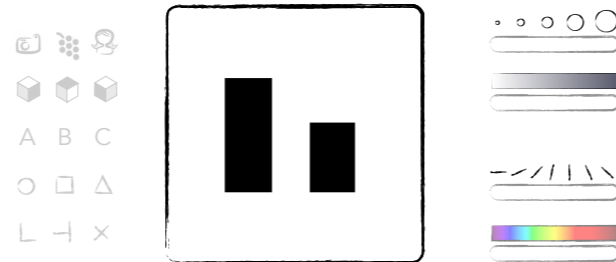
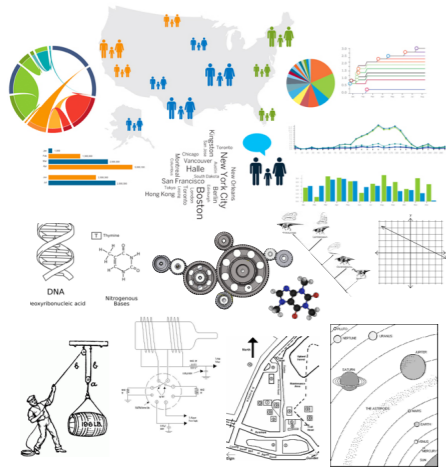
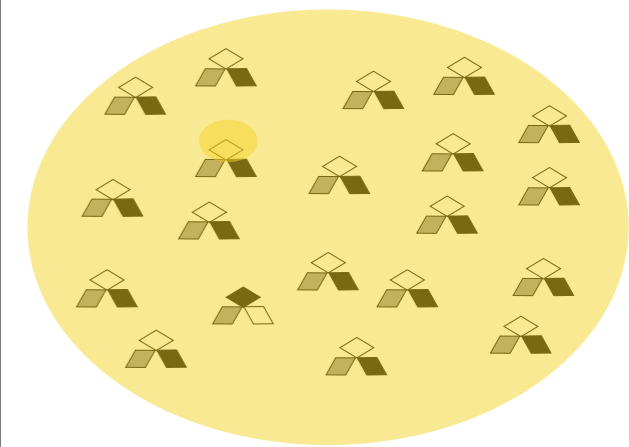
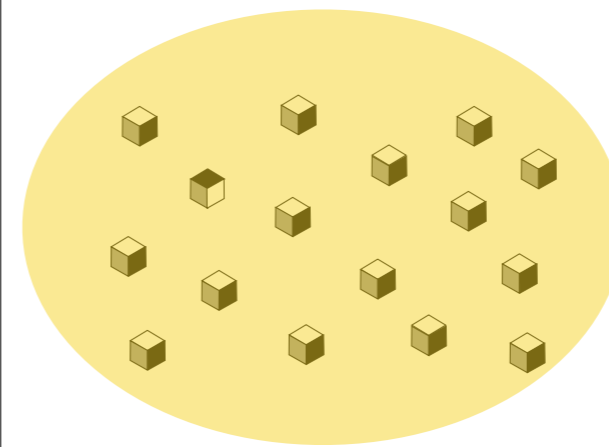
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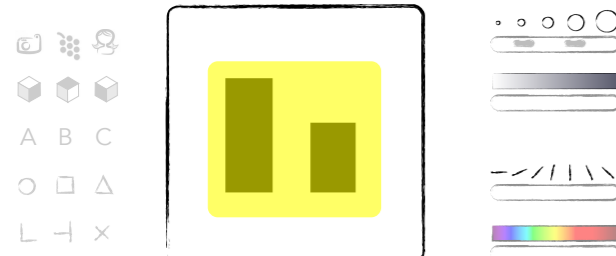




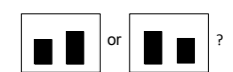
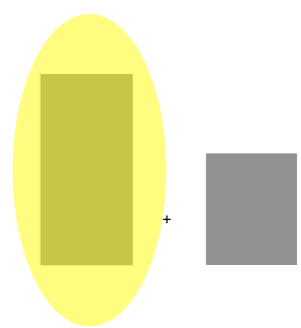
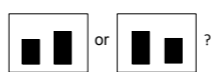
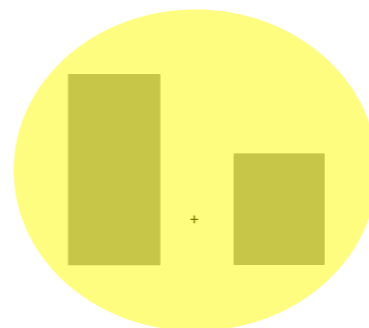
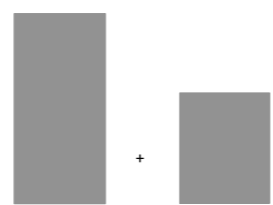
Enns & Rensink, 1990
(see also Wolfe, 1998)

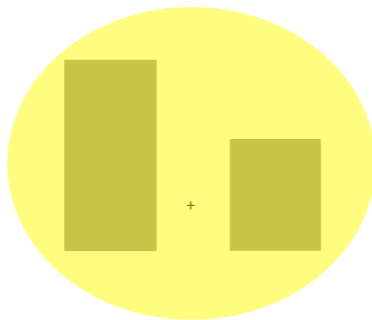


You should need to shift to judge BIGsmall vs. smallBIG



You should need to shift to judge BIGsmall vs. smallBIG
But not same-different!

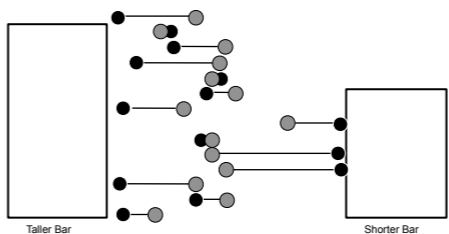




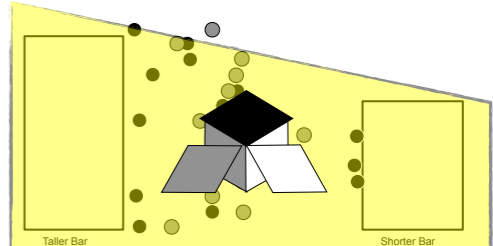
S or D ?



S or D ?



S or D ?



S or D ?

FAST

Shape recognition (Sloped roof)

FAST

Histograms (Different sizes)

SLOW

Comparisons (Left bigger; Right smaller; Right lighter...)

FAST

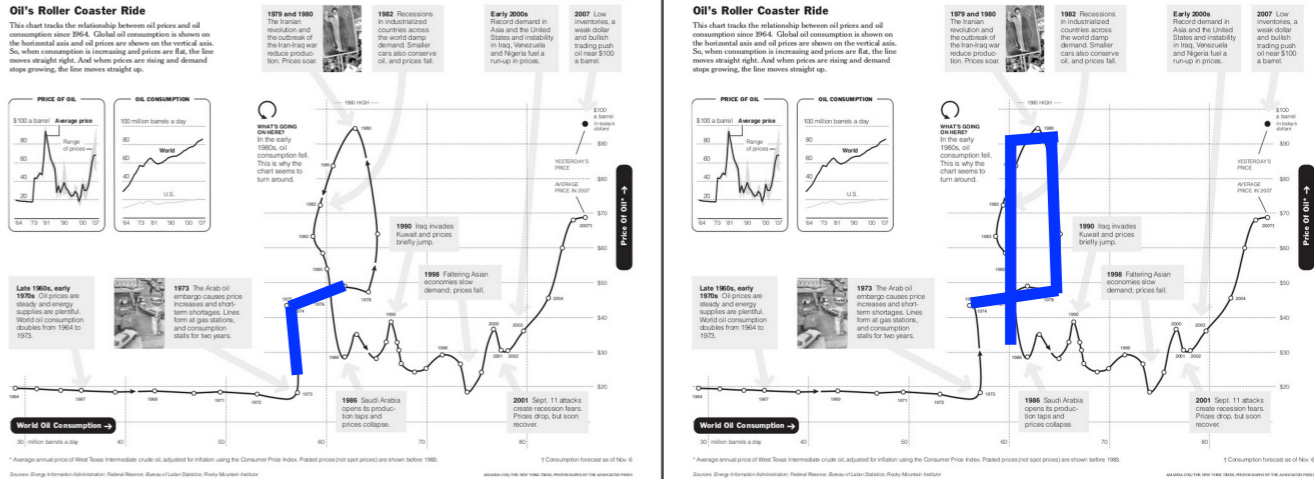
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SLOW

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Students need to learn which to use, when

SteveHaroz.com

The Connected Scatterplot for Presenting Paired Time Series

Collaborators: Steve Haroz - Psychology, Northwestern University; Robert Kosara - Tableau Research; Steven Franconeri - Psychology, Northwestern University.

An effective tool for journalists? An far back as the 1970s, the connected scatterplot was used to visualize the cycle of a steam piston. Economists have since used it to report data about unemployment and job openings over time. Recently, journalists have begun using the technique to convey information to readers. But how well do those readers understand this unfamiliar format? We tested how well viewers understand what the chart depicts, whether they can translate back & forth to more traditional formats, and whether they are more likely to engage with this new chart.

Try it out: Drag the points to make your own connected scatterplot

Turning a Corner?

A chart of industrial production – the output of manufacturers, miners and utility companies – suggests that the economy is poised to turn around, but that the climb out of the current downturn will be a long one.

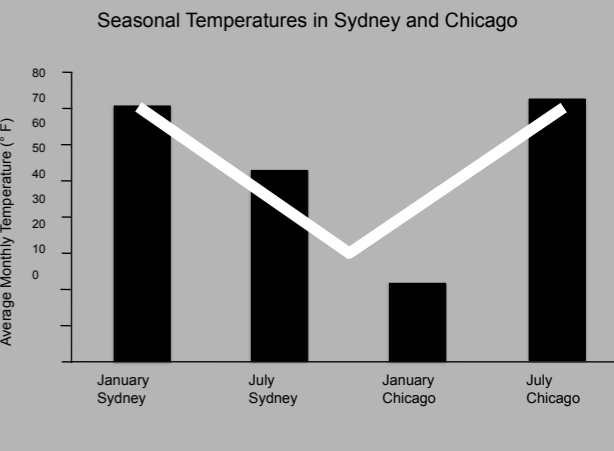
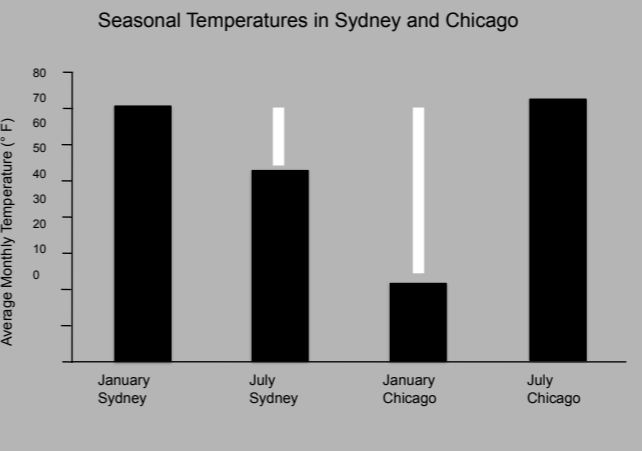
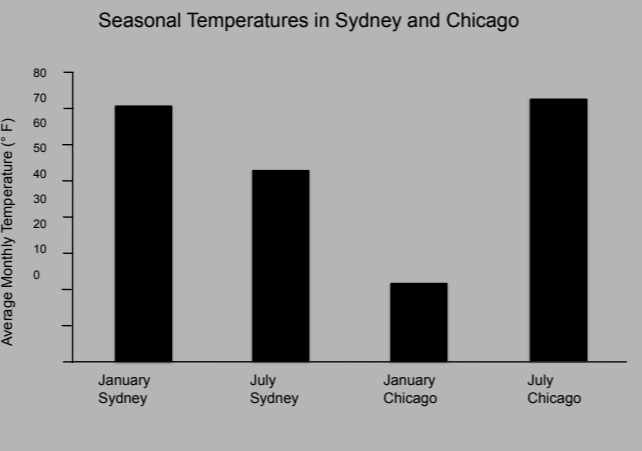
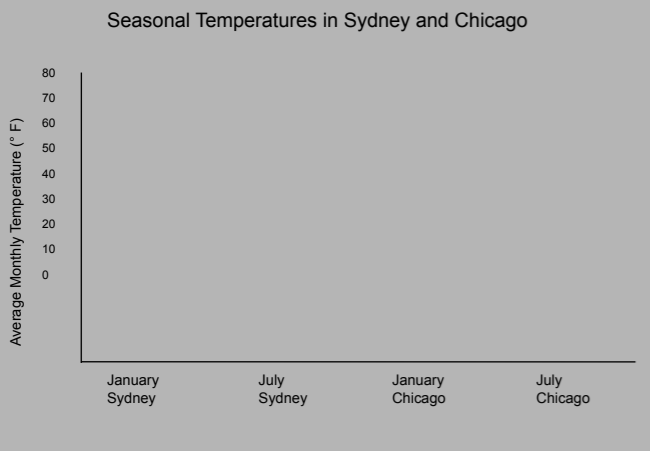
Looking for turning points

Economic turning points are notoriously hard to identify, especially when a parade of data can seem to contradict itself. To get a feeling for how cycles are evolving, economists at the Organization for Economic Cooperation and Development have been watching a chart that illustrates the business cycle.

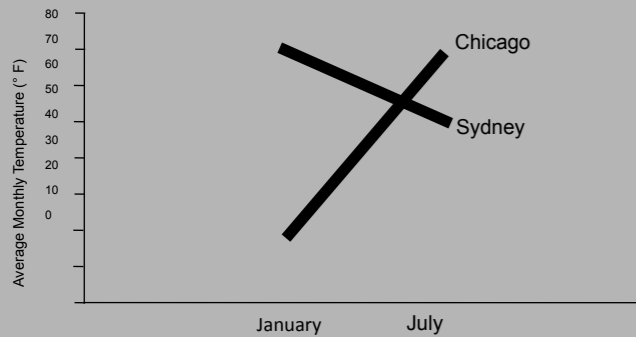
Phase Shift

K:Y Ratio	Frequency	Phase
1:1	0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°	Expansion
1:2	0°, 22°30', 45°, 67°30', 90°, 112°30', 135°, 157°30'	Expansion
1:3	0°, 15°, 30°, 45°, 60°, 75°, 90°, 105°, 120°	Expansion
1:4	0°, 11°15', 22°30', 33°45', 45°, 56°15', 67°30', 78°45'	Expansion

Haroz, Kosara, & Franconeri (2016)



Seasonal Temperatures in Sydney and Chicago



FAST

Shape Recognition

Different sizes

SLOW

Left bigger; Right smaller; Left taller; Smaller on the right..

FAST

Shape Recognition

Different sizes

SLOW

Left bigger; Right smaller; Left taller; Smaller on the right..

Interactive tool interface with icons for shape recognition, different sizes, and a central image of raspberries.

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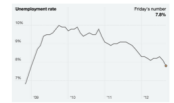
FAST

Shape Recognition

Different sizes

SLOW

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One Report, Diverging Perspectives

Friday's jobs report is the second-to-last of the presidential campaign. Each party will interpret the numbers in a way to convince voters that its policies will help economic growth.

How a Democrat Might See Things

September Jobs Report

How a Republican Might See Things

The U.S. economy added 114,000 jobs in September.

The unemployment rate fell to 7.8%.

Monthly change in jobs in thousands

Friday's number +114,000

Unemployment rate

Friday's number 7.8%

By MIKE BOSTOCK, SHAN CARTER, AMANDA COX and KEVIN QUEALY | Send Feedback

Source: Bureau of Labor Statistics

<http://www.nytimes.com/interactive/2012/10/05/business/economy/one-report-diverging-perspectives.html>

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How a Democrat Might See Things

September Jobs Report

How a Republican Might See Things

There have been 31 consecutive months of job growth.

The rate has fallen more than 2 points since its recent peak.

Monthly change in private-sector jobs in thousands

Friday's number +104,000

Unemployment rate

Friday's number 7.8%

Democrats have preferred to focus on recent private-sector job growth.

Friday's drop was larger than expected.

By MIKE BOSTOCK, SHAN CARTER, AMANDA COX and KEVIN QUEALY | Send Feedback

Source: Bureau of Labor Statistics

<http://www.nytimes.com/interactive/2012/10/05/business/economy/one-report-diverging-perspectives.html>

One Report, Diverging Perspectives

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How a Democrat Might See Things

September Jobs Report

How a Republican Might See Things

Job growth has been weak.

The rate was above 8 percent for 43 months.

Monthly change in jobs in thousands

Friday's number +114,000

Unemployment rate

Friday's number 7.8%

In September, Paul Ryan noted the economy would need to add 100,000 jobs a month just to keep pace with population growth.

8% unemployment

By MIKE BOSTOCK, SHAN CARTER, AMANDA COX and KEVIN QUEALY | Send Feedback

Source: Bureau of Labor Statistics

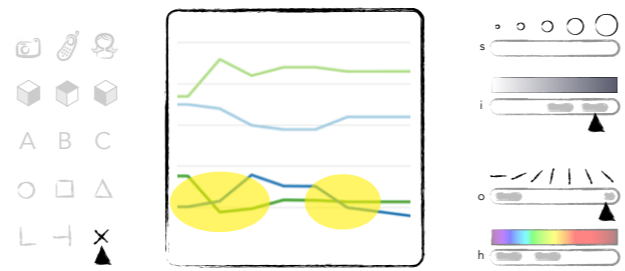
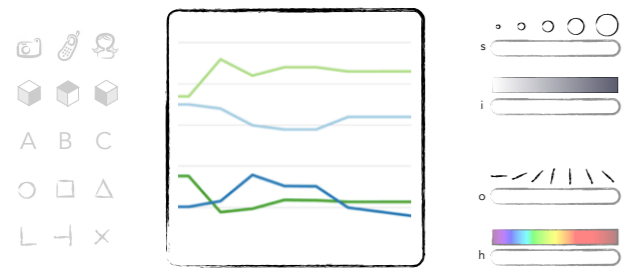
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Interactive tool interface with icons for shape recognition, different sizes, and a central image of raspberries.

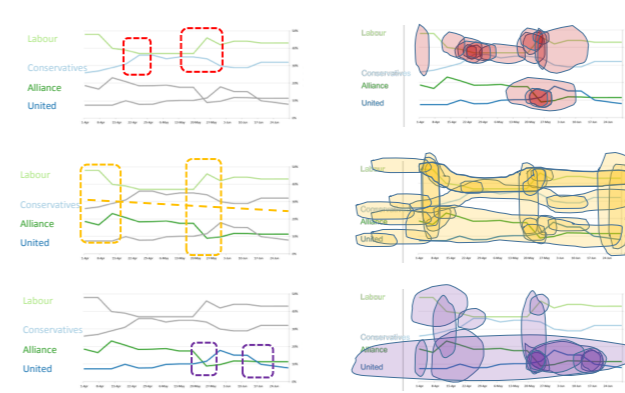
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Interactive tool interface with icons for shape recognition, different sizes, and a central image of raspberries.

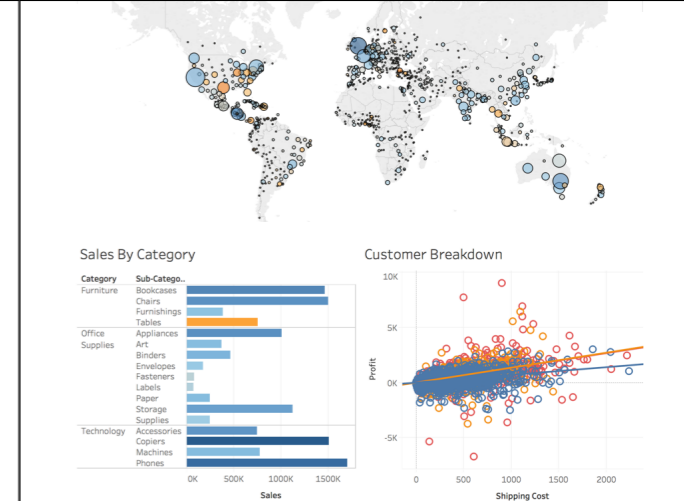
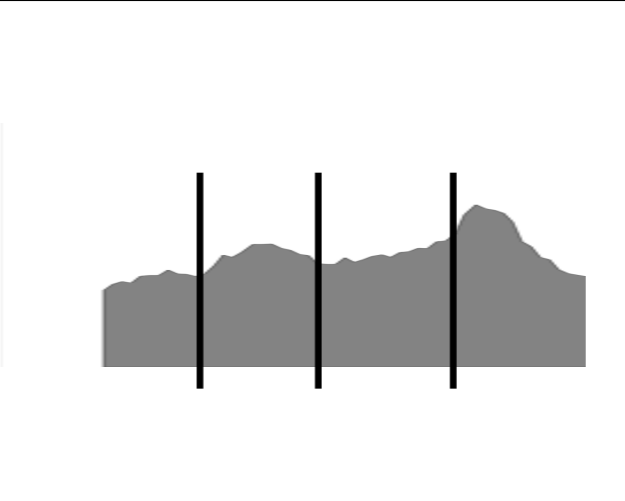
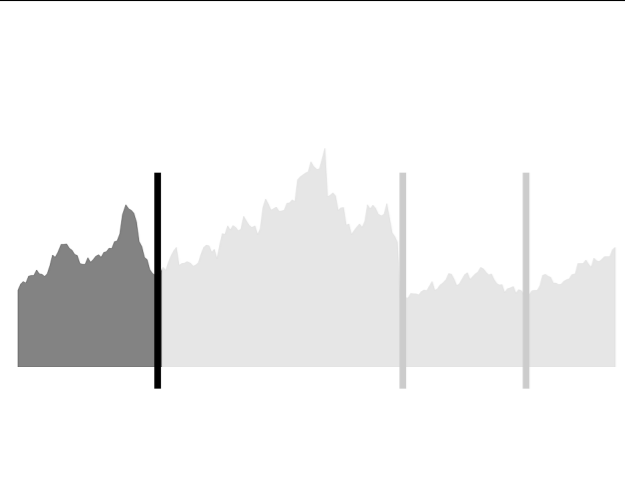
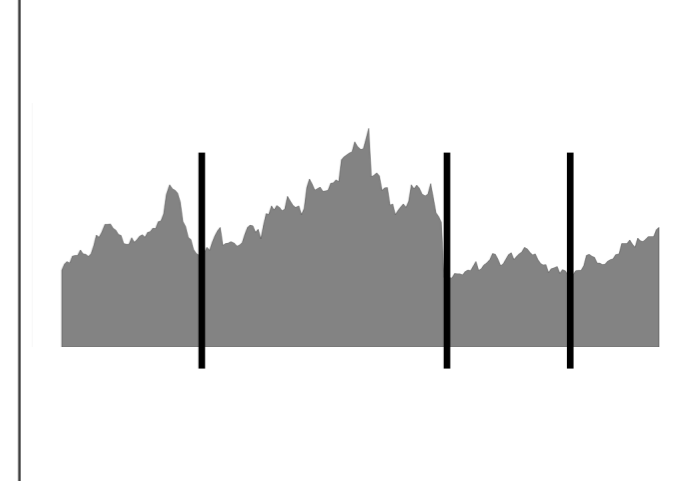
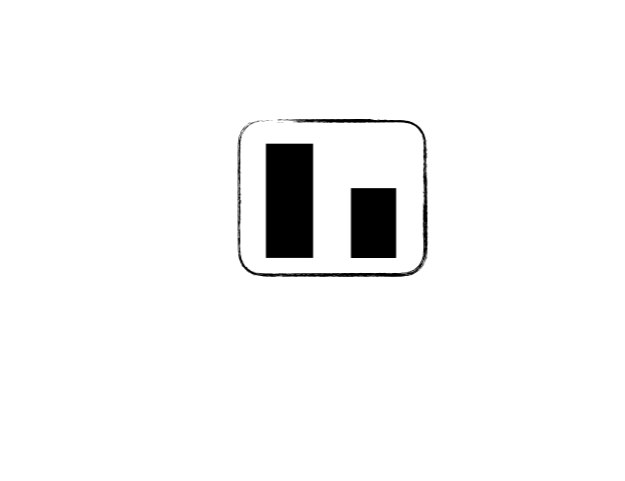
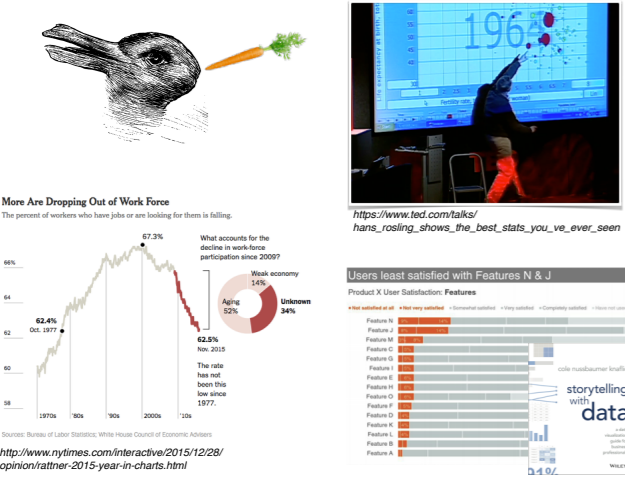
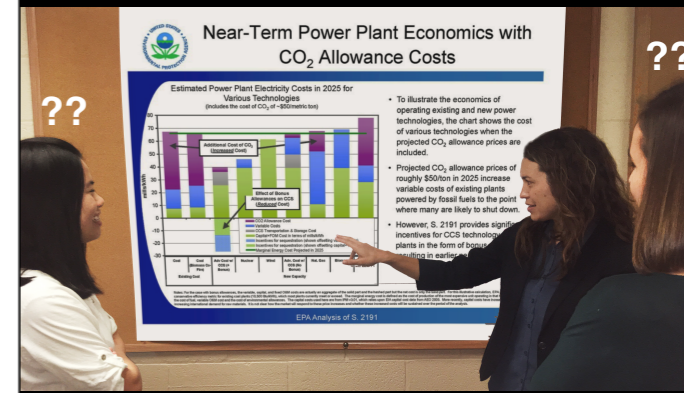
Interactive tool interface with icons for shape recognition, different sizes, and a central image of raspberries.



Knowledge + Expertise
changes what you see



Xiang, van Weelden, & Franconeri (DECSIVE 2017)



Many ways to see one visualization

Three tools

Shape **FAST**

Histograms **FAST**

Comparisons **SLOW**

Dangerous for novices
But critical for experts

Not just 'popout',
histogram info for features

Flexible, uniquely human
But slow & limited

BCS-1056730 CAREER
IIS-1162067
DRL-1661264
SBE-0541957

IES-R205A120531

The opinions expressed are those of the authors and do not represent views of the National Science Foundation or the U.S. Department of Education.

@SteveFranconeri

Steve Franconeri
Data Visualizations are Ambiguous Figures. Summary of my panel talk for #evisvis. InfoVis panel on Perception visxvision.com/via-2017/ (1/8)

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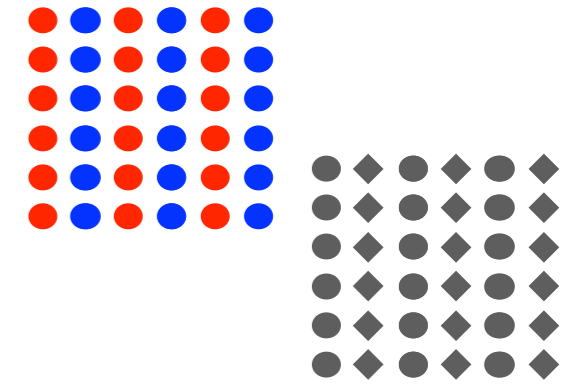
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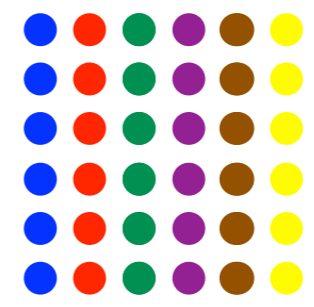
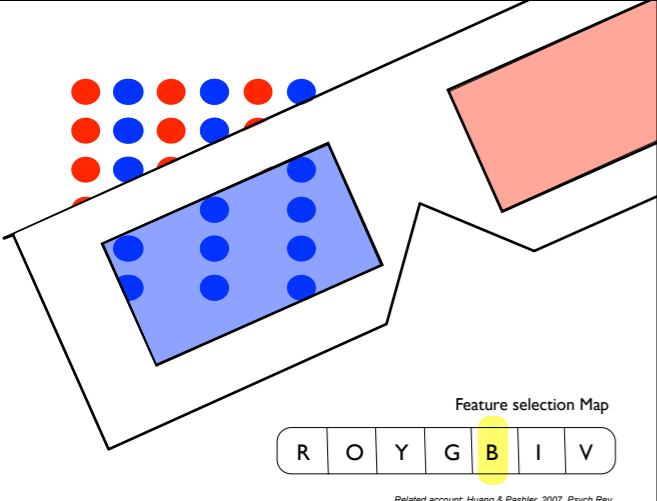
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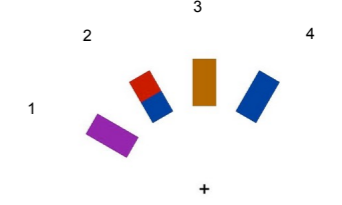
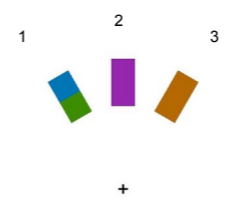
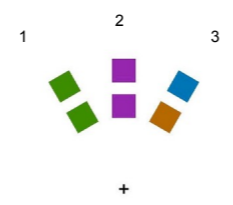
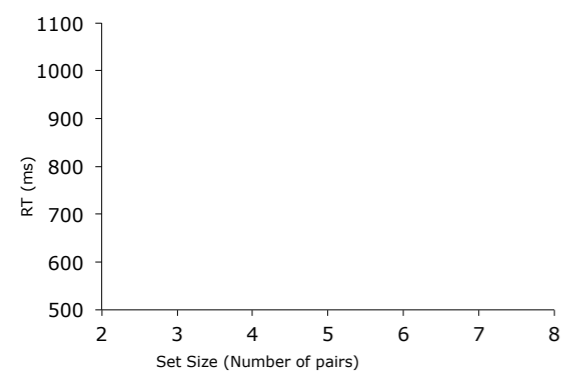
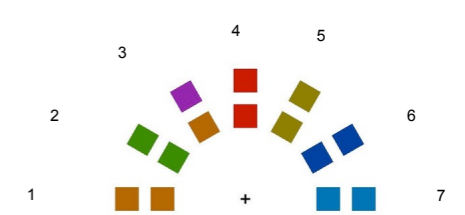
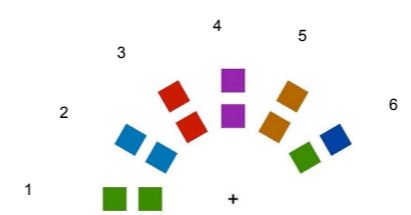
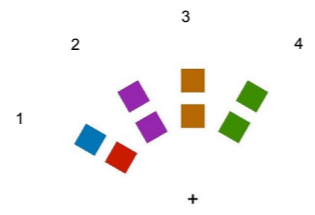
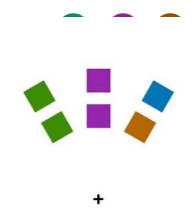


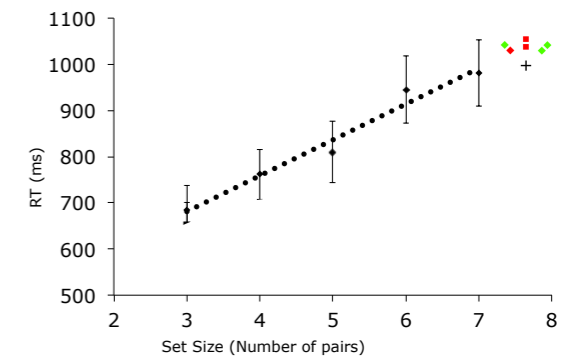
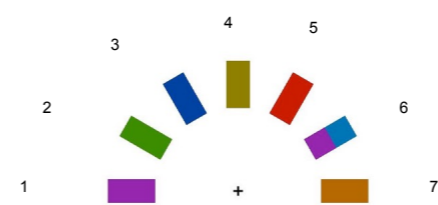
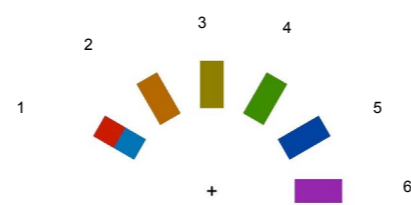
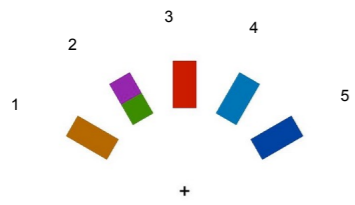
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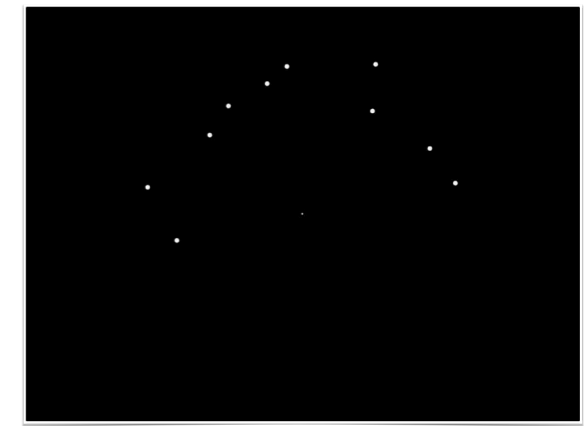
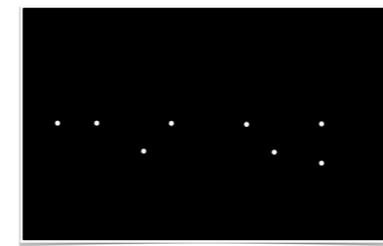
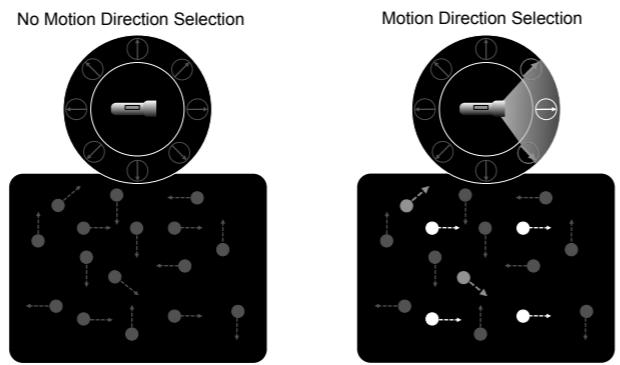
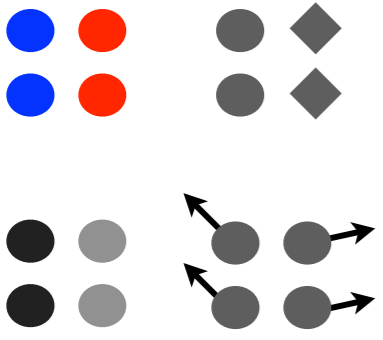


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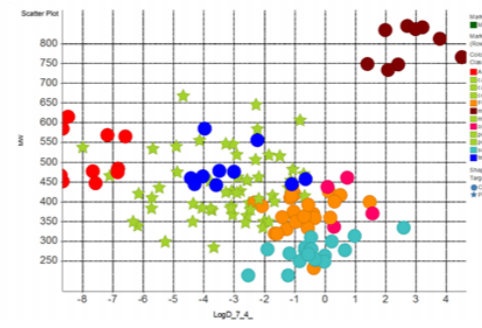
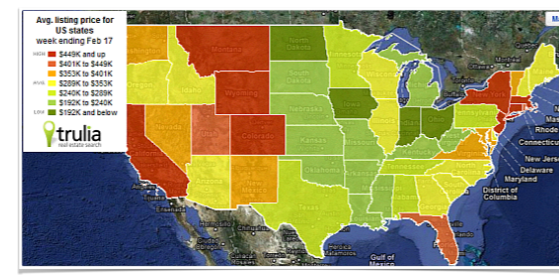
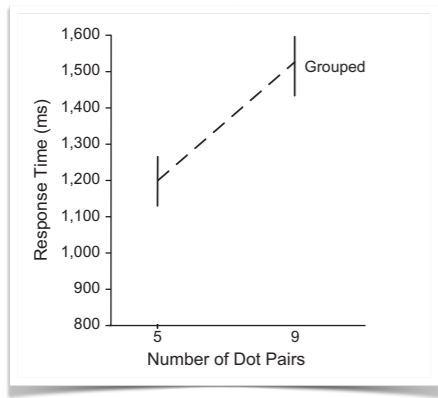




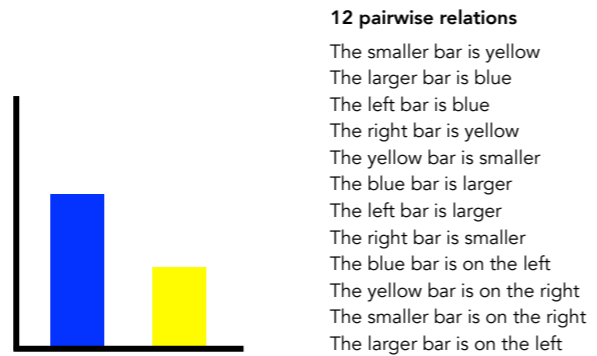
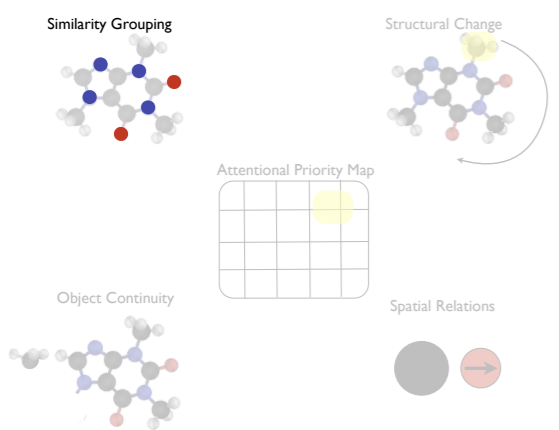
Yu, Tam, Levinthal, & Franconeri (submitted)



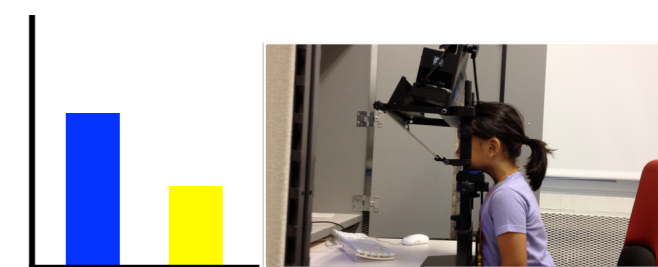
Levinthal & Franconeri (2010), Psychological Science



Collins, Penn, & Carpendale, 2009

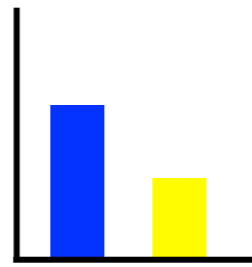


Reading a graph can be like reading a paragraph
Carpenter & Shah, 1998

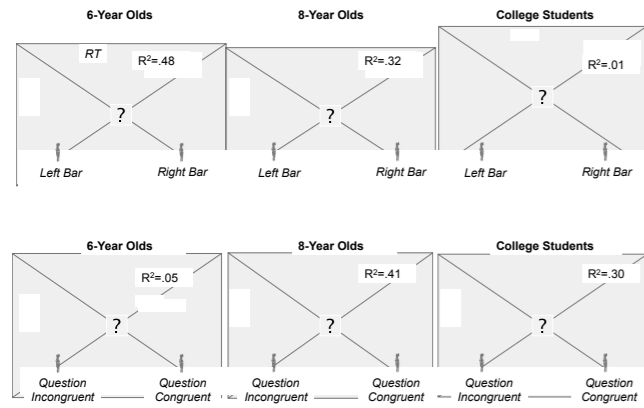
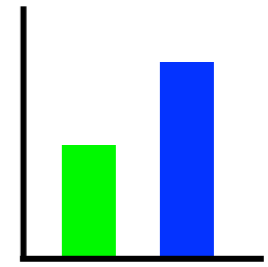


Perceptual Routines

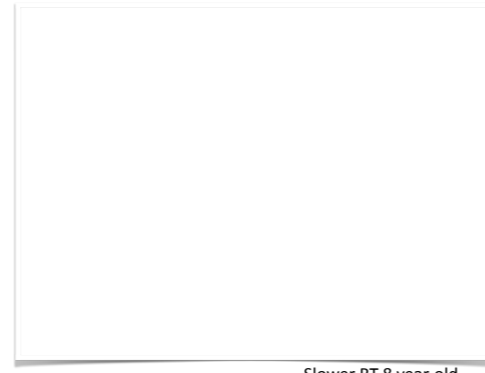
Are there fewer pears than blueberries?



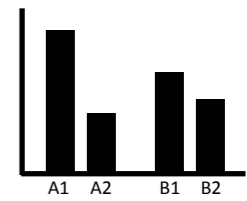
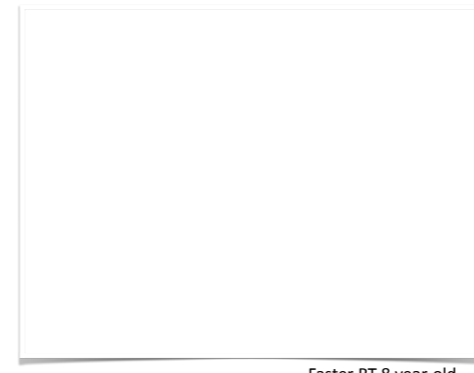
Are there more limes than blueberries?



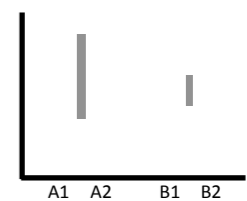
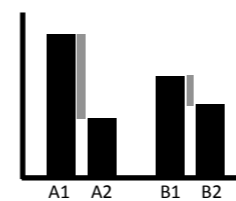
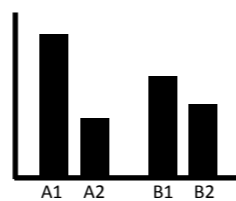
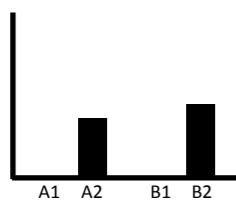
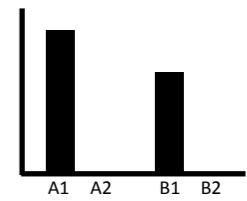
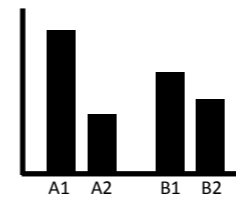
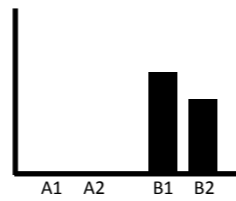
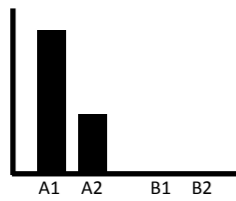
Are there more blueberries than oranges?

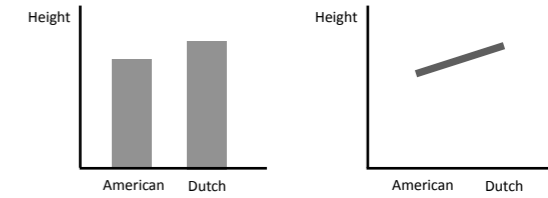
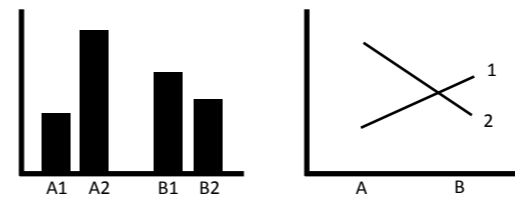
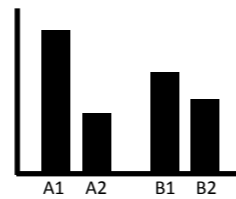
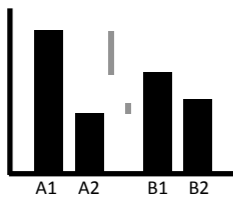
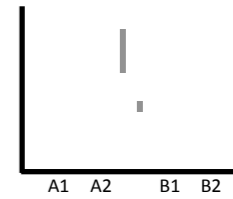
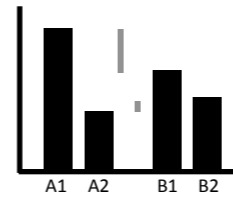
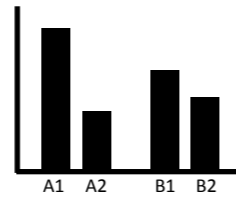
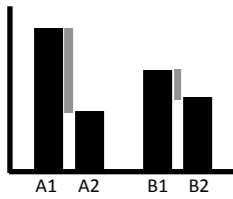


Are there more oranges than blueberries?



Michal, Uttal, Shah, & Francoeri (2016). PB&R.





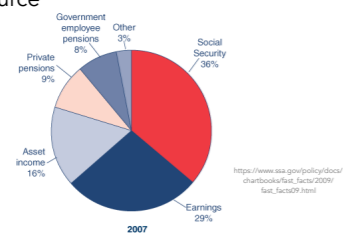
“On average, Dutch people are taller than Americans”

“On average, people become taller as they become more Dutch”

Zachs & Tversky, 1999

185

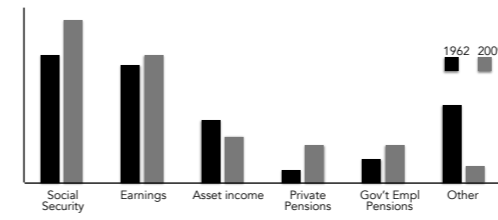
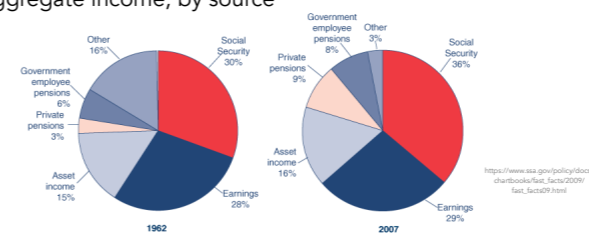
Aggregate income, by source



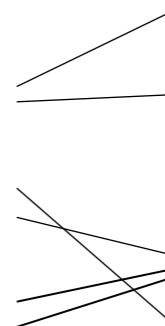
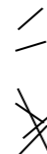
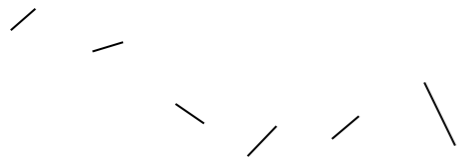
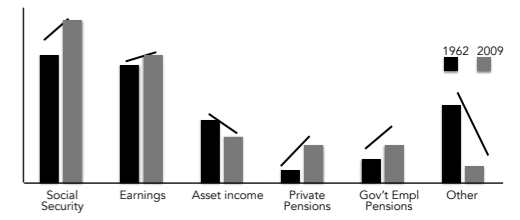
Move past the limits of spreadsheets and canned BI reports. #GartnerBI #dataviz
2.sas.com/6011BeY3c



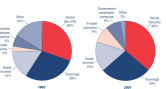
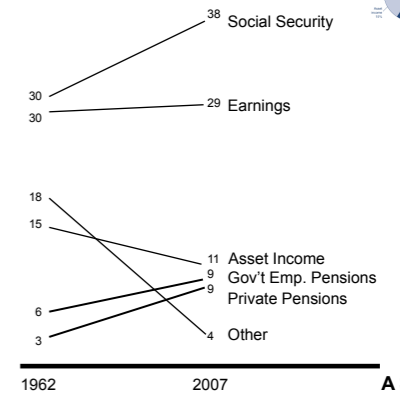
Aggregate income, by source



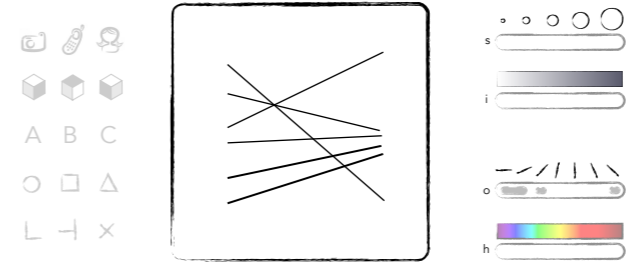
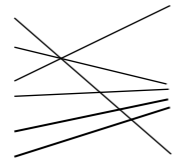
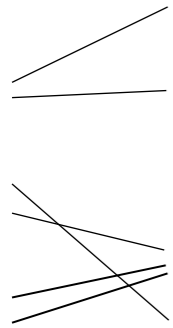
Jon Schwabish



Aggregate income share

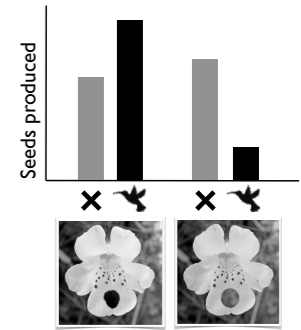


A SlopeGraph



Nonadditive effects of flower damage and hummingbird pollination on the fecundity of *Mimulus luteus*

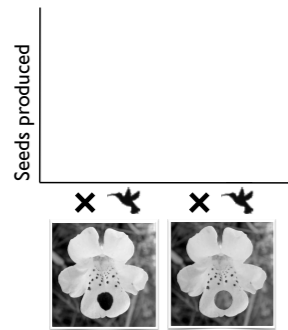
Néida Pohl - Gastón Carvallo - Carezza Botto-Mahan - Rodrigo Medel



Nonadditive effects of flower damage and hummingbird pollination on the fecundity of *Mimulus luteus*

Néida Pohl - Gastón Carvallo - Carezza Botto-Mahan - Rodrigo Medel

• Main effect of damage



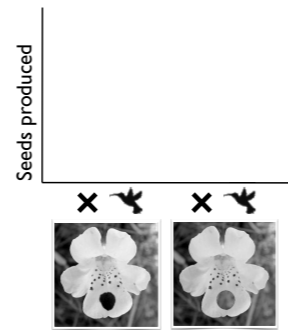
Nonadditive effects of flower damage and hummingbird pollination on the fecundity of *Mimulus luteus*

Néida Pohl - Gastón Carvallo - Carezza Botto-Mahan - Rodrigo Medel

• Main effect of damage

• But not whole story - seed impact not from damage per se.

- Hummingbirds show a big impact
- No hummingbirds = no impact



Nonadditive effects of flower damage and hummingbird pollination on the fecundity of *Mimulus luteus*

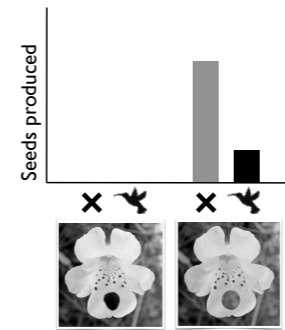
Néida Pohl - Gastón Carvallo - Carezza Botto-Mahan - Rodrigo Medel

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Nonadditive effects of flower damage and hummingbird pollination on the fecundity of *Mimulus luteus*

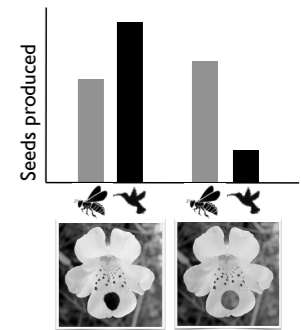
Néida Pohl - Gastón Carvallo - Carezza Botto-Mahan - Rodrigo Medel

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