

# Elements of effective graphs

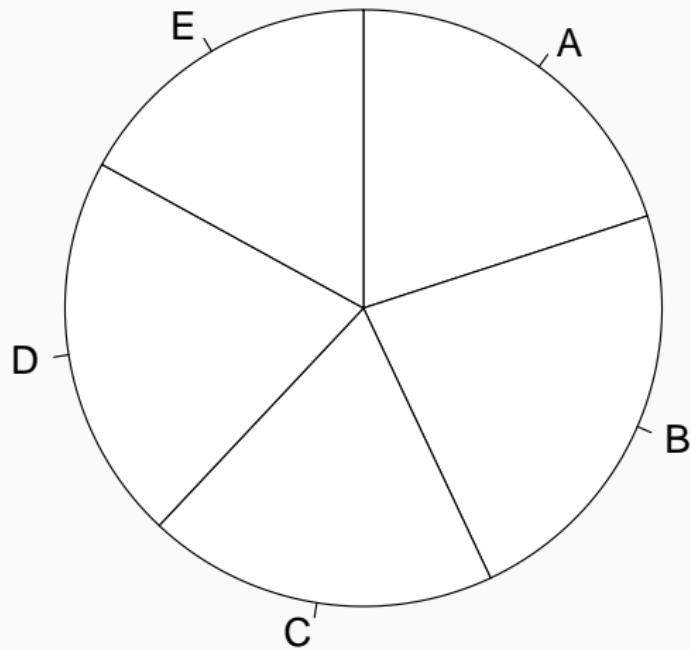
2019 MIDFIELD Institute

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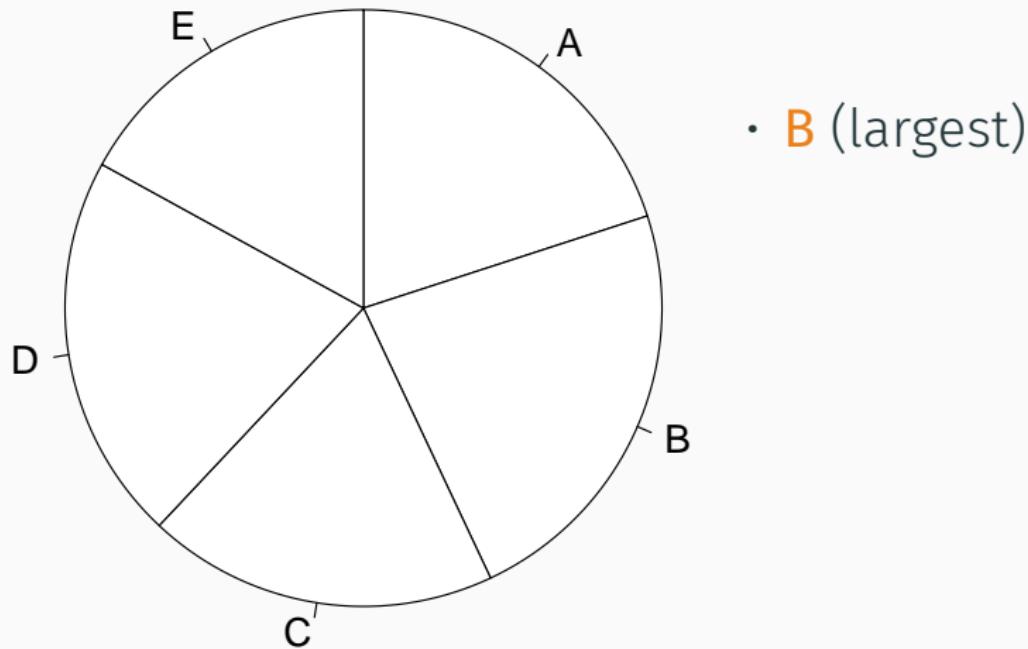
Richard Layton

June 2019

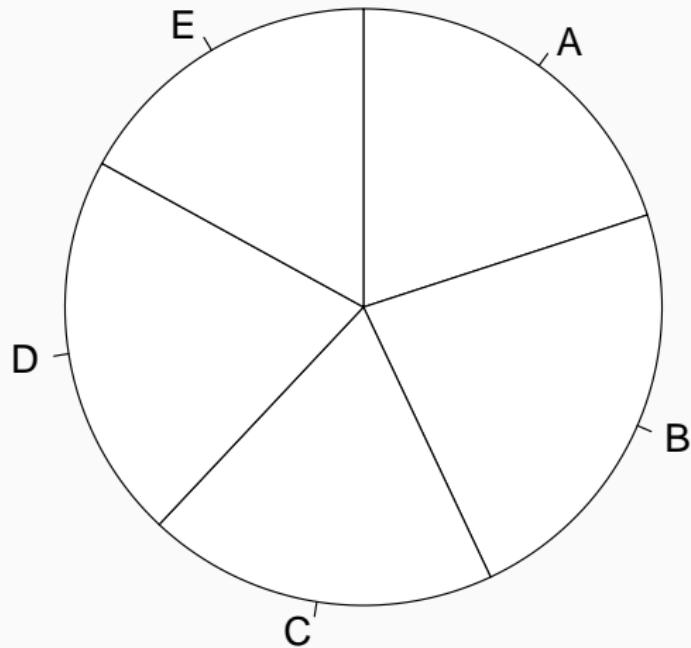
In your handout, list the slices A thru E from largest to smallest



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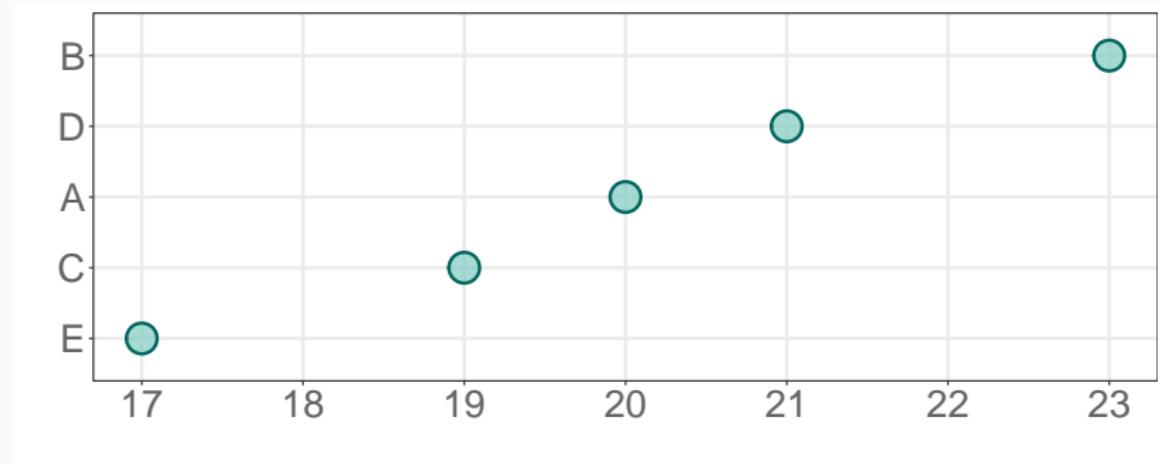
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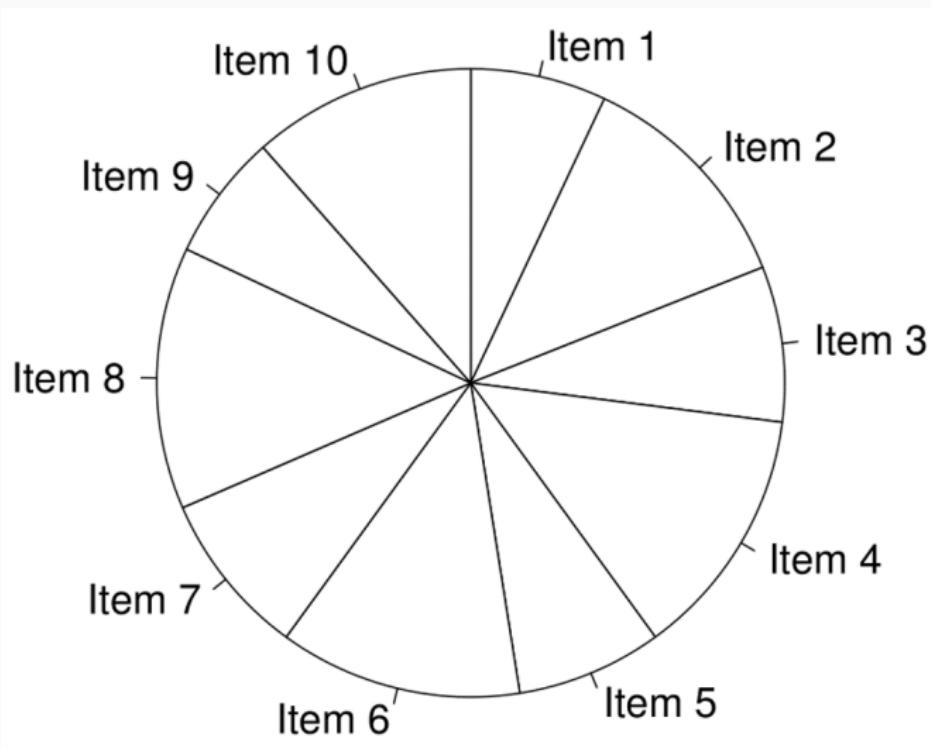
- B (largest)
- D
- A
- C
- E (smallest)

The same data arranged along a common axis

Comparing values along a common axis is a high-accuracy visual task.

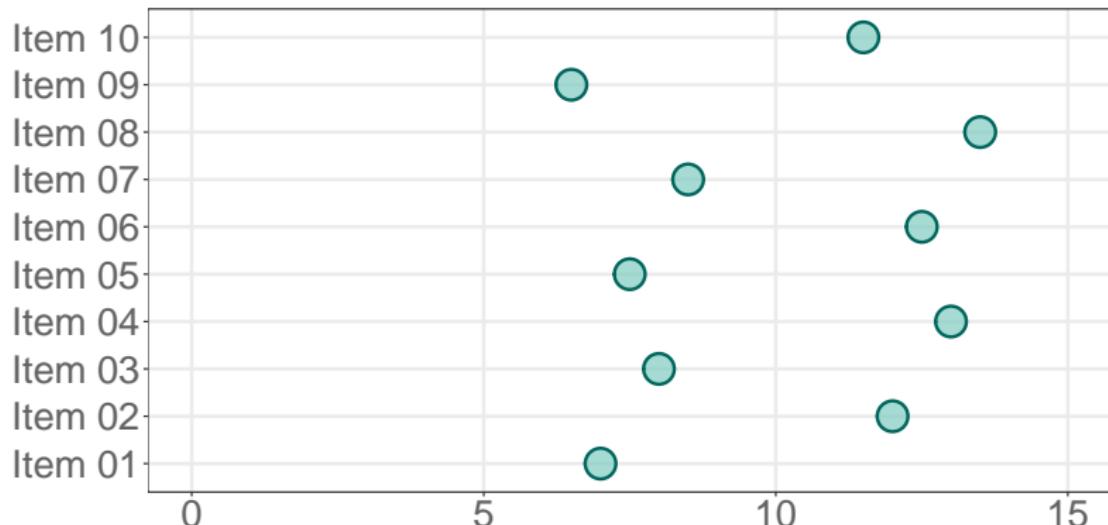


Structured data. What patterns do you see in these data?

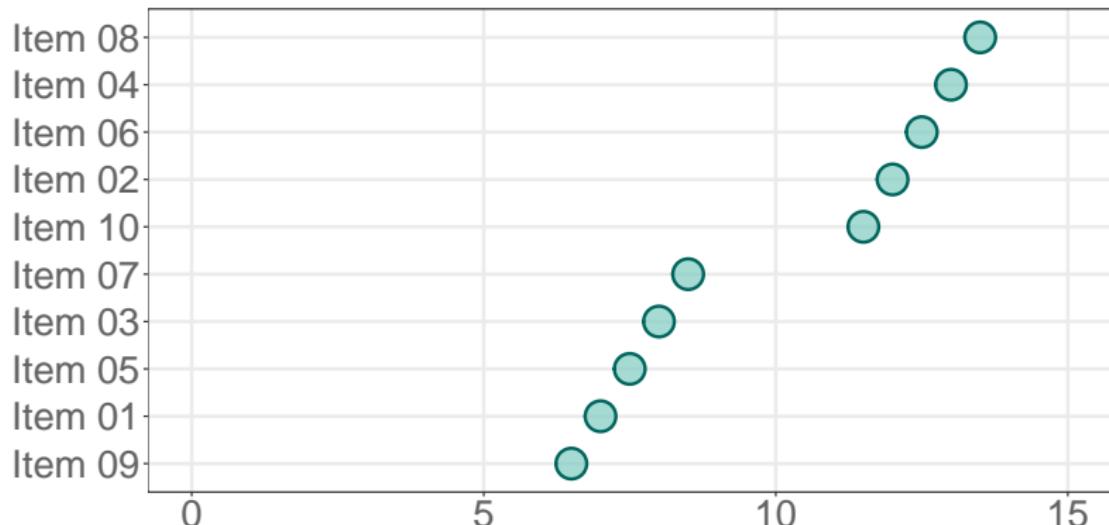


Adapted from (Robbins, 2013, Ch 2)

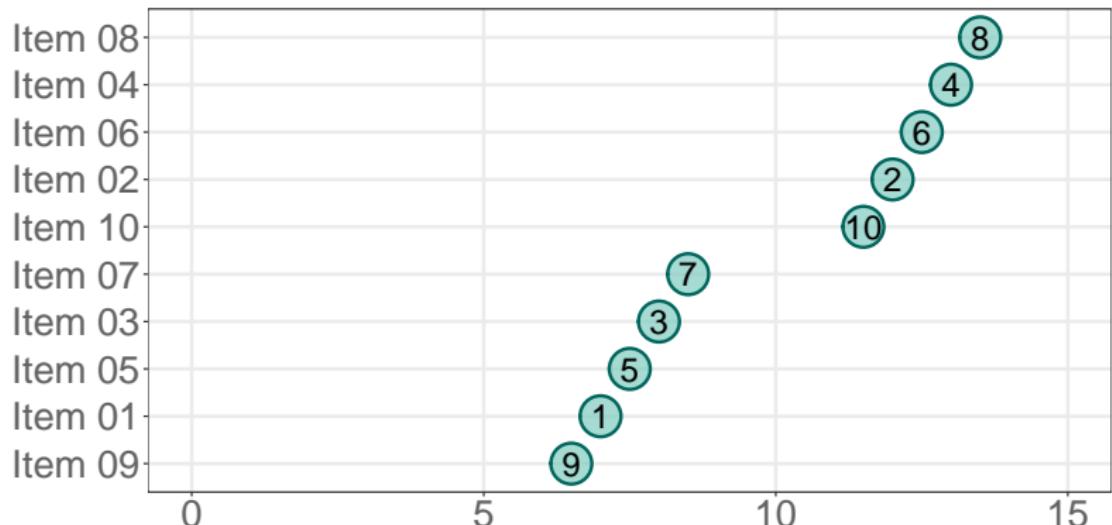
Structured data on a common scale. Any new observations?



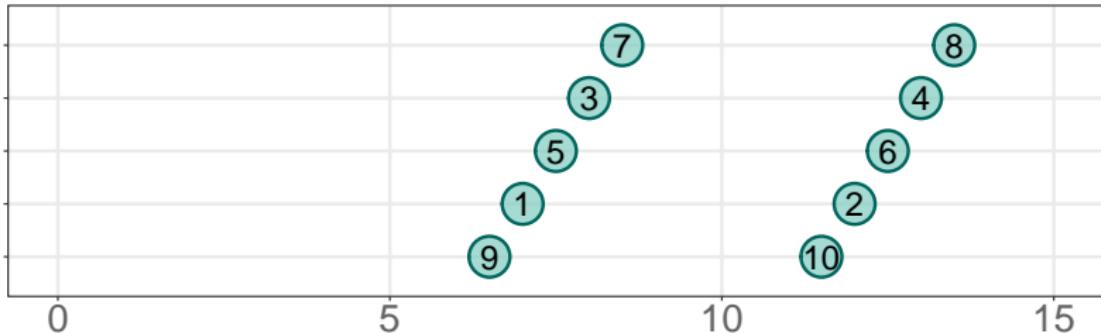
Reorder the rows by the data values. New observations?



Suppose we move the item number to the data marker.



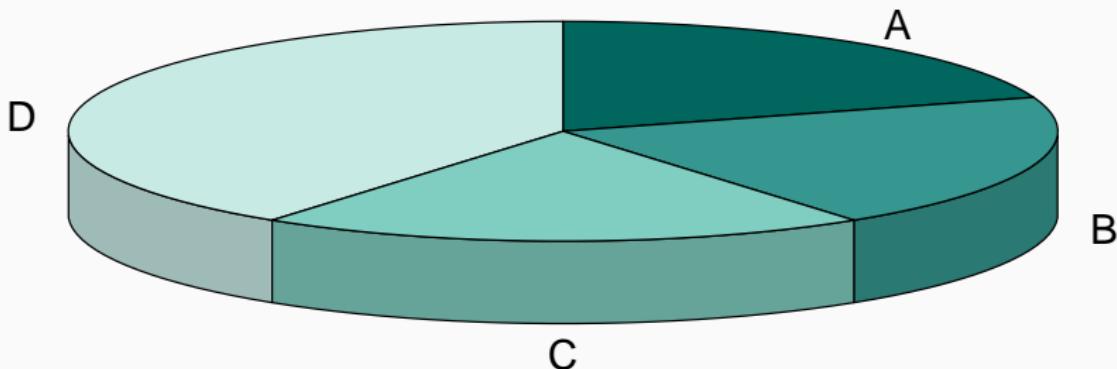
# Even-odd pairs emerge



The greatest value of data visualization is when  
it forces us to notice what we never expected to see.

— John Tukey (1915–2000)

Slices are what percentage of the whole?



Fill in the blanks

A. \_\_\_\_\_

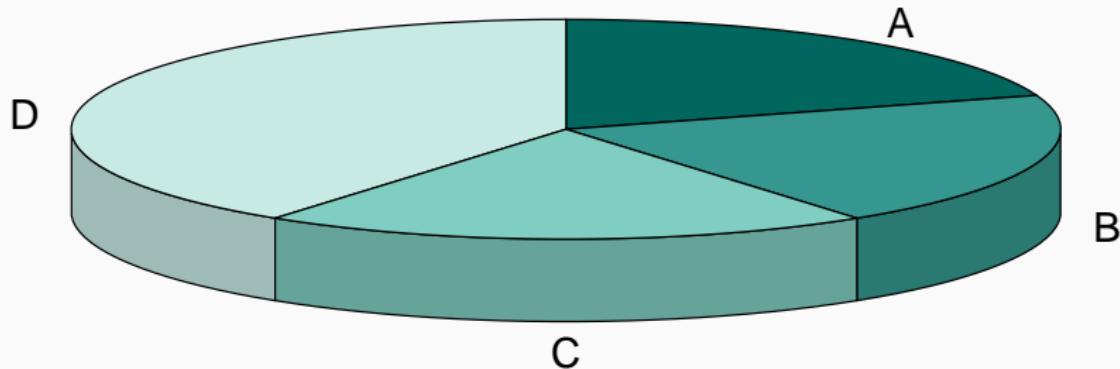
The total should be 100%

B. \_\_\_\_\_

C. \_\_\_\_\_

D. \_\_\_\_\_

## 3D-effects distort our judgment



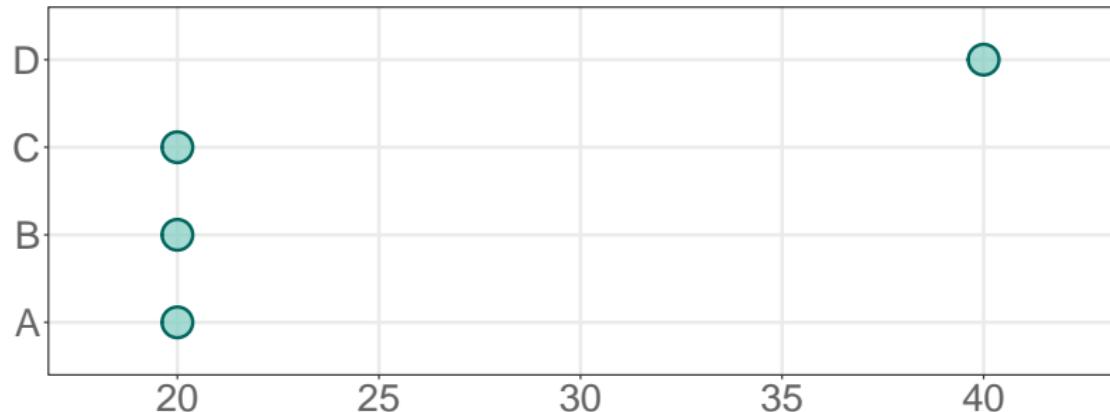
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The total should be 100%

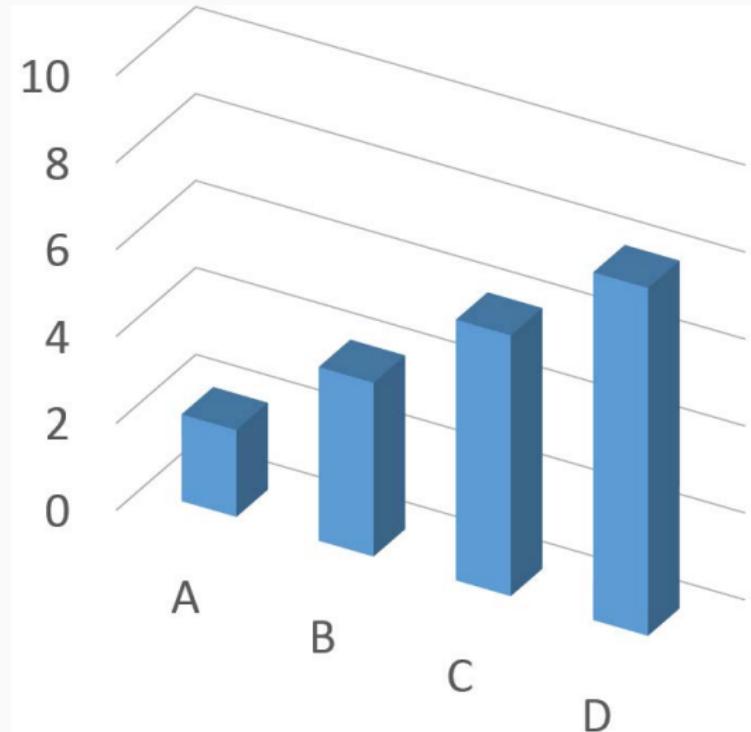
- A. 20%
- B. 20%
- C. 20%
- D. 40%

Again, the same data arranged along a common axis

A high-accuracy visual task.



Write down the heights of the bars



This is a visual inspection only.

Fill in the blanks

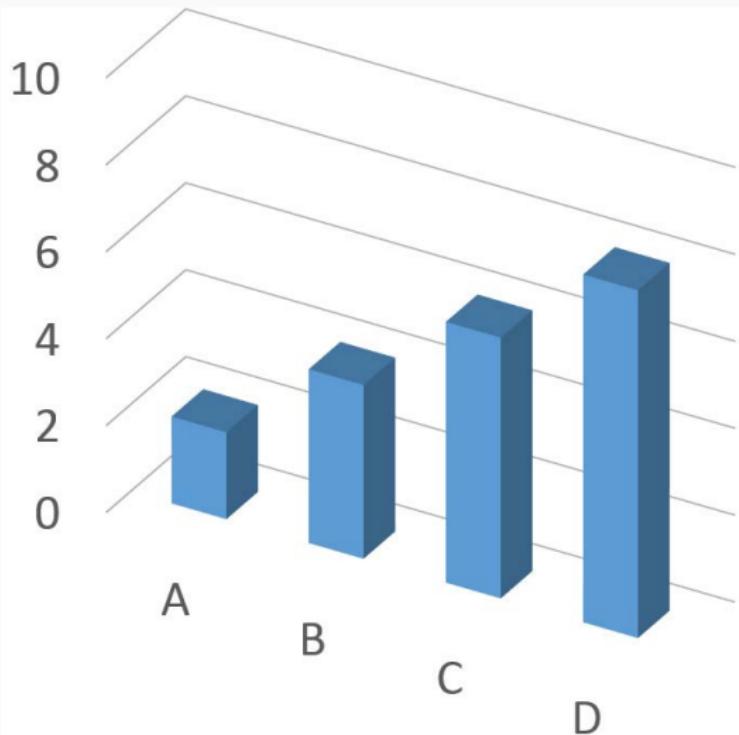
A. \_\_\_\_\_

B. \_\_\_\_\_

C. \_\_\_\_\_

D. \_\_\_\_\_

# Again, 3D-effects distort our judgment

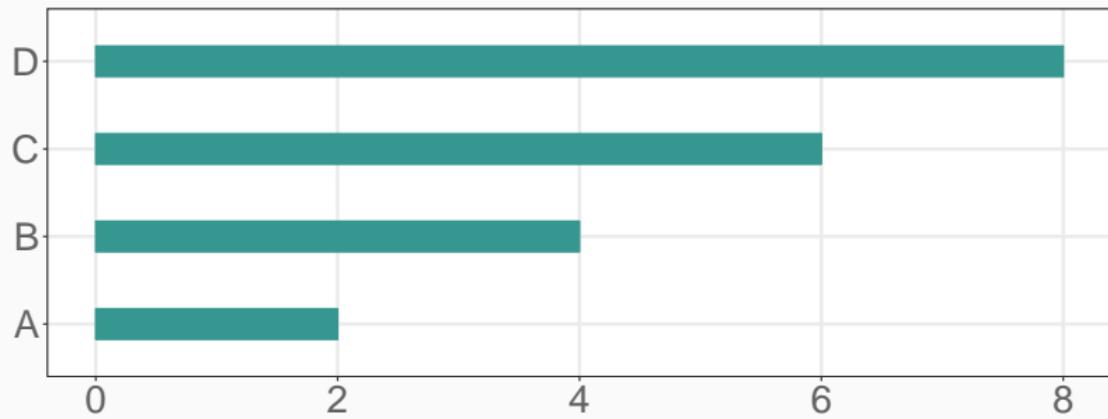


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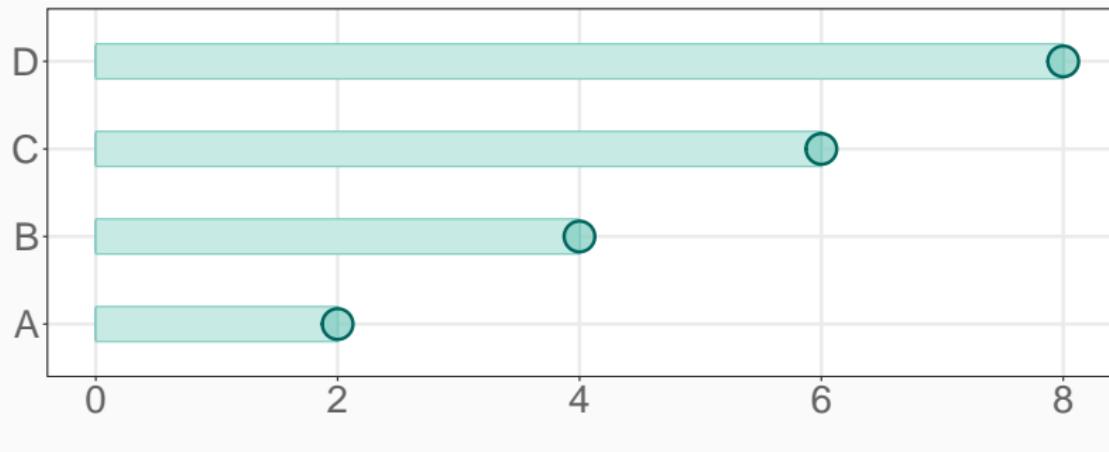
Fill in the blanks

- A. 2
- B. 4
- C. 6
- D. 8

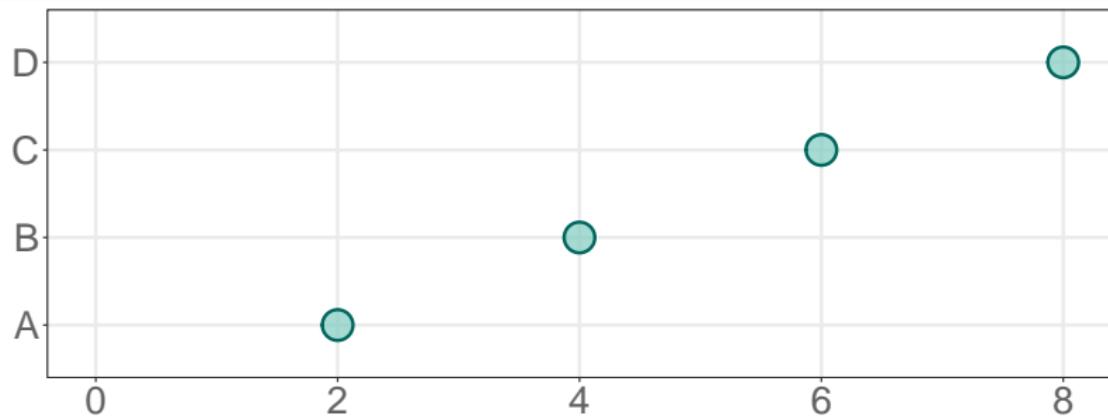
You can use bars, but must include zero



If you mark the endpoints, you can omit the bar



## Producing a “dot plot” with rows ordered per the data



## 1st attempt: Visually estimate the state areas

Visual estimation of area is a low-accuracy task.



South Carolina (SC)  $\approx$  83,000 sq km.

FL \_\_\_\_\_  $\times$  1000 sq. km

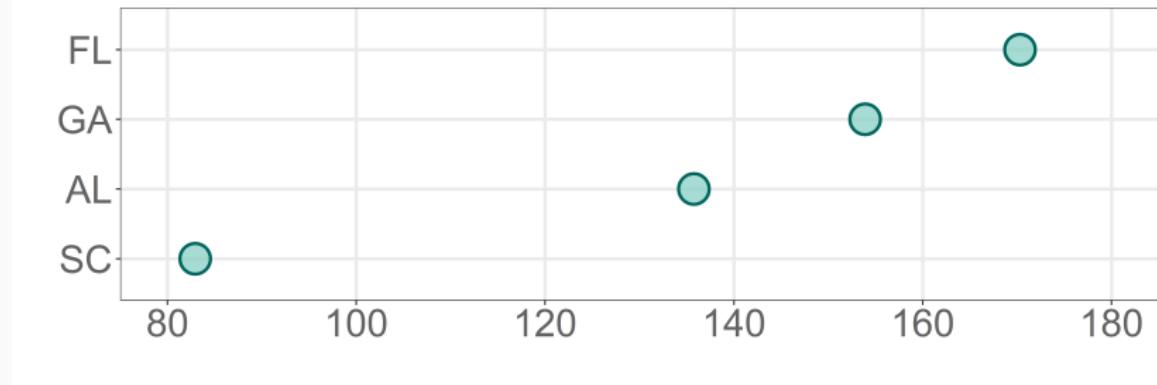
GA \_\_\_\_\_  $\times$  1000 sq. km

AL \_\_\_\_\_  $\times$  1000 sq. km

SC 83  $\times$  1000 sq. km

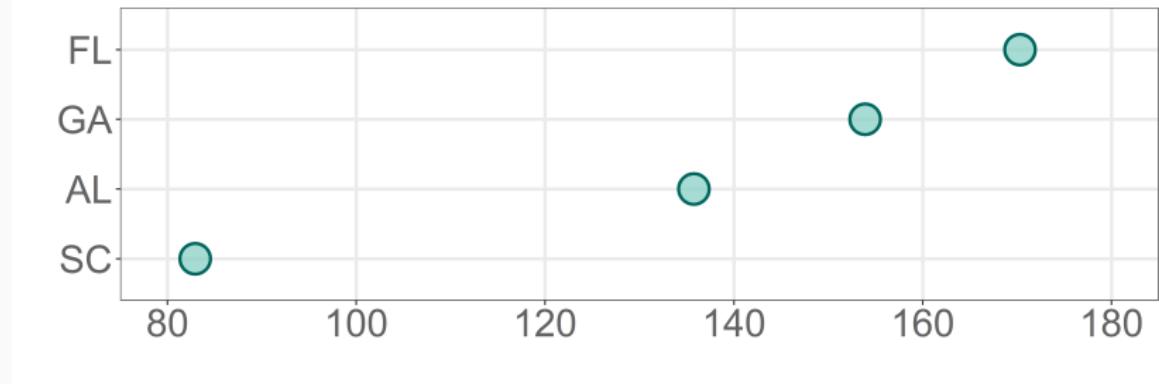
Adapted from (Ihaka, 2007)

## 2nd attempt: Visually estimate the state areas



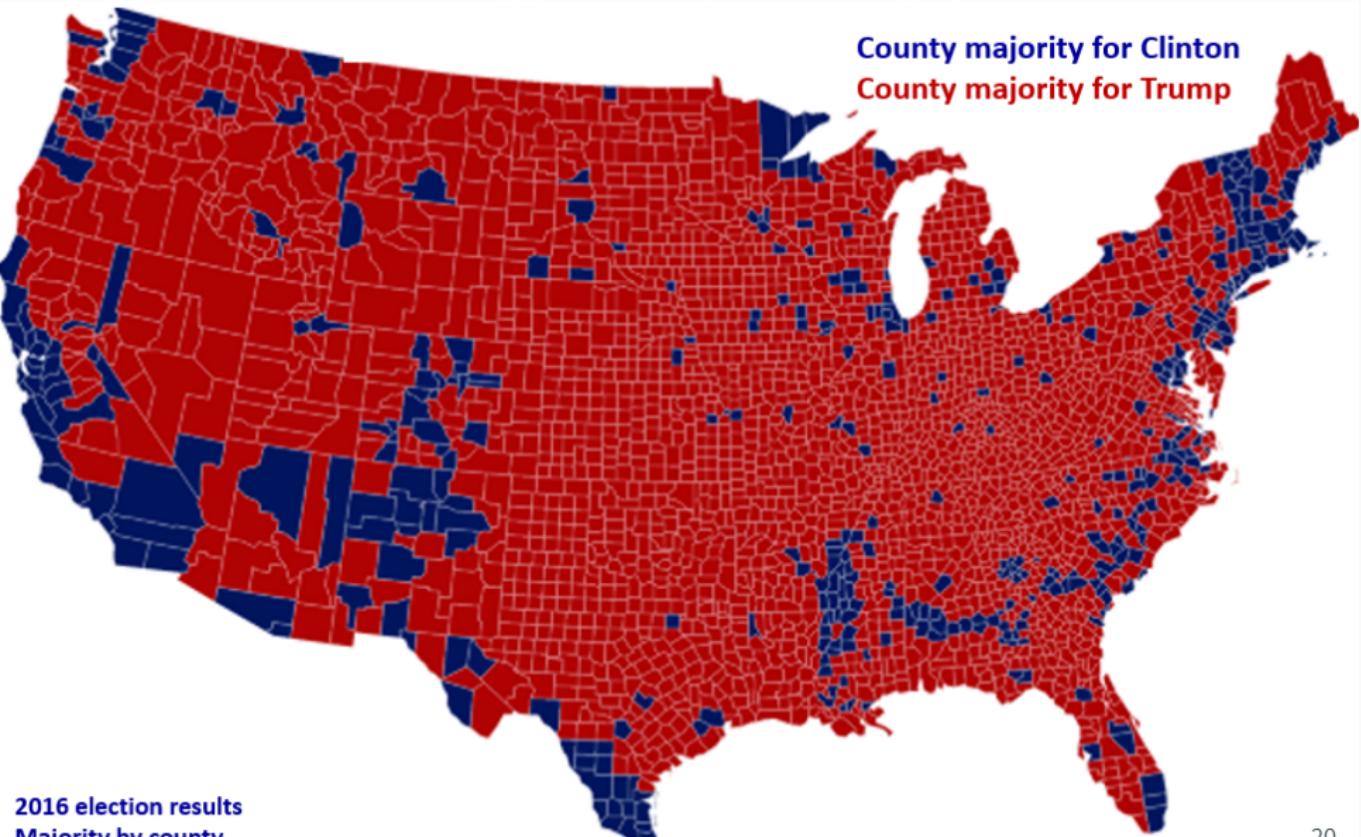
FL	_____	x 1000 sq. km
GA	_____	x 1000 sq. km
AL	_____	x 1000 sq. km
SC	83	x 1000 sq. km

Your estimates have probably improved

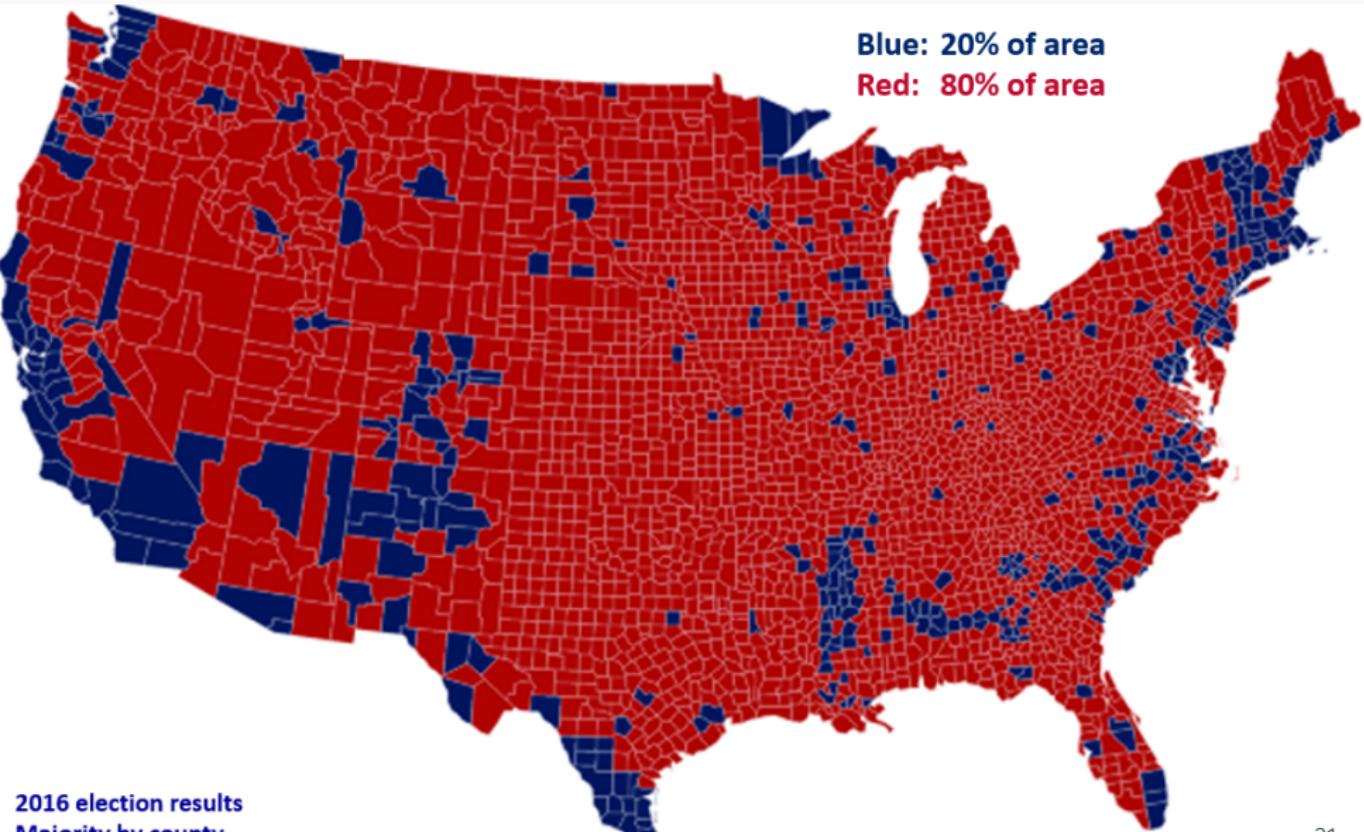


- FL    **170** x 1000 sq. km
- GA    **154** x 1000 sq. km
- AL    **136** x 1000 sq. km
- SC    **83** x 1000 sq. km

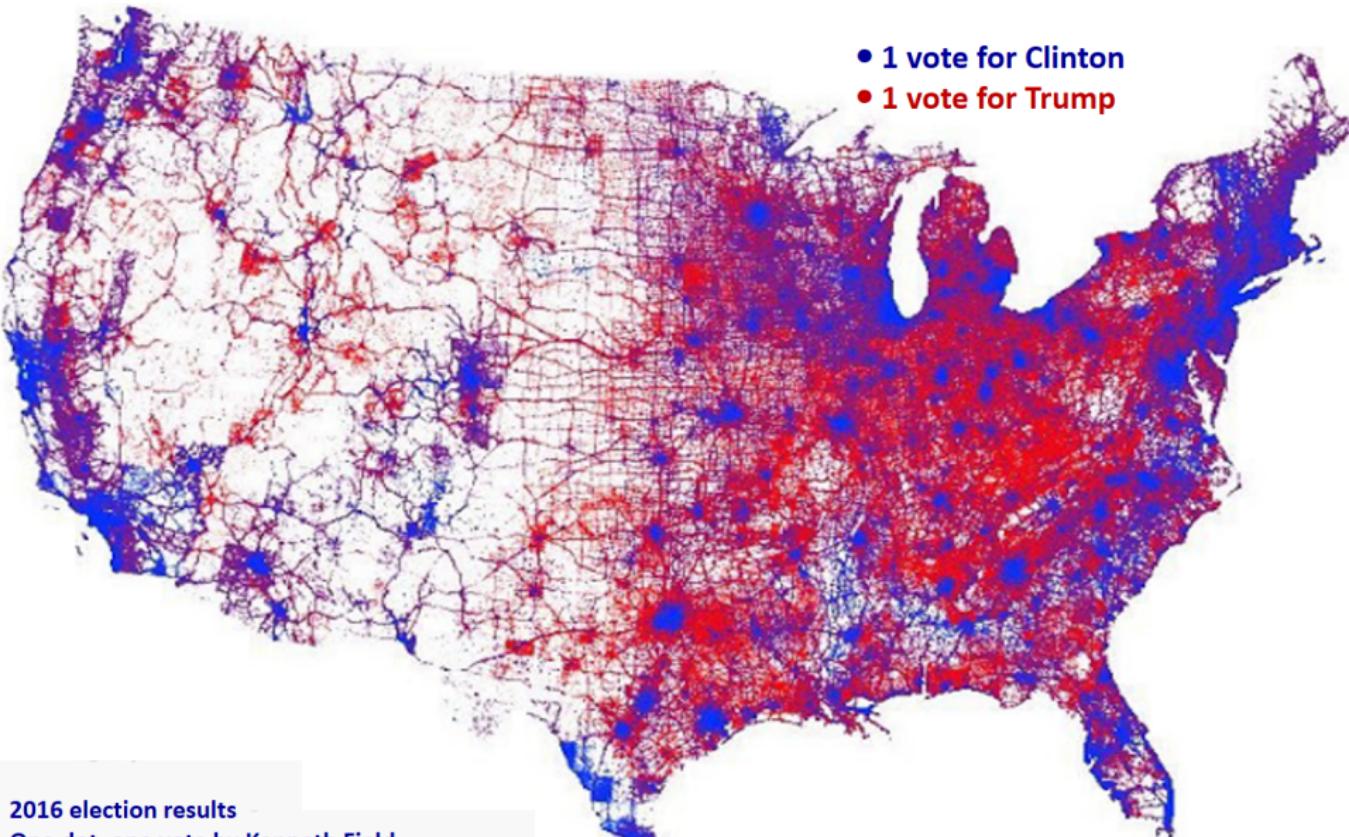
Color represents surface area. What is the visual story?



The visual ratio of surface areas  $\approx 1 : 4$



The visual ratio of votes cast  $\approx 1.05 : 1$  (65.9 M to 63.0 M)

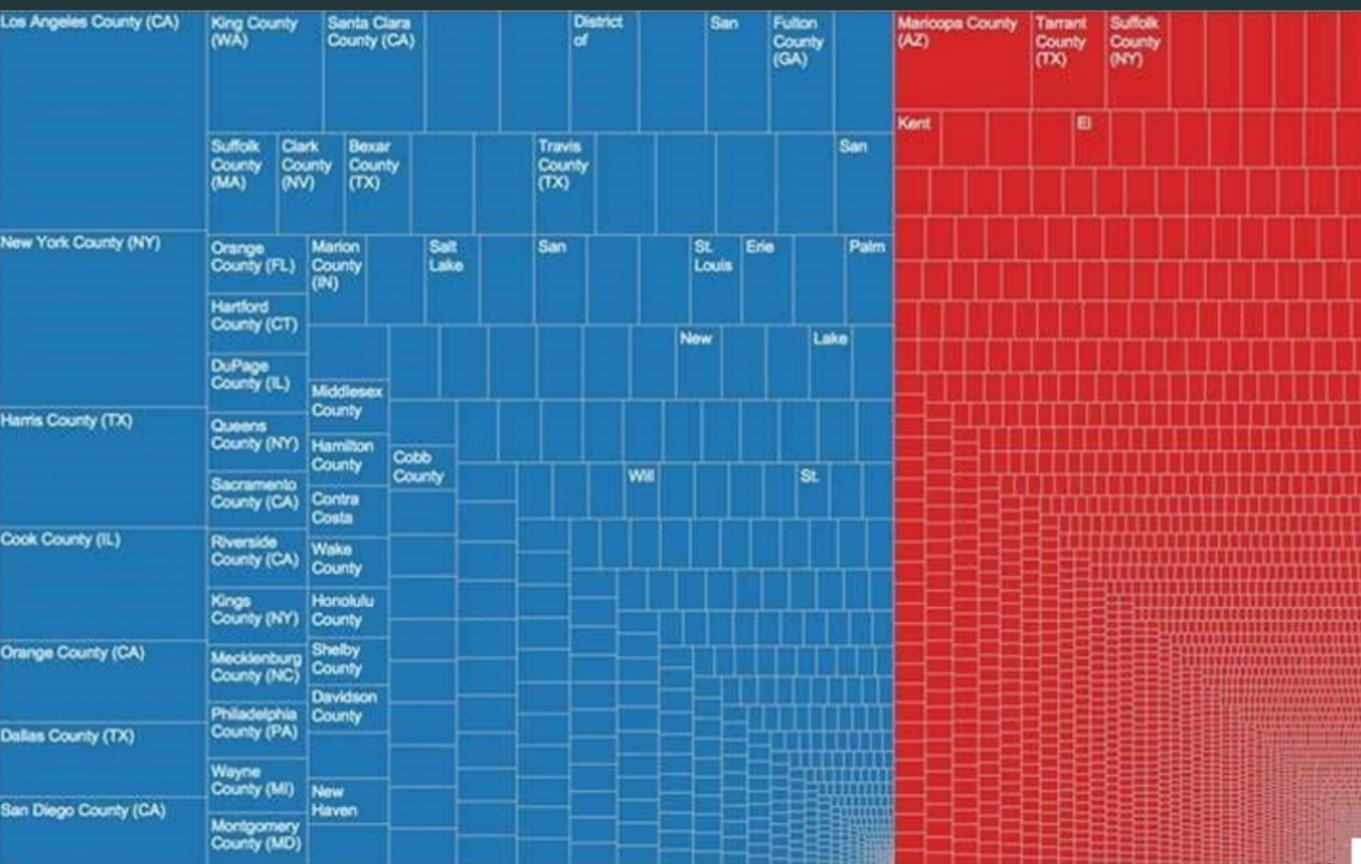


2016 election results

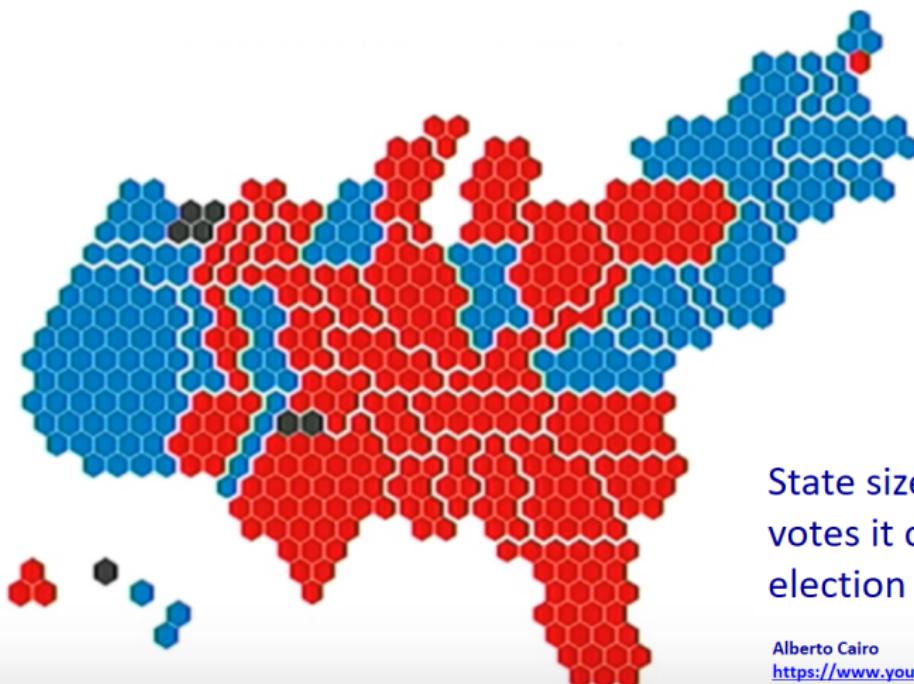
One dot, one vote by Kenneth Field

<http://cartonerd.blogspot.com/2018/03/dotty-election-map.html>

# Area is county GDP. Color by party. What is the visual story?



# The metric that matters. What is the visual story?

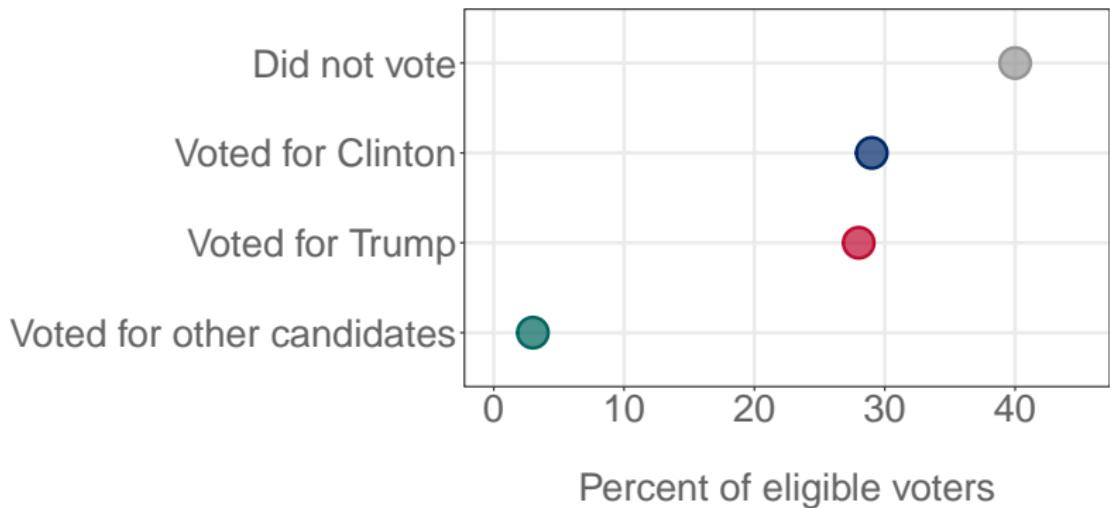


State size adjusted by electoral  
votes it contributes to the  
election

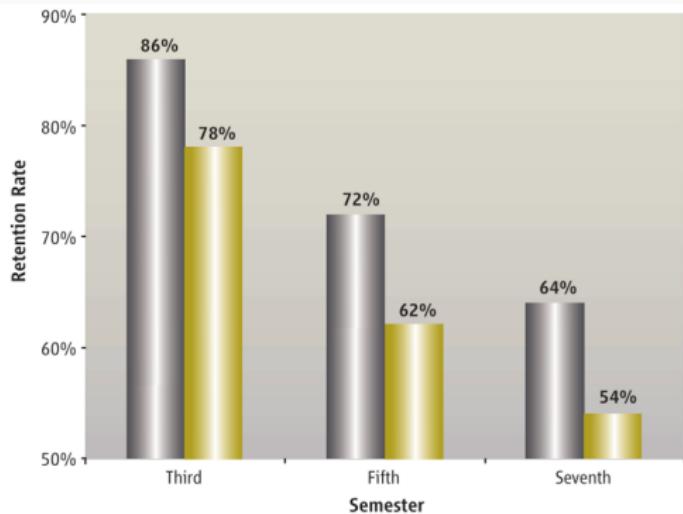
Alberto Cairo

[https://www.youtube.com/watch?v=Cd046xZhO\\_8](https://www.youtube.com/watch?v=Cd046xZhO_8)

The previous graphs conceal what story ?



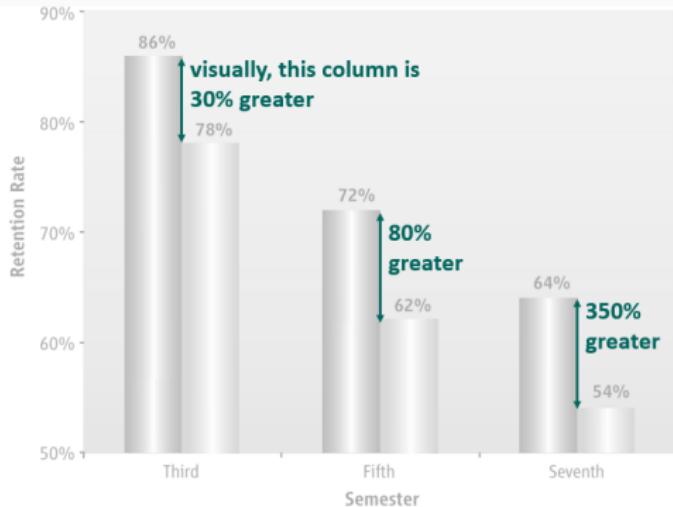
# The trouble with bars. What's wrong with this graph?



**Gains in retention.** The FYEP course improved retention of engineering students into the third, fifth, and seventh semester. There were 2128 students who took the FYEP course (gray) and 2942 students who did not (gold). All retention gains over expected retention rates shown are significant ( $P < 0.05$ ).

Norman L. Fortenberry, Jacquelyn F. Sullivan, Peter N. Jordan, and Daniel W. Knight (2007), Engineering education research aids instruction, *Science*, 31:1175–1176.

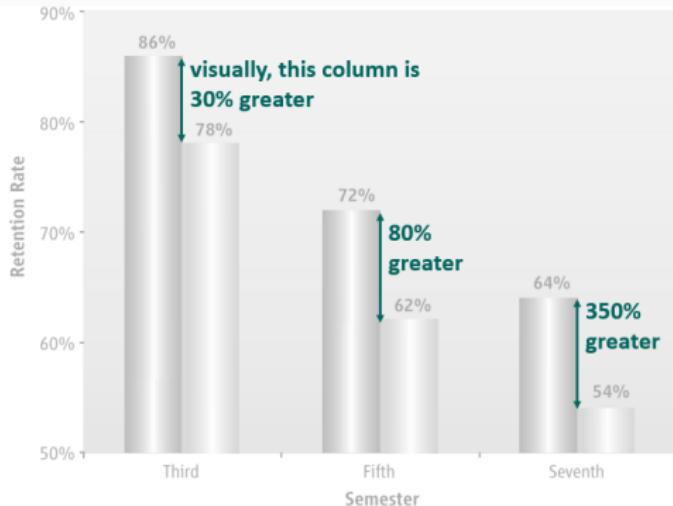
# A nearly constant difference seems to increase in significance



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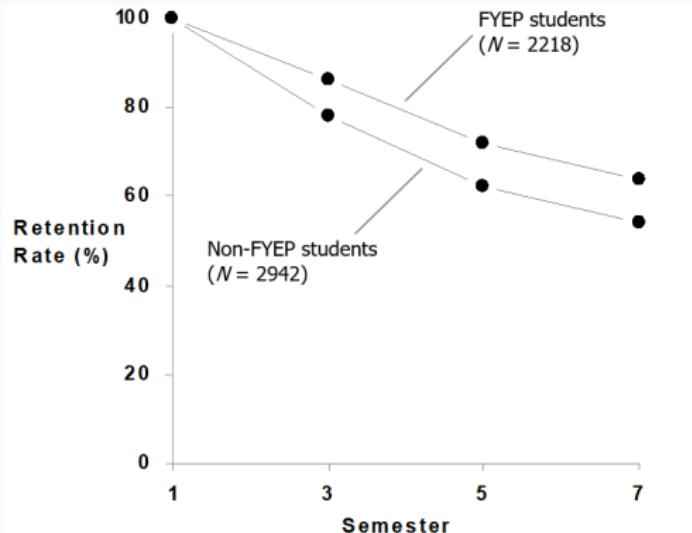


- Can you identify the missing information?

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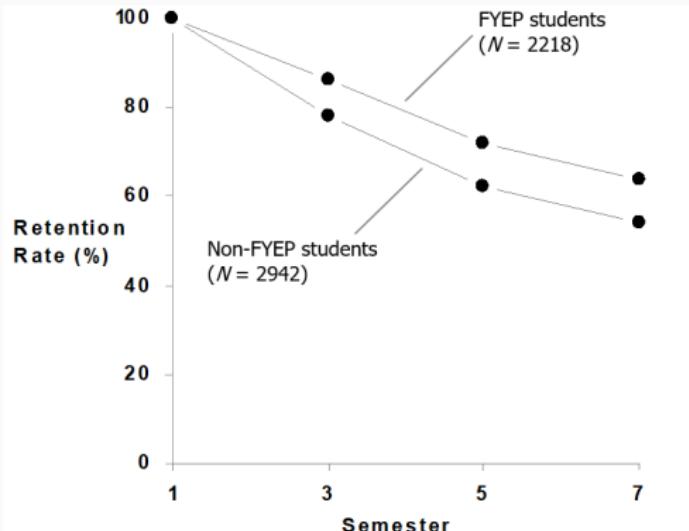
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## Redesigned, with full scales, a different story emerges



**First-year gains in retention.** The primary impact of the first-year engineering projects (FYEP) course is in the higher retention rate in the third semester. Subsequently, both groups lose students at about the same rate with a persistent 10% difference between FYEP and non-FYEP students.

# Redesigned, with full scales, a different story emerges



- FYEP impact is in the first year.
- Attrition rate afterwards is about the same for both groups.

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## The experts tell us



“Graphicacy” is as important as numeracy to the modern educated citizen

Be aware that we all like charts that pander to our expectations or biases

(Cairo, 2018)

Image from <https://tinyurl.com/y5g7jbzt>

## The experts tell us



(Doumont, 2009)

Image from <http://www.principiae.be/pdfs/Principiae-2014.pdf>

Optimal design primarily depends on

- The message to be conveyed
- The variables to be shown

## The experts tell us



The task of the designer is to give visual access to the subtle and the difficult — that is, reveal the complex.

(Tufte, 1983)

Image from [https://en.wikipedia.org/wiki/Edward\\_Tufte](https://en.wikipedia.org/wiki/Edward_Tufte)

## The experts tell us



(Evergreen, 2017)

Image from <https://tei.cgu.edu/people/stephanie-evergreen-phd/>

What's your point?

Seriously, that's the most important question.

# References

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