

# Statistical Methods: Advanced Common Sense

<https://tinyurl.com/ahastats>

Prof Ken Rice, University of Washington

Research  
Leaders  
Academy

# Statistics is...



- 1. Fun and exciting**
- 2. Something I passed a course in once**
- 3. Confusing and difficult**



# Overview



- **Statistical thought (3 examples)**
- **Why is thinking this way *hard*? (psychology)**
- **Your turn!**
- **Discussion – including care and feeding of statisticians**

1.



# Statistical thought: Example #1



**British hospitals  
with bad results  
are put into  
“special measures”**

**Based on the  
headline from [this  
story](#), do you think  
they work?**



## 'Deaths averted' at hospitals put into special measures

By Smitha Mundasad  
Health reporter

🕒 8 February 2015 | Health

**BBC**



THINKSTOCK

Under special measures some trusts have hired extra staff

# Statistical thought: Example #1



**Daily Record** AND SUNDAY MAIL

News - Politics - Football - Sport - TV & Celebs - Life & Style - Scotland Now

## Speeding drivers will be targeted on A82 following road deaths

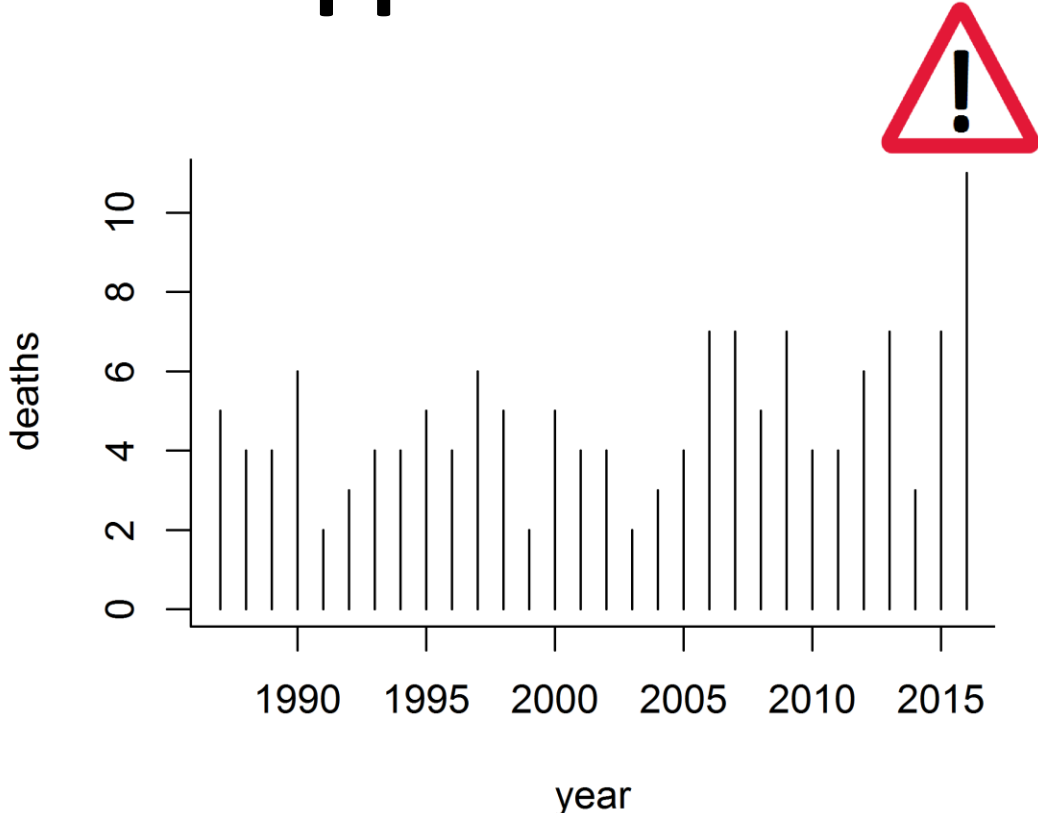
13:53, 19 AUG 2016 BY JENNY FOULDS

Extra police patrols and safety initiative following a rise in fatal and serious road crashes



Drivers warned to drive carefully on the A82.

## Same idea for a public health intervention... What happens next?

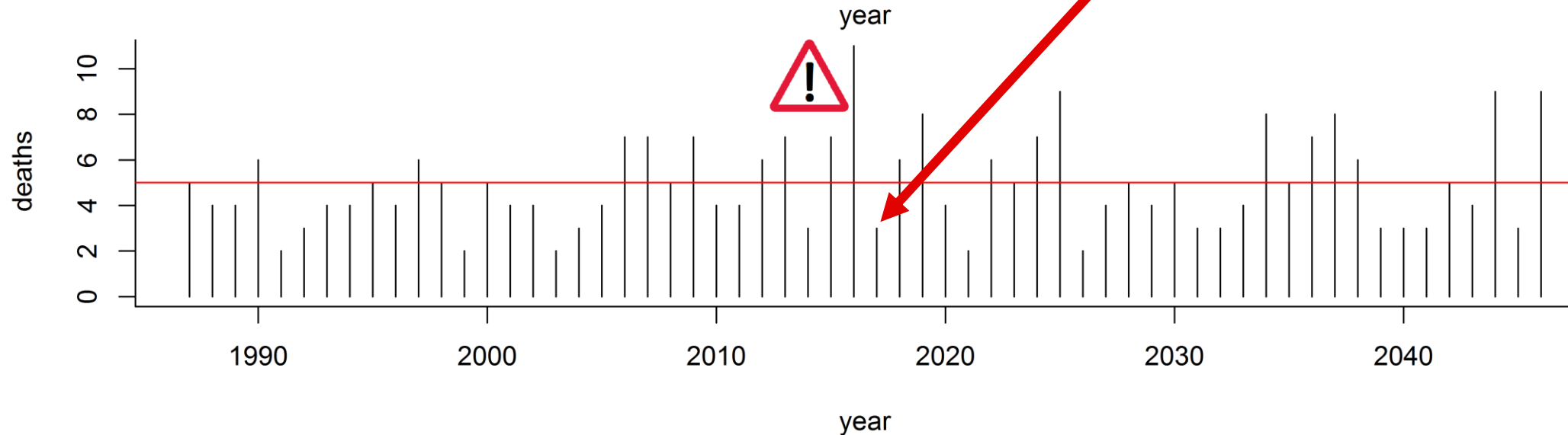
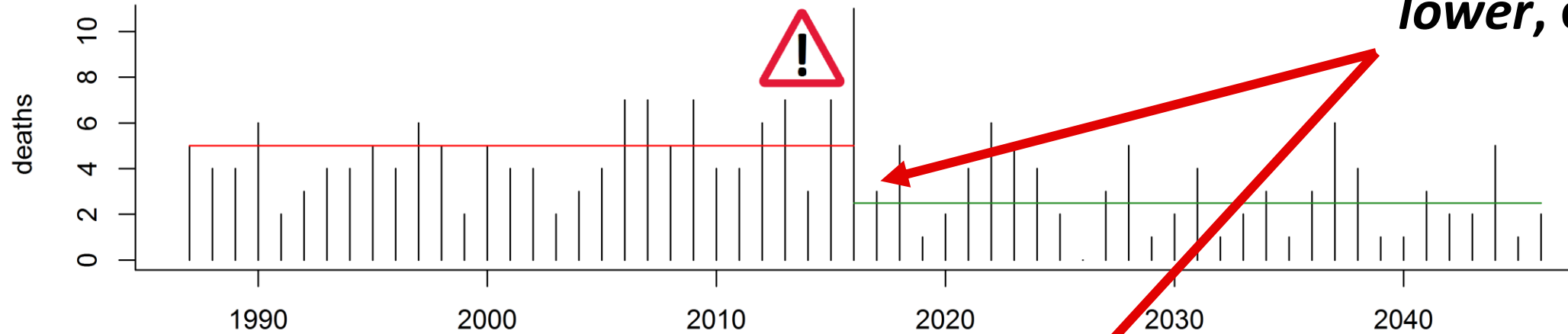


# Statistical thought: Example #1



What happens *later*? Two possibilities:

Next year's count is *lower*, either way!



# Statistical thought: Example #1



Extreme random events *are extreme* –  
so they are usually followed by less-extreme events.

Statisticians know this – we call it *Regression To The Mean*

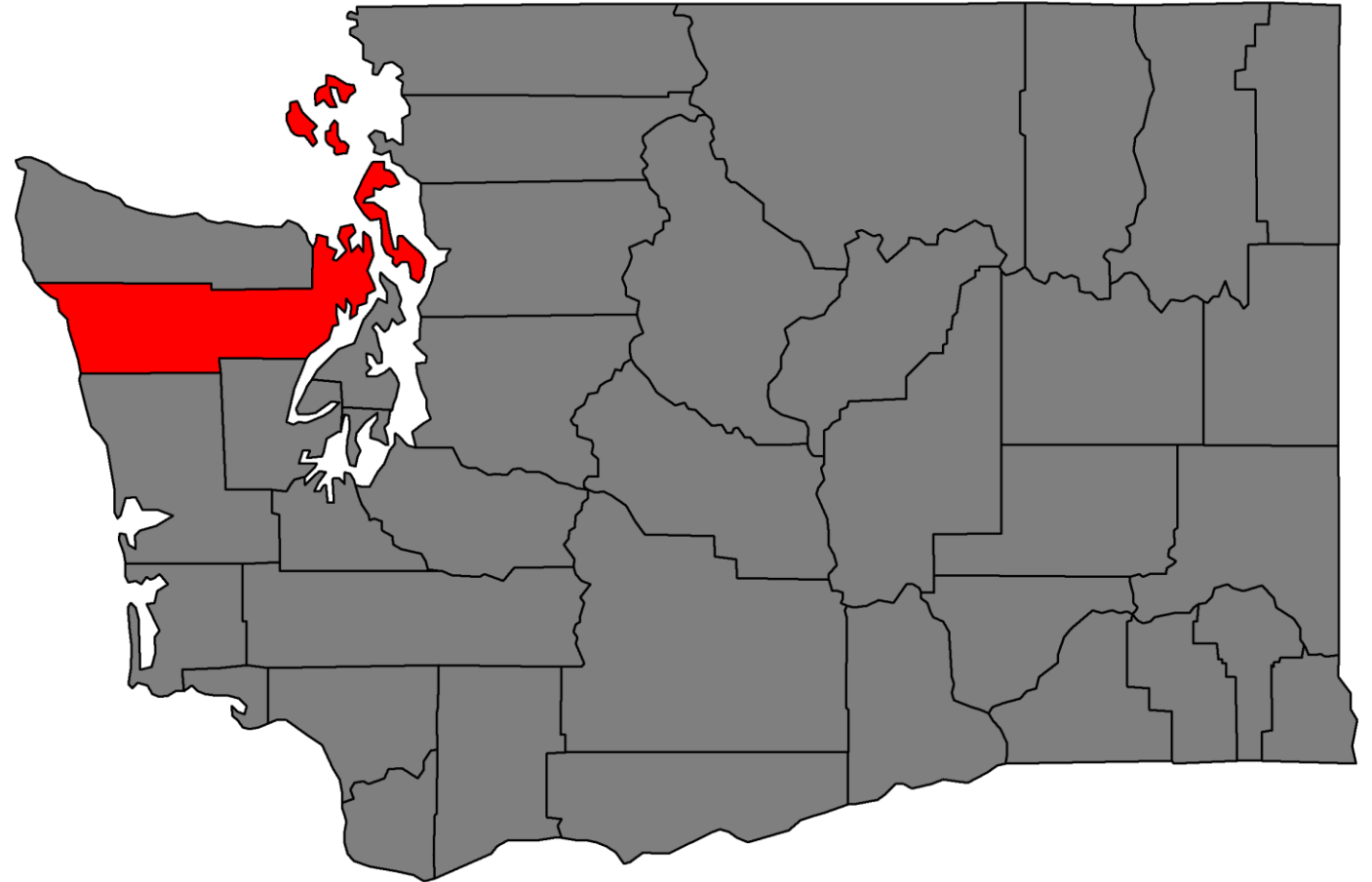


# Statistical thought: Example #2



**Melanoma incidence rate in Washington State by county:  
(2011-2015, case-mix adjusted)**

**The 3 worst counties  
are red: how might  
you explain the  
pattern?**



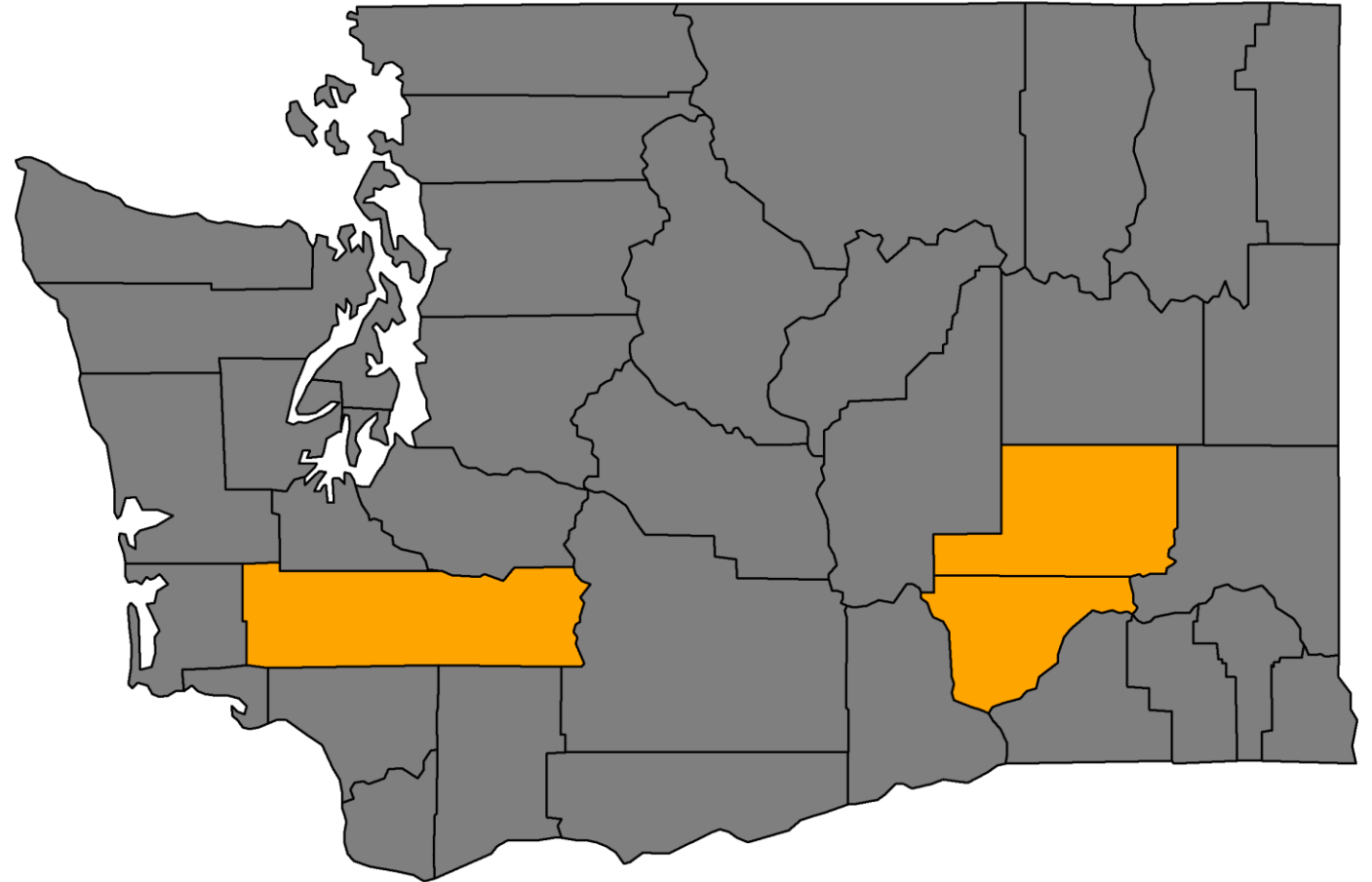


# Statistical thought: Example #2



**Melanoma incidence rate in Washington State by county:  
(2011-2015, case-mix adjusted)**

**The 3 best counties  
are orange: how  
might you explain the  
pattern?**

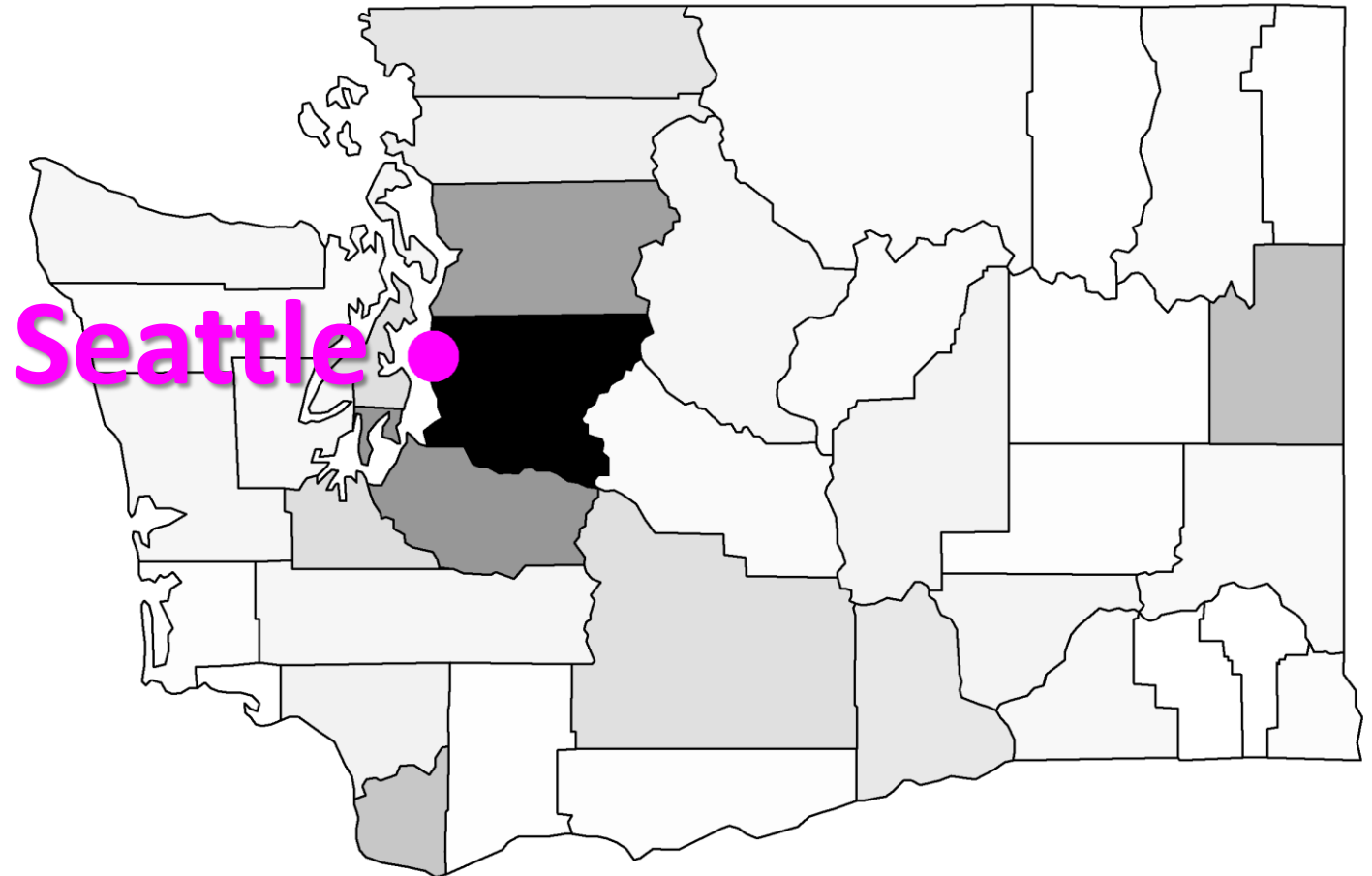


# Statistical thought: Example #2



**Where people live in Washington State by county:  
(2011-2015, grayscale indicates population size)**

***Now what do you  
think?***

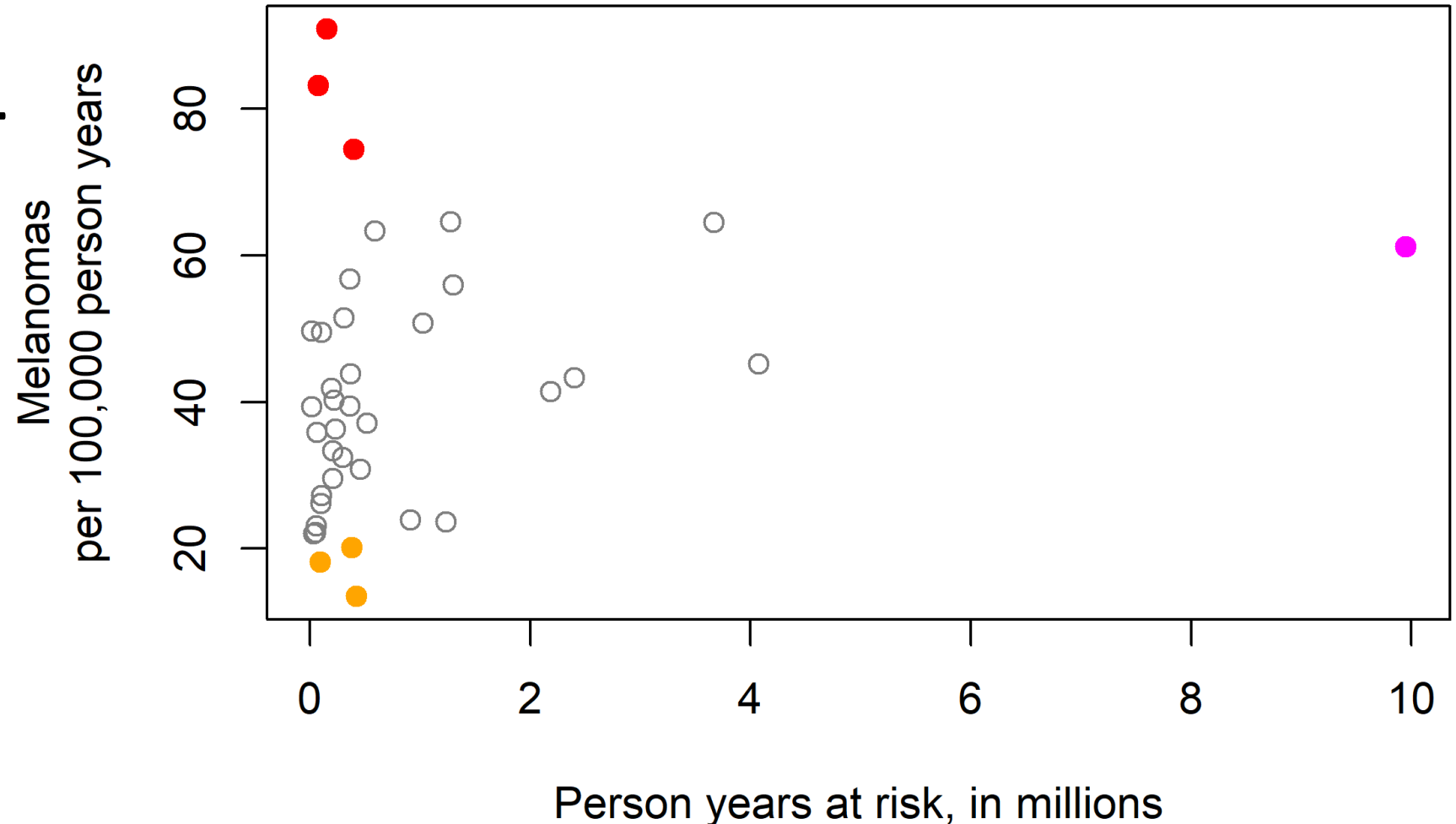


# Statistical thought: Example #2



A funnel plot shows *variability* as well as rates:

- Most counties have few people – so their rates are *very noisy*
- Larger counties may tell us more about *why* rates differ



# Statistical thought: Example #2

## Over-interpret very noisy results? Really? Who does that?



# Statistical thought: Example #3



Be careful not to over-interpret noisy results

Ignoring external information is a fallacy [Daniel Kahneman](#) (right) calls *What You See Is All There Is*.



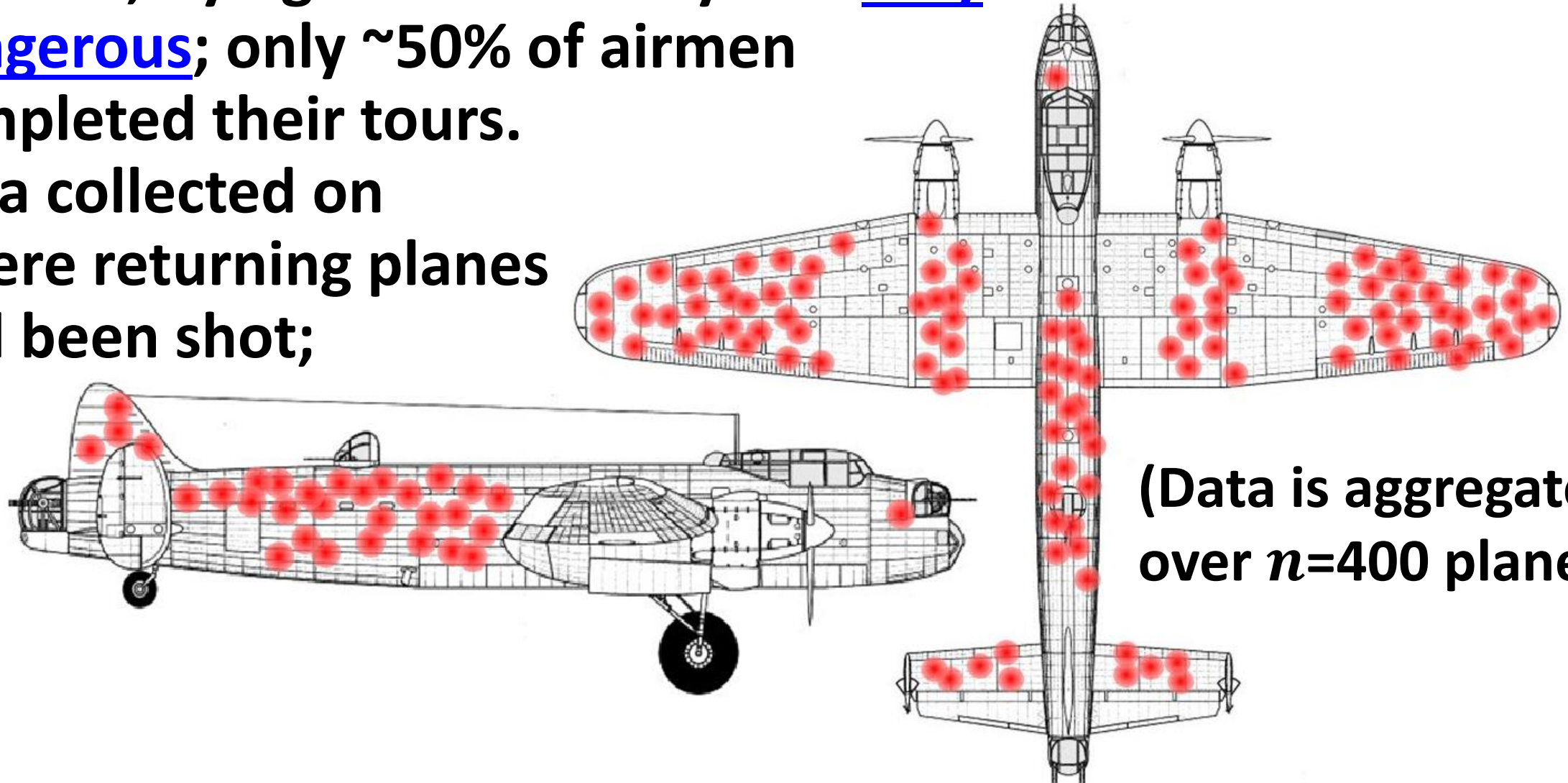
Bayesian statistical methods “use prior information” to avoid being misled like this.



# Statistical thought: Example #3



In WWII, flying over Germany was very dangerous; only ~50% of airmen completed their tours. Data collected on where returning planes had been shot;



(Data is aggregated over  $n=400$  planes)

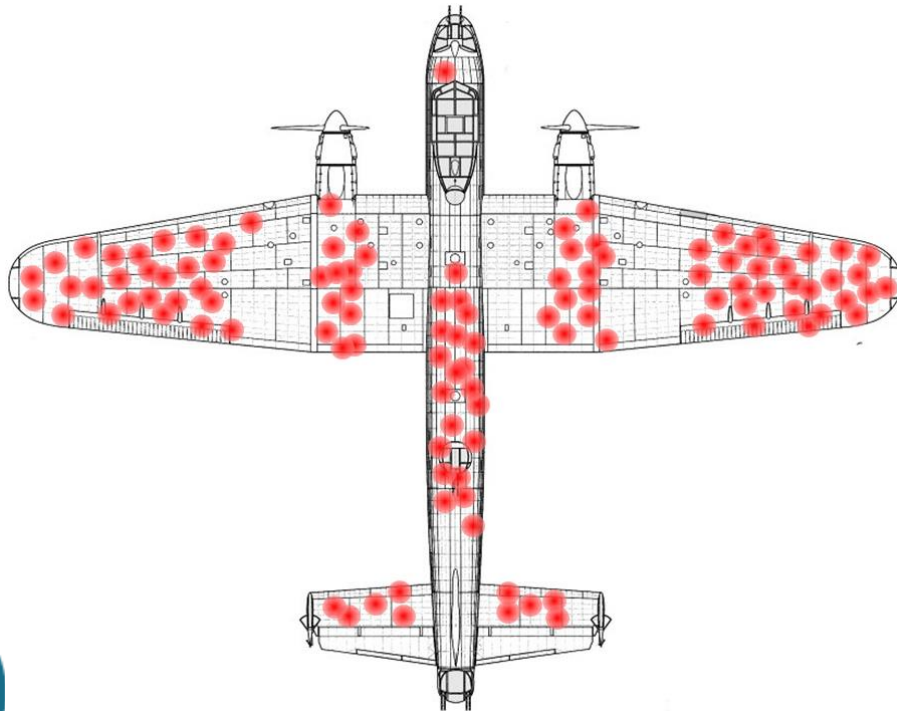


# Statistical thought: Example #3



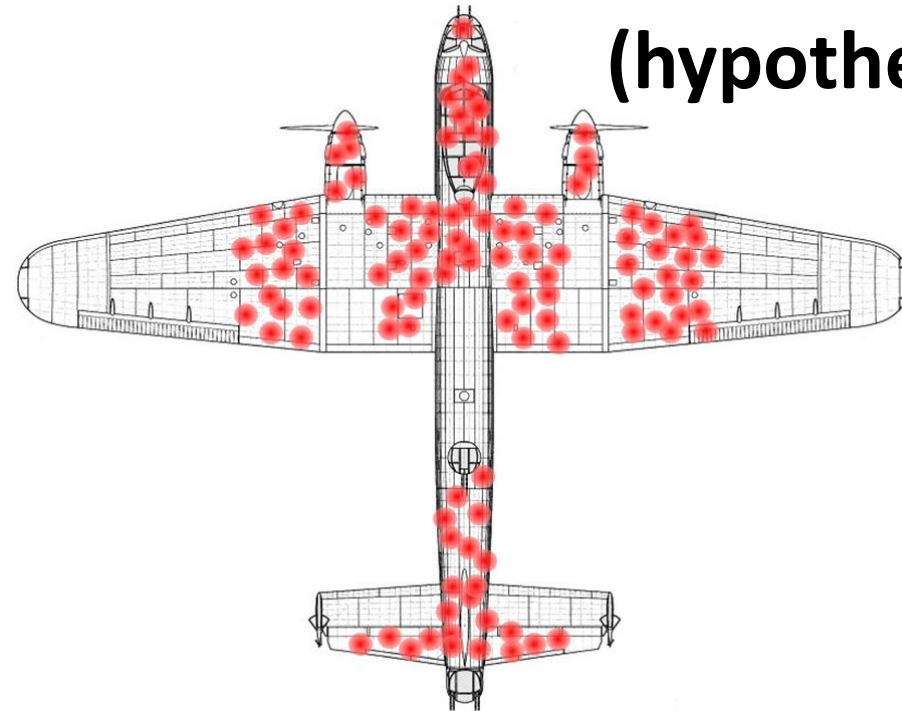
The “obvious” answer was armor-plating shot-at areas. Until statistician [Abraham Wald](#) suggested *doing the opposite*:

Shot at, survived



Shot at, did not survive

(hypothetical)



# Statistical thought: Example #3



Ask why you are looking at *this* dataset,  
and not some other

Statisticians call any differences (between the data we have vs data we want) *selection bias*

“The statistician who supposes that his main contribution to the planning of an experiment will involve statistical theory, finds repeatedly that he makes his most valuable contribution simply by persuading the investigator to explain why he wishes to do the experiment.”

Statistician [Gertrude Cox](#) speaking to USDA... in 1950

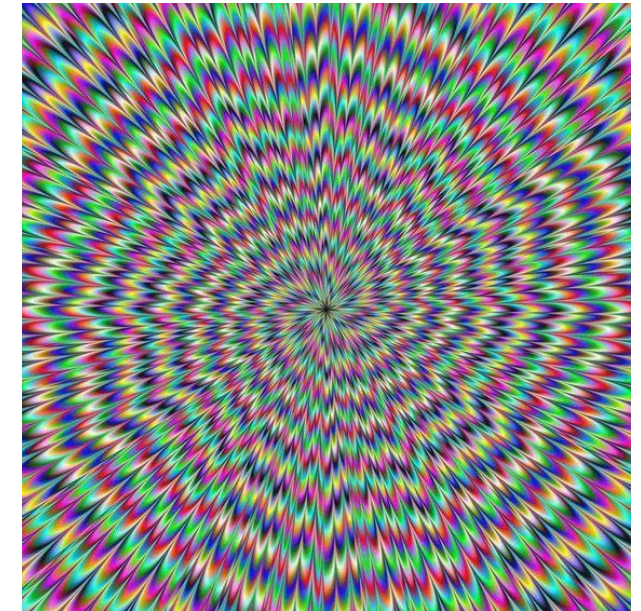
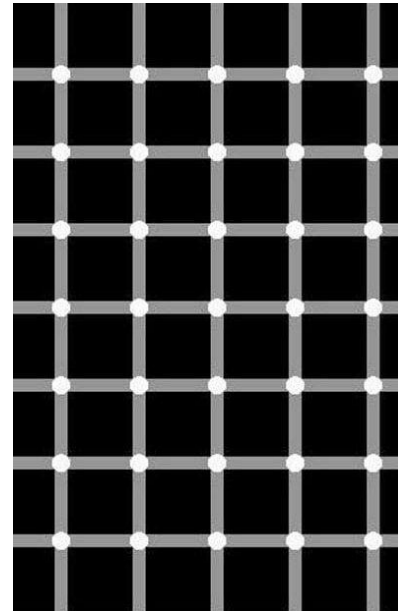
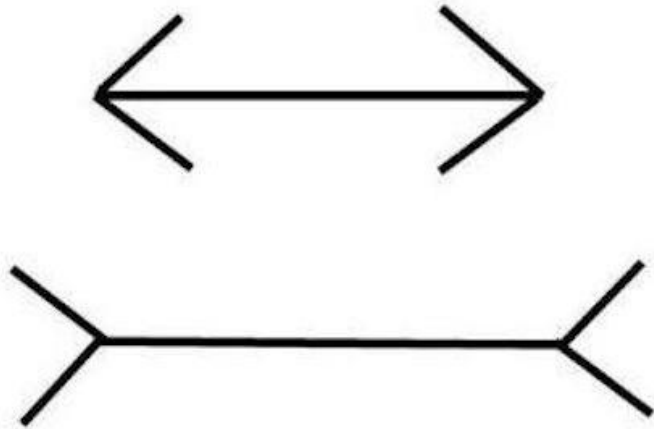




# Why is thinking this way *hard*?



Common sense says these are optical illusions:



Doing statistics requires a *more advanced* common sense, where we carefully put together all the information we have – rather than “eyeballing it”

# Why is thinking this way *hard*?

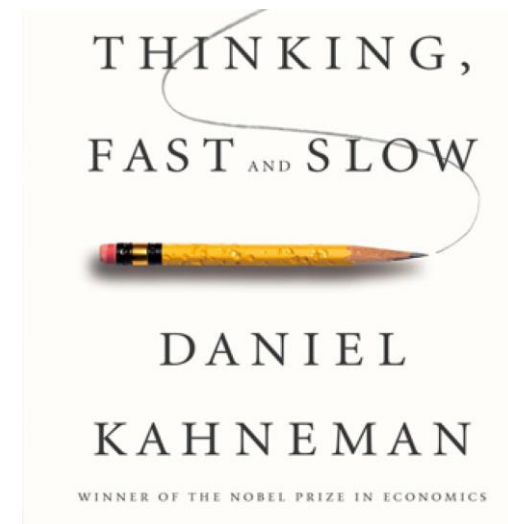


See [Kahneman, Thinking Fast and Slow](#) (right) for an intro to the psychology.

In this session we'll just illustrate some *cognitive biases*:

- Seeking only the simplest answer/explanation
- *What you see is all there is* – only using information immediately to hand
- *Framing* – i.e. trying make everything coherent

For the next three slides (only!) try to answer the questions *as quickly as possible*.



# Why is thinking this way *hard*?



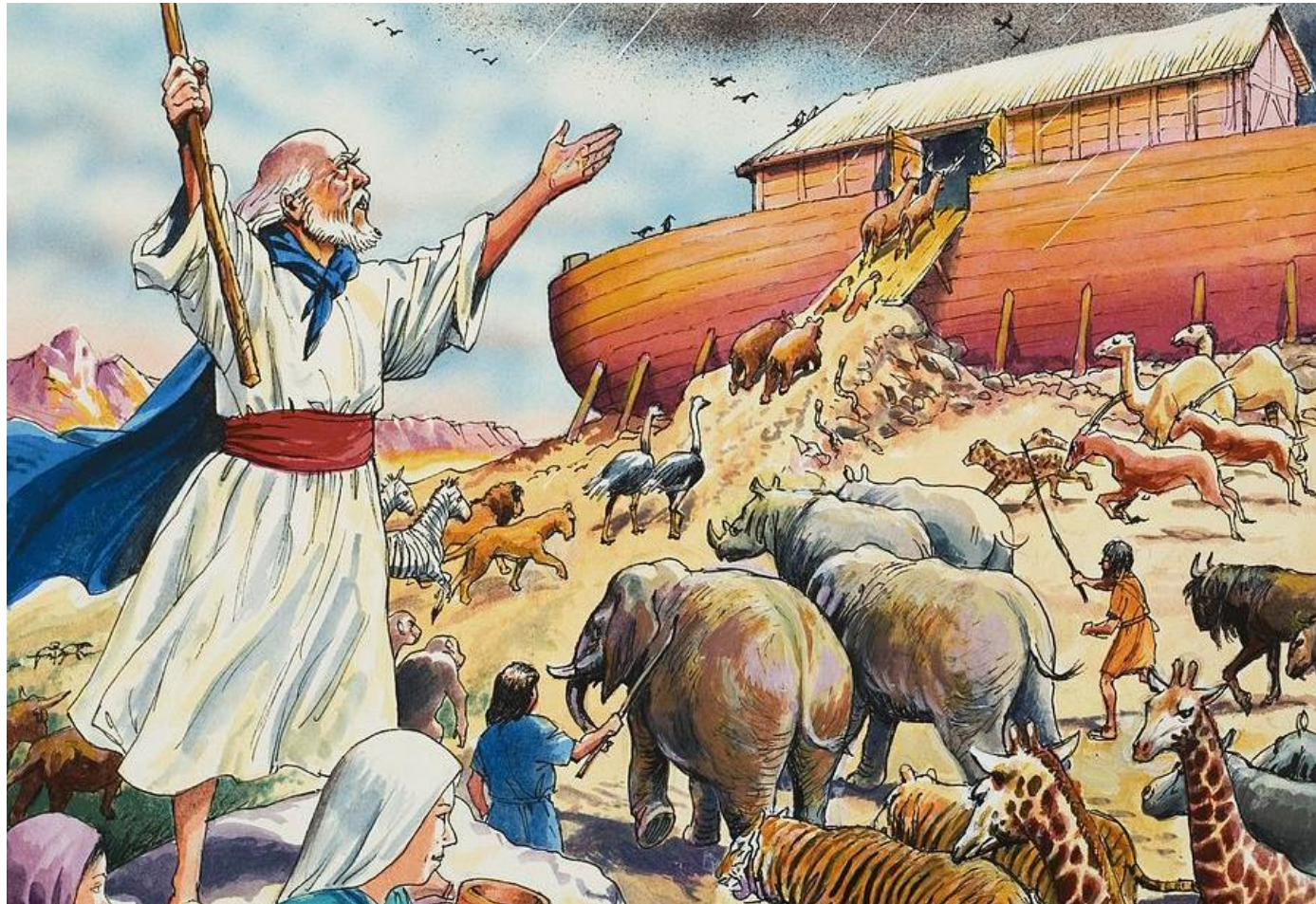
**A bat and a ball  
together cost \$1.10**

**The bat costs \$1.00  
more than the ball**

**Q. How much does  
the ball cost?**



# Why is thinking this way *hard*?



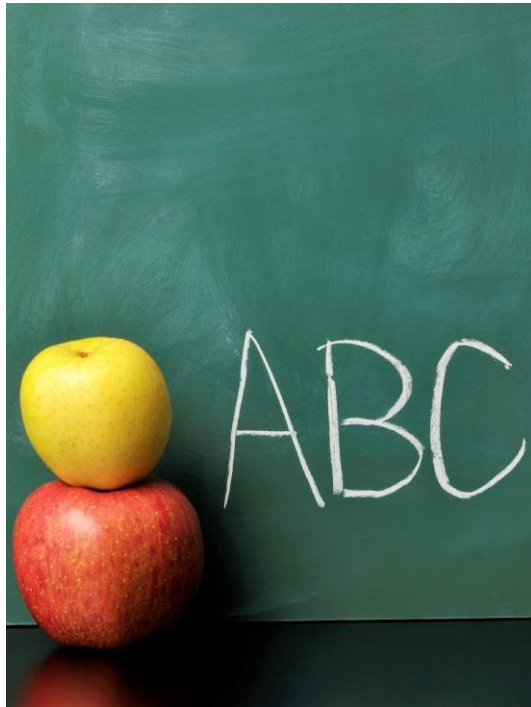
**Q. How many animals of each type did Moses take into the Ark?**



# Why is thinking this way *hard*?



**Sarah loves to listen to New Age music and faithfully reads her horoscope each day. In her spare time, she enjoys aromatherapy and attending a local spirituality group.**



**Q. Is Sarah's job more likely to be a school teacher or holistic healer?**



# Why is thinking this way *hard*?



To have advanced common sense, think carefully (and *slowly*!) about all the information:

- What question are we asking?
- How, *if at all*, does our data help answer that question?
  - What scientific assumptions am I making (e.g. causal effects) and why?
  - What statistical assumptions am I making (e.g. constant variance across groups) and why?
- Why this dataset and not others?
- What other explanations are available? What can be ruled out?



# Your turn!



1. With your group, answer the question – carefully and slowly!
2. Explain the answer to us!

Slides & other resources at <https://tinyurl.com/ahastats>



# Your turn!



Slides & other resources at <https://tinyurl.com/ahastats>

1. Will women run faster?
2. Switch Insurers?
3. Who's faking data?
4. Why is NEJM clueless?
5. Guardian data error
6. Why is Will Rogers funny?
7. Why graph Shelby County?

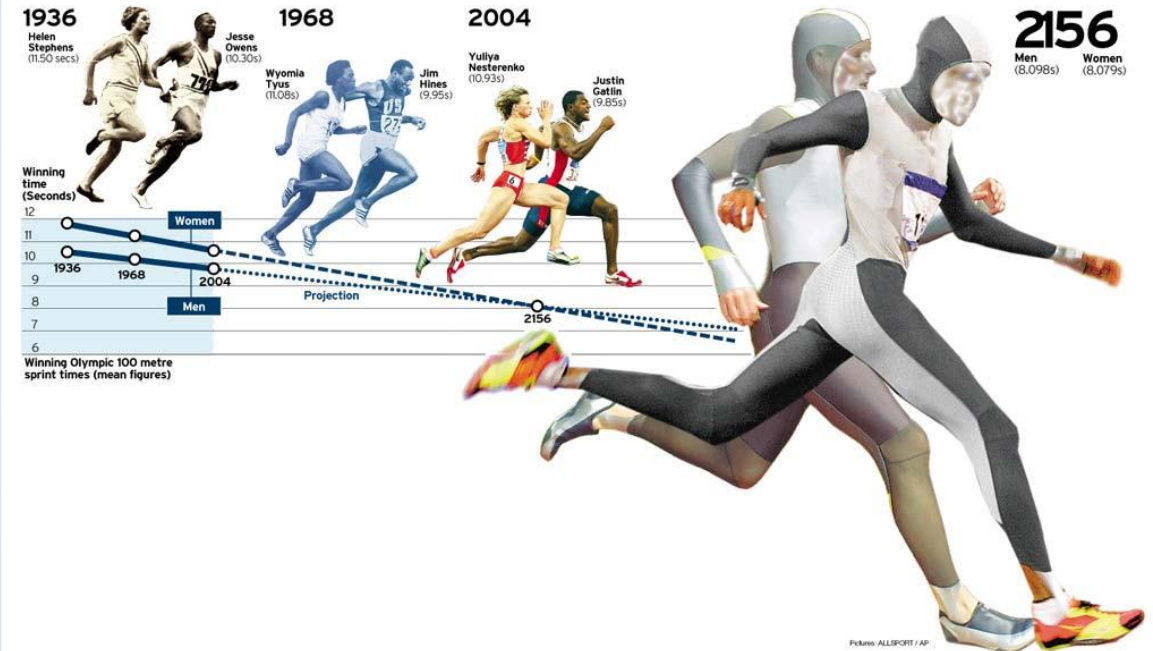
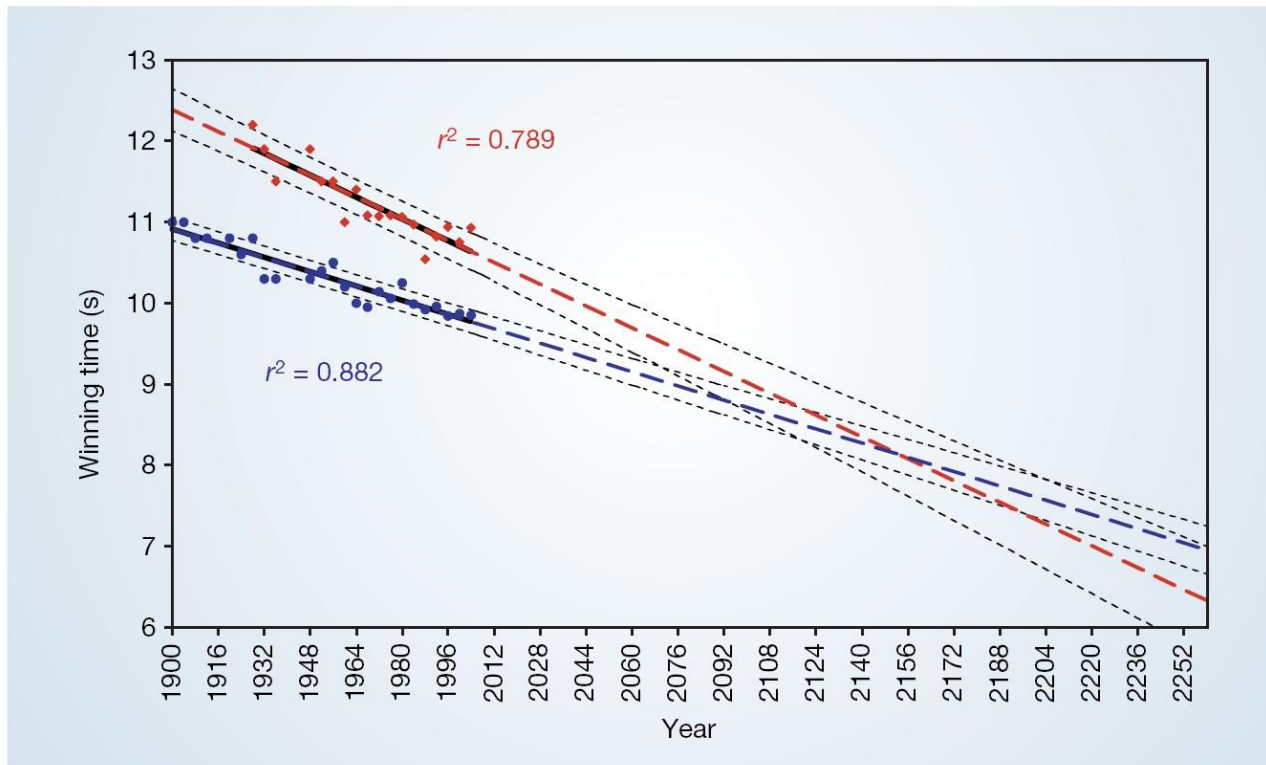




# Your turn! #1



## What assumption does the work in this analysis?



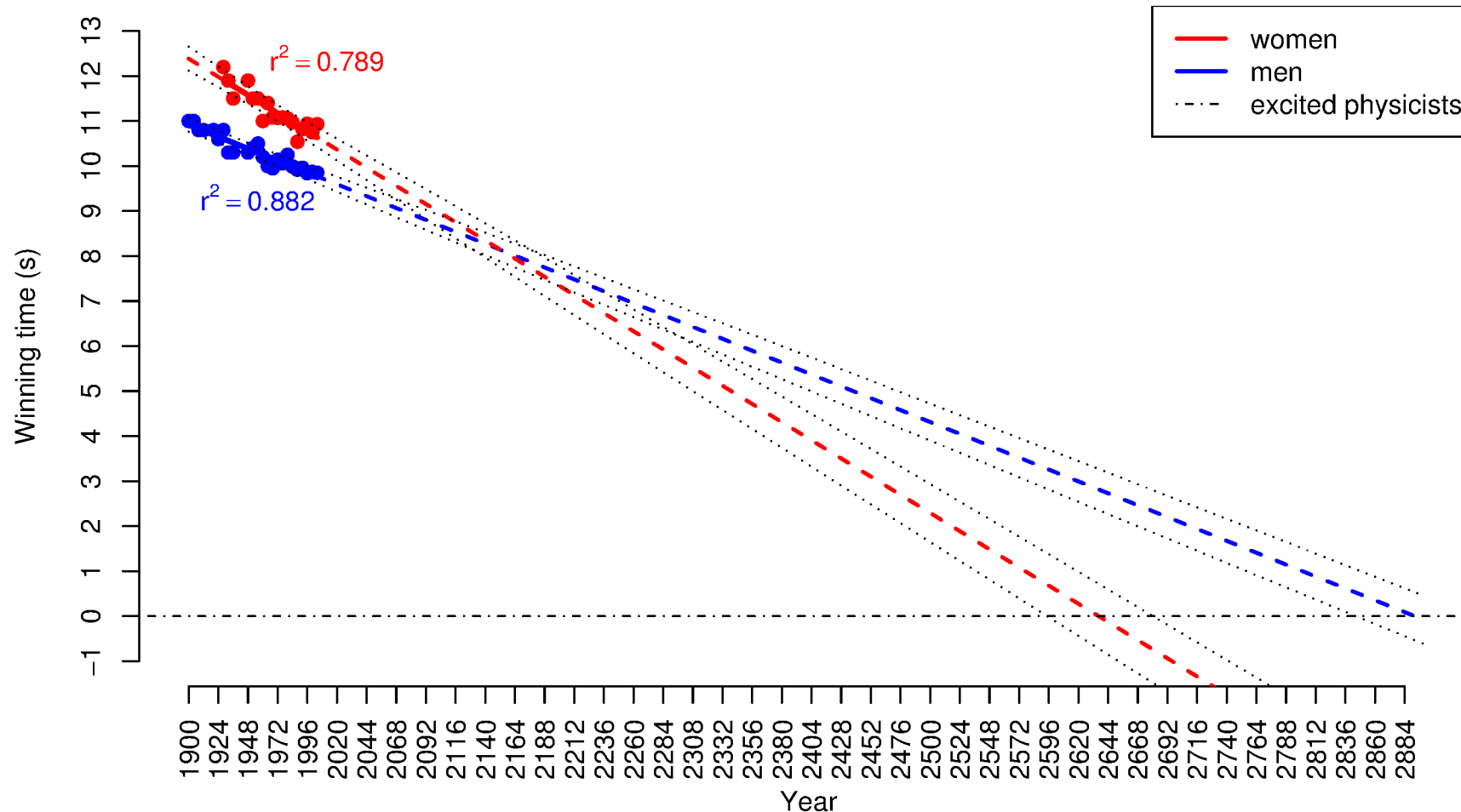
**Figure 1** The winning Olympic 100-metre sprint times for men (blue points) and women (red points), with superimposed best-fit linear regression lines (solid black lines) and coefficients of determination. The regression lines are extrapolated (broken blue and red lines for men and women, respectively) and 95% confidence intervals (dotted black lines) based on the available points are superimposed. The projections intersect just before the 2156 Olympics, when the winning women's 100-metre sprint time of 8.079 s will be faster than the men's at 8.098 s.

NATURE | VOL 432 | 11 NOVEMBER 2004

# Your turn! #1



## That assumption of linearity goes a loooooong way:



## Sprint research runs into a credibility gap

*Sir*— A. J. Tatem and colleagues calculate that women may outsprint men by the middle of the twenty-second century (*Nature* **431**, 525; 2004). They omit to mention, however, that (according to their analysis) a far more interesting race should occur in about 2636, when times of less than zero seconds will be recorded.

In the intervening 600 years, the authors may wish to address the obvious challenges raised for both time-keeping and the teaching of basic statistics.

**Kenneth Rice**

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Forvie Site, Robinson Way, Cambridge CB2 2SR, UK*

## Your turn! #2



A slogan you may know:

**\$396**  
Drivers who switched to  
Allstate saved \$396 a year  
on average.\*

» Talk to an agent now.

- Based on this (true) statement, from a very large sample, is it reasonable to think that Allstate's average premium is lower than all other companies?
- It turns out almost all drivers do *not* switch their car insurance provider, most years. What explanations are there?

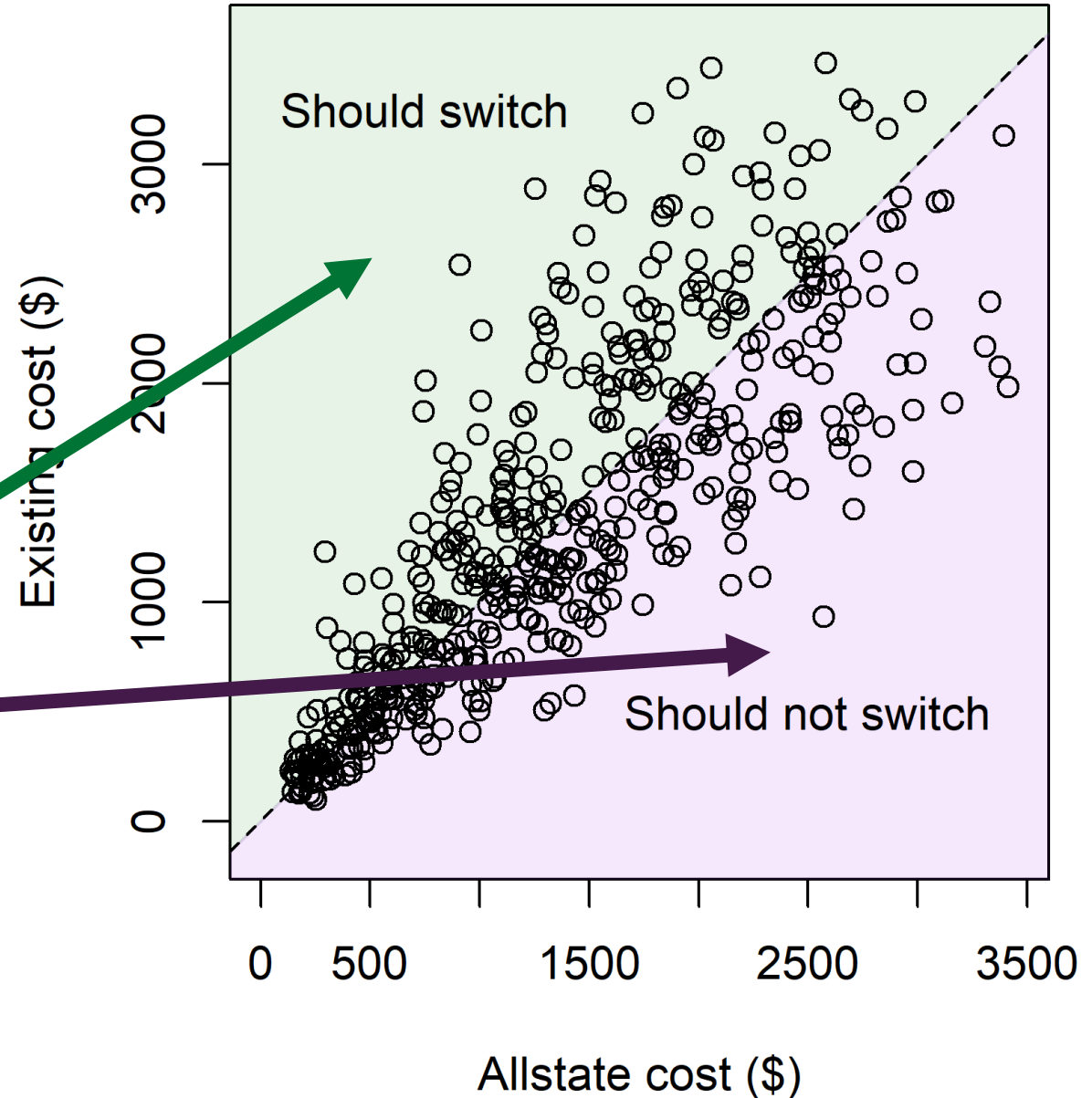
# Your turn! #2



Some plausible data – and who would save *or not* by switching:

**Average saving \$396!**

**Average saving \$396!**

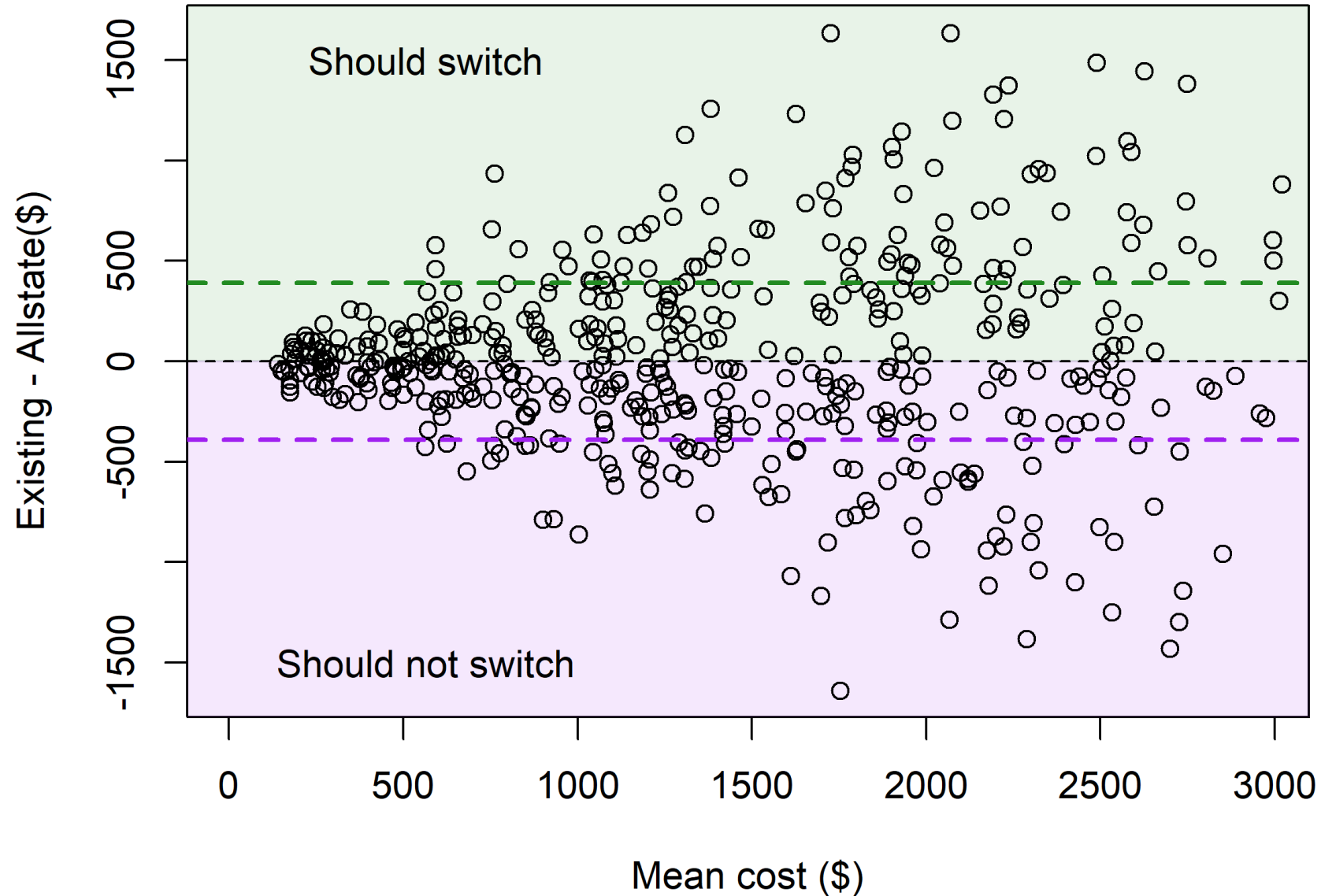


# Your turn! #2



A [Bland-Altman plot](#)  
of that data:

To learn about  
differences, *actually*  
*analyze* differences!



# Your turn! #3



One of these is 100 random flips of a fair coin. Which? Why?

H	T	T	H	T	H	T	H	T	H
T	T	H	H	T	H	T	H	H	H
T	T	T	T	H	H	H	T	T	T
T	H	H	T	T	H	T	H	T	H
T	H	H	H	T	H	T	T	H	T
H	H	H	H	T	T	T	H	H	H
H	T	H	H	T	T	T	T	H	H
T	H	H	H	T	T	T	H	H	H
T	H	T	H	H	T	H	T	T	H
H	H	T	H	T	H	T	T	T	T

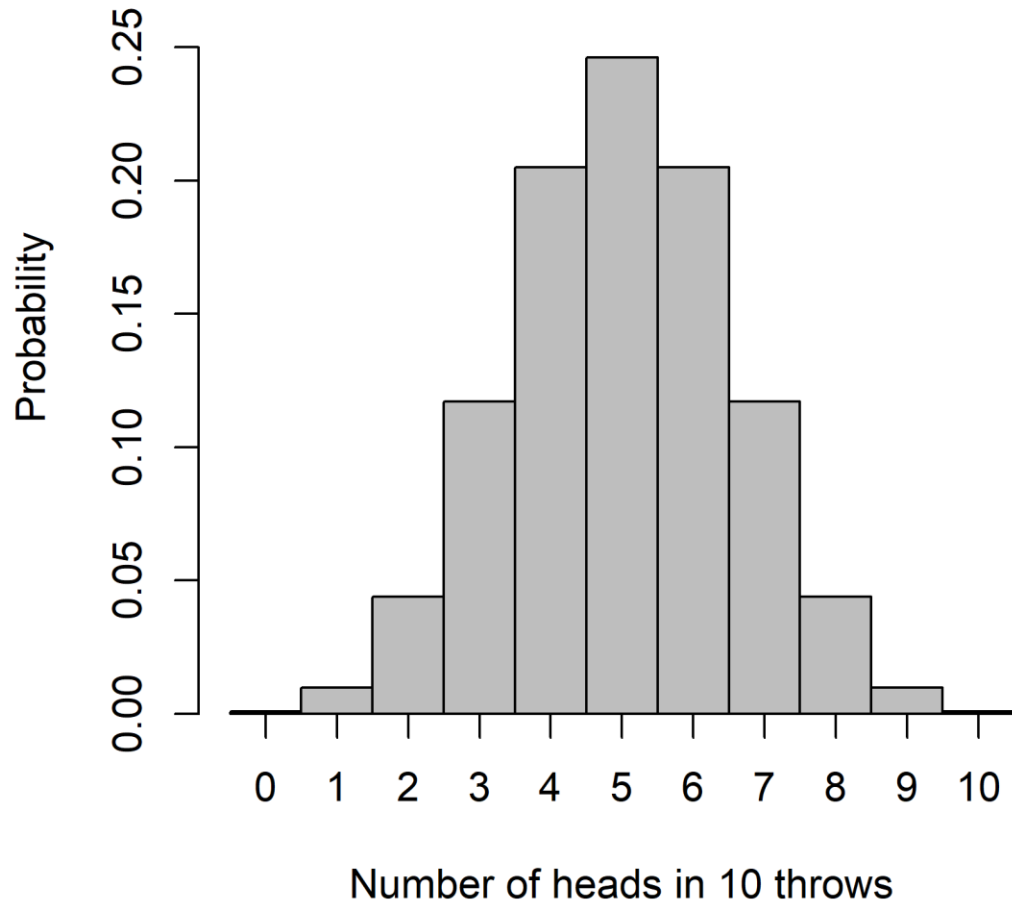
T	T	H	H	H	H	T	T	T	H
T	T	H	H	T	H	T	T	H	H
H	T	H	H	T	H	H	T	T	T
H	T	T	H	H	T	T	H	T	H
H	H	H	H	T	T	T	T	H	T
H	T	T	T	T	H	H	H	T	H
H	T	T	H	T	T	T	H	H	H
T	H	T	T	H	T	H	T	H	H
H	T	H	T	T	H	H	T	T	H
H	H	H	T	H	H	T	T	T	T



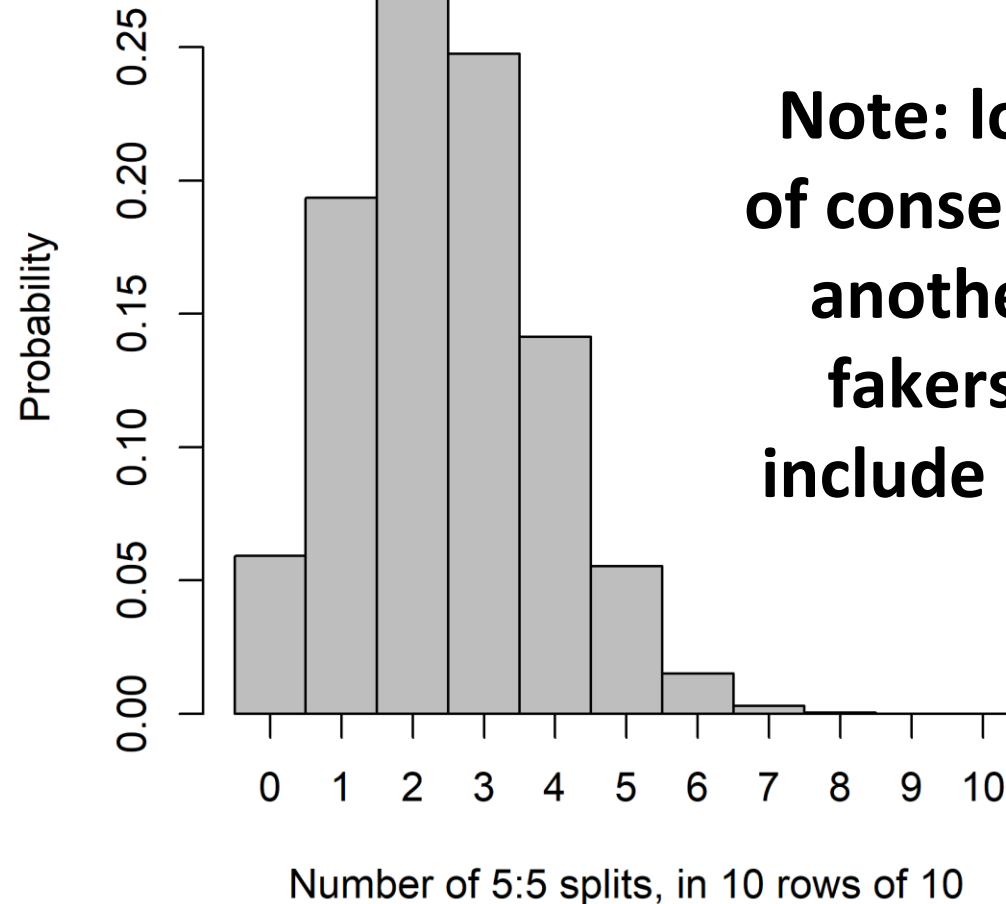
# Your turn! #3



In any row, what's the chance of 5 Heads & 5 Tails?



Over all the rows, how often would we see 5H & 5Ts?

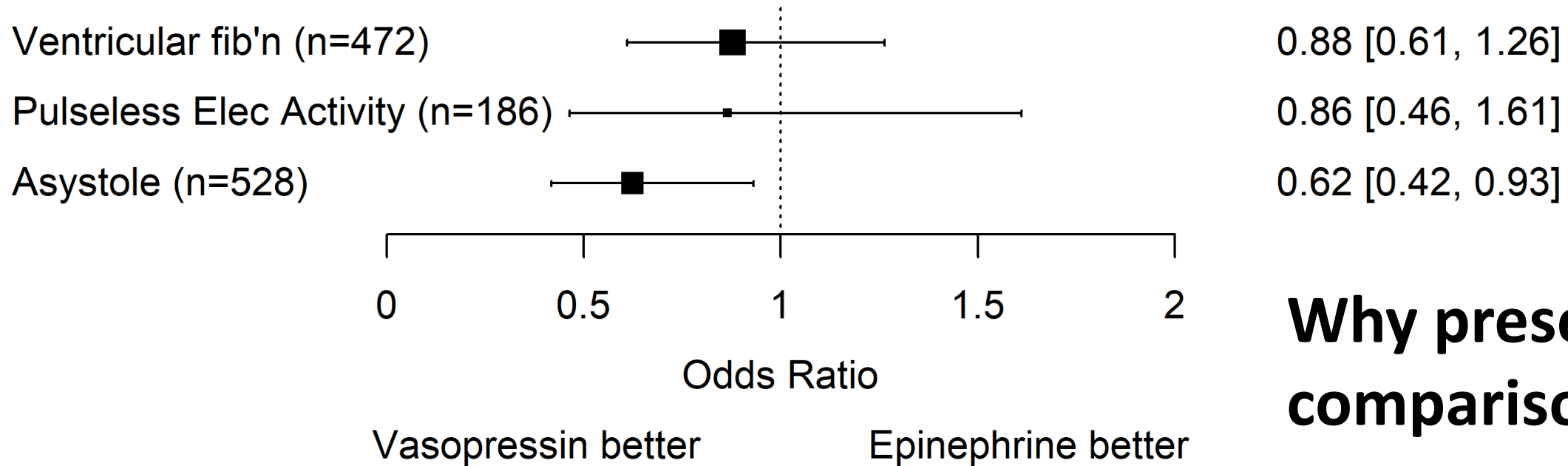


**Note: longer “runs” of consecutive Hs/Ts another good test, fakers tend to not include any of these**

# Your turn! #4



Survival to hospital admission from a [2004 CPR trial](#), that concluded “*vasopressin was superior to epinephrine in patients with asystole ... in contrast to ... patients with ventricular fibrillation or pulseless electrical activity.*”



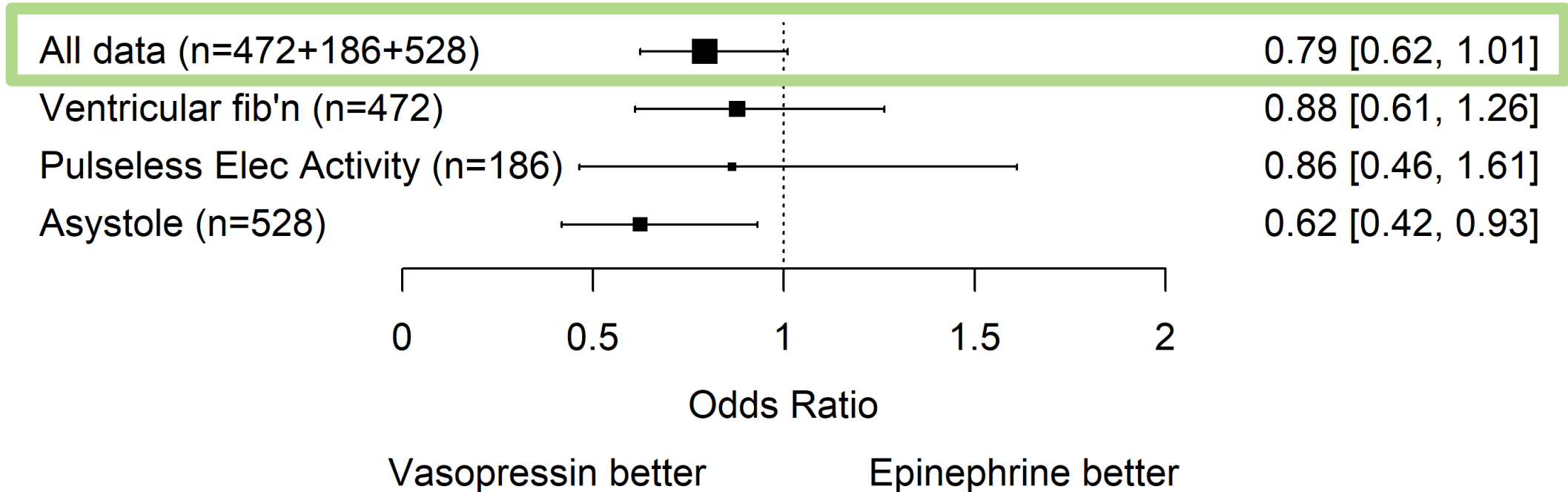
**Why present *this* comparison?**



# Your turn! #4



...probably because the primary one wasn't significant!



- Test of interaction (different OR in 3 groups?) gives  $p=0.42$
- The difference between significant and non-significant is not itself significant ([Gelman & Stern 2006](#))

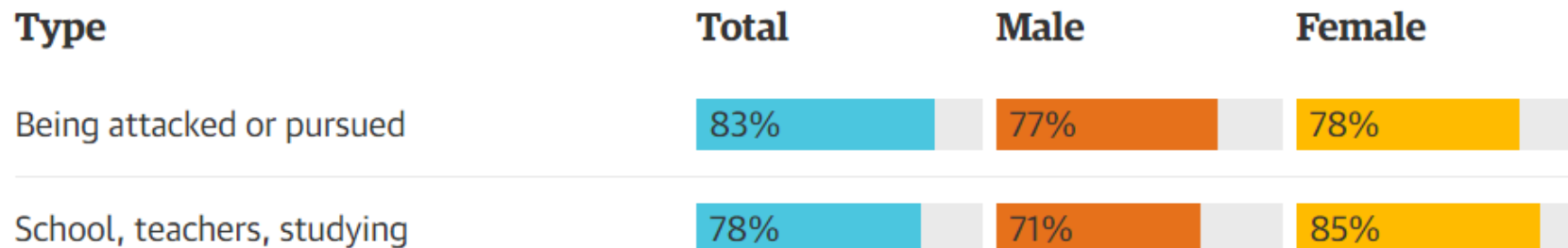
# Your turn! #5



A headline and table [from The Guardian](#):

What do dreams mean? The five most common explained

Have you ever had a dream of...?



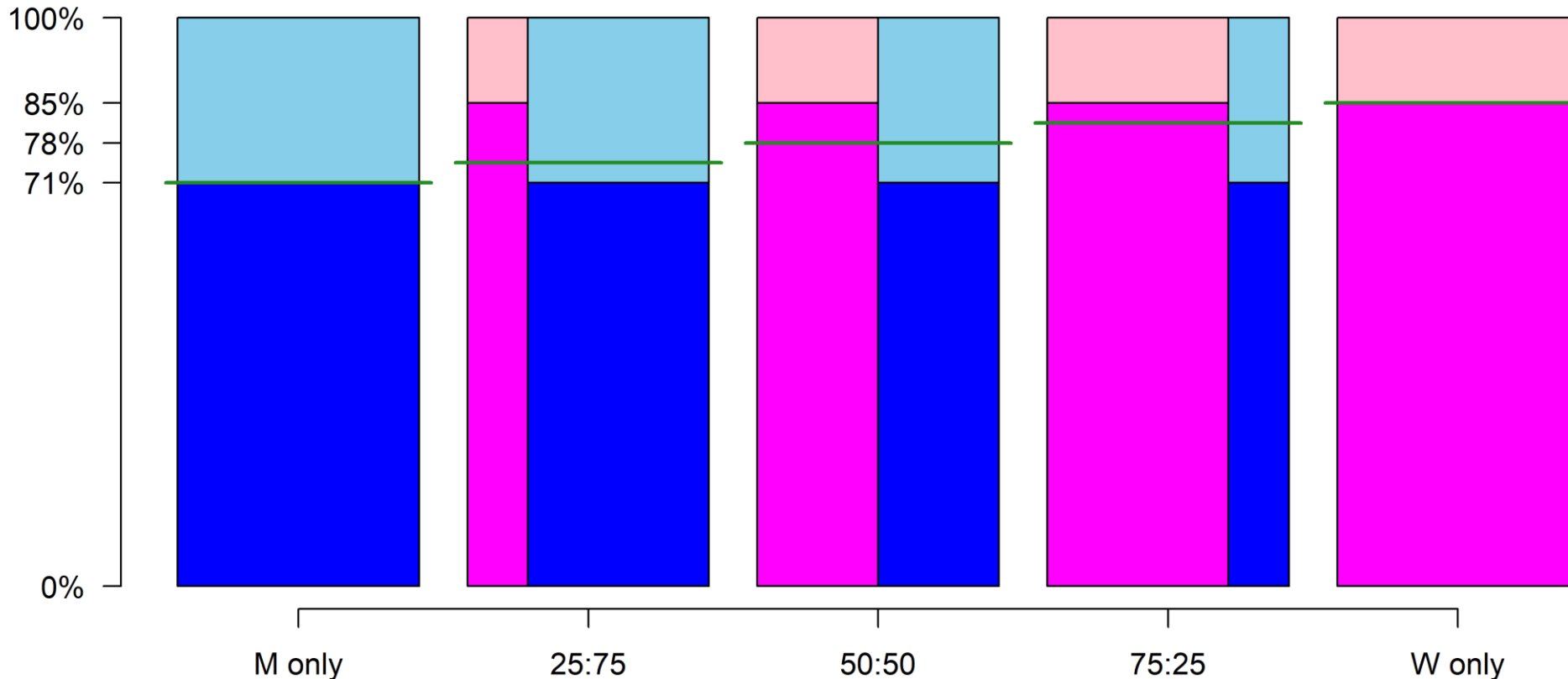
One row contains an error. Which is it? Why?



# Your turn! #5



Total %age answering “yes” is a weighted average of sex-specific %ages – so for 2<sup>nd</sup> question, must be a 50:50 mix:



Can we do this for Q1?  
Why?

# Your turn! #6



[Will Rogers](#) (right) joked that

*“When the Okies\* left Oklahoma for California, they raised the average intelligence level in both states.”*

What was he saying about the Okies, and Californians vs Oklahomans?

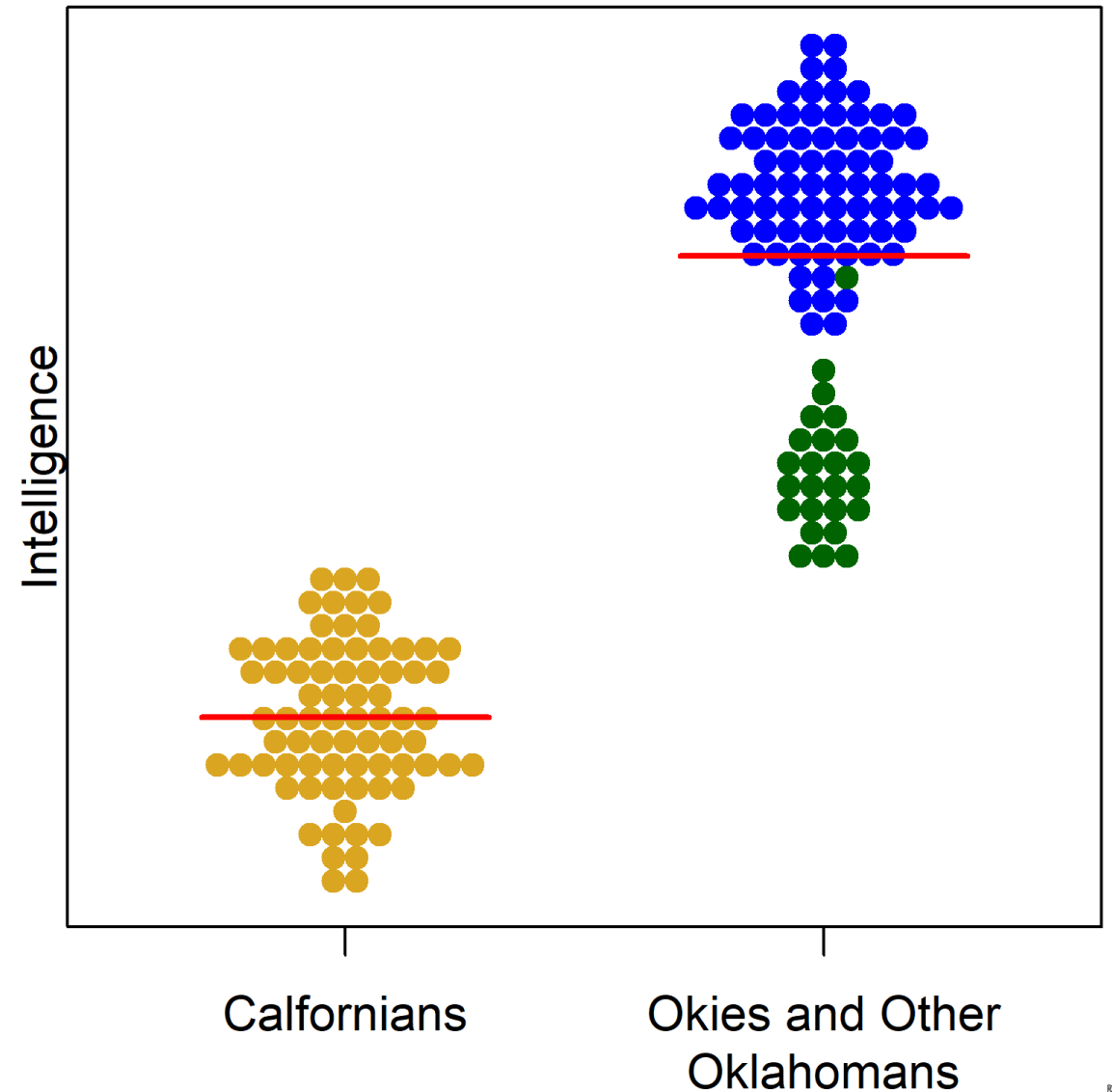


\* a group of 1930s economic migrants

# Your turn! #6



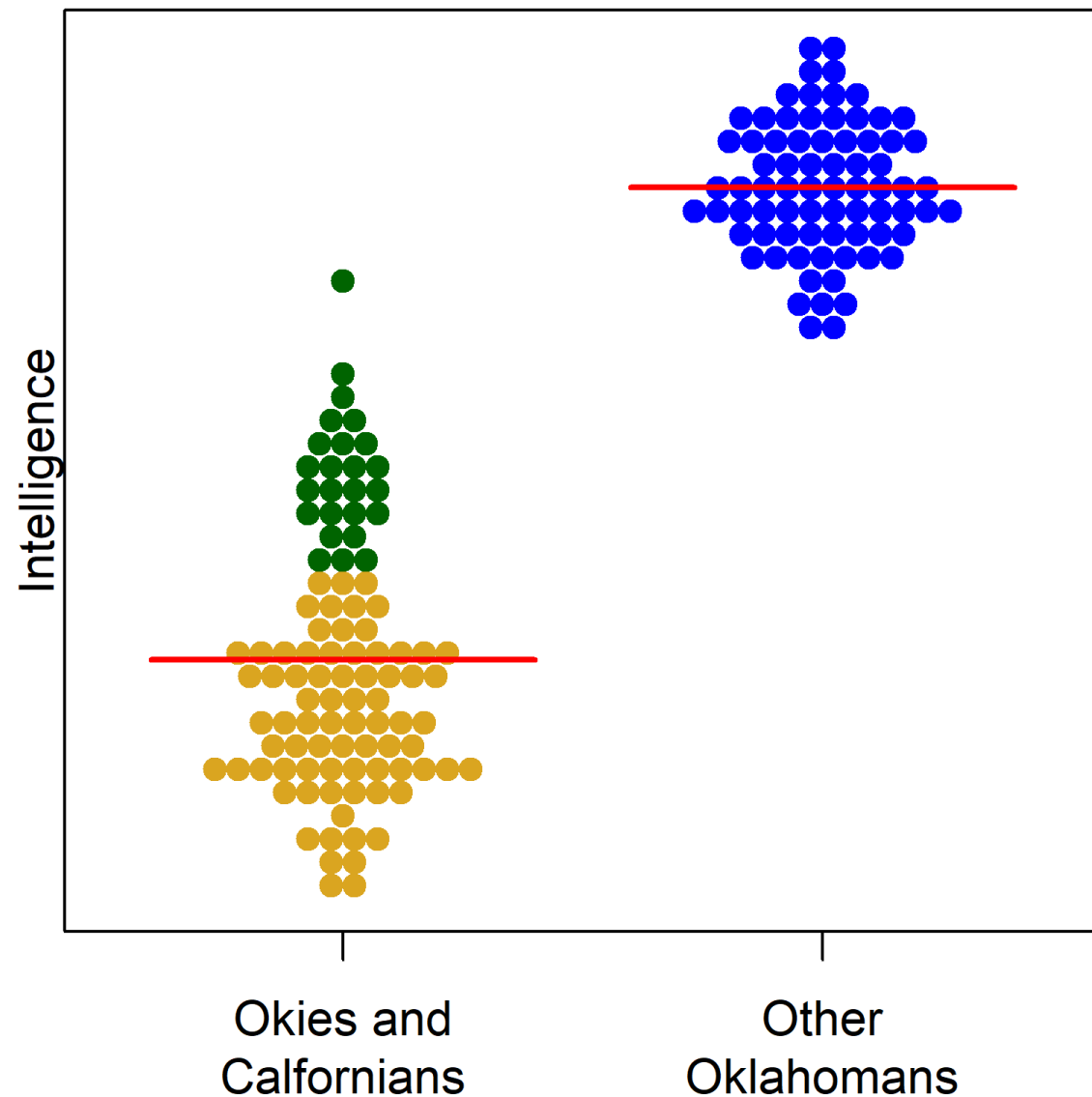
Some *beeswarm plots* illustrating a sample of the 3 groups – before:



# Your turn! #6



Some *beeswarm plots* illustrating a sample of the 3 groups – after:

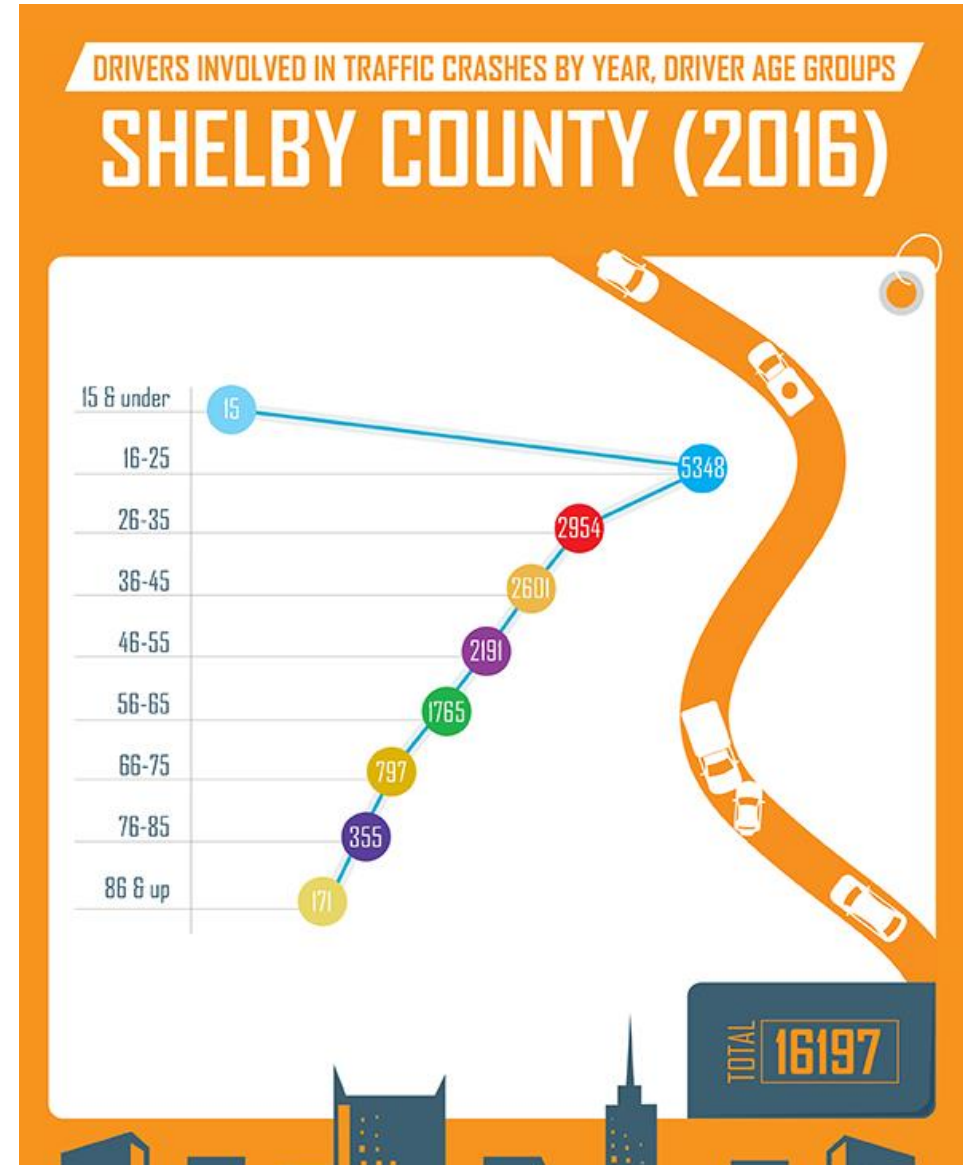


# Your turn! #7



What important information is omitted from [this plot](#)?

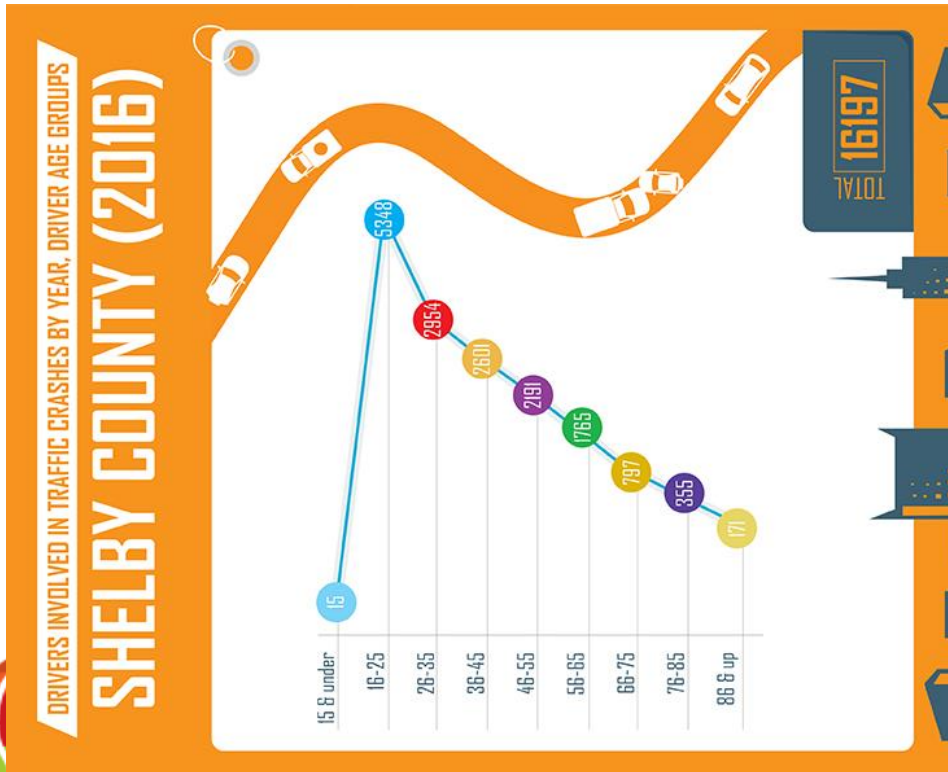
How could this be misleading?



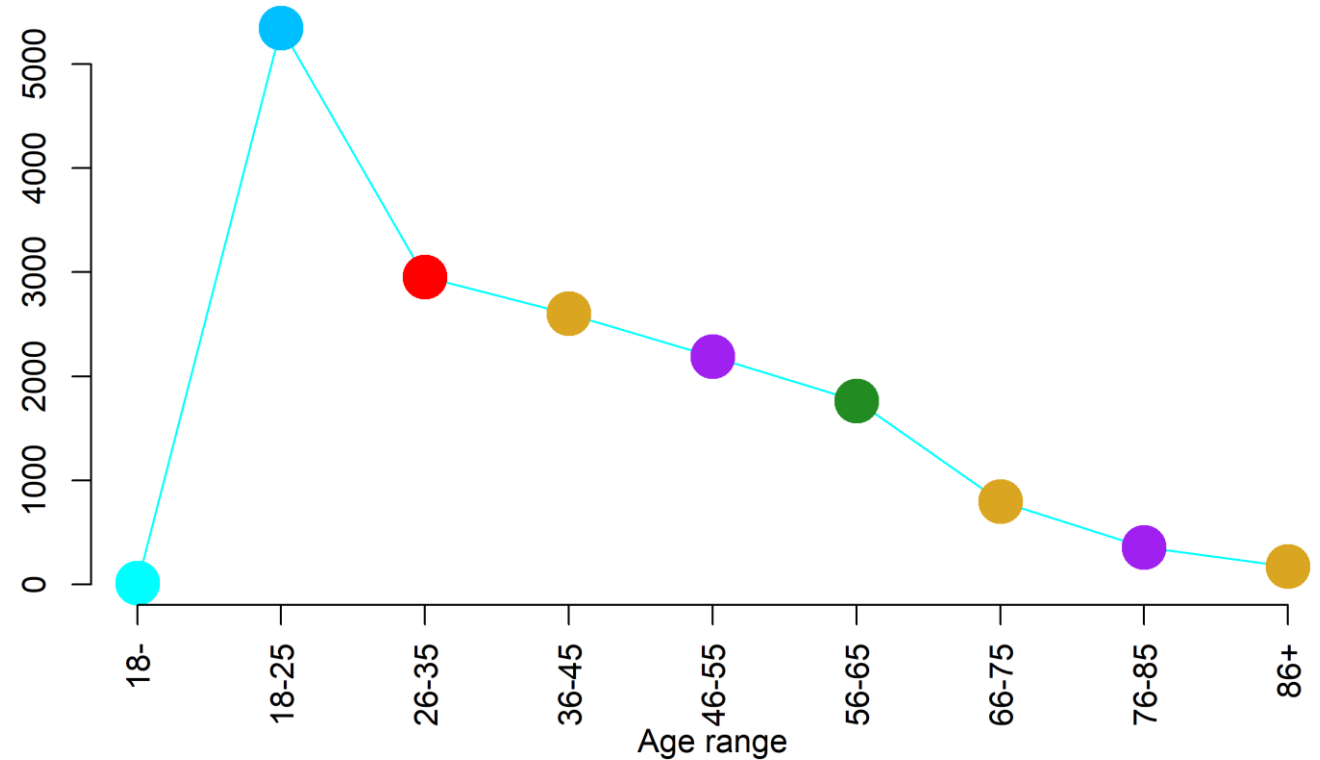
# Your turn! #7



Population counts (and better, hours of driving) are important, but also note...



Drivers involved in accidents

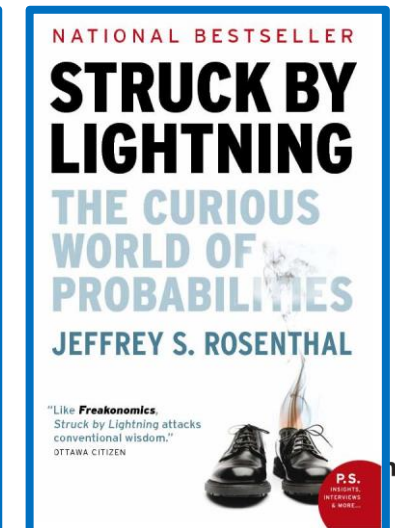
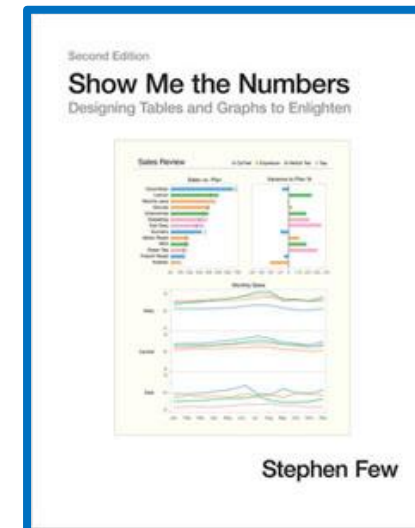
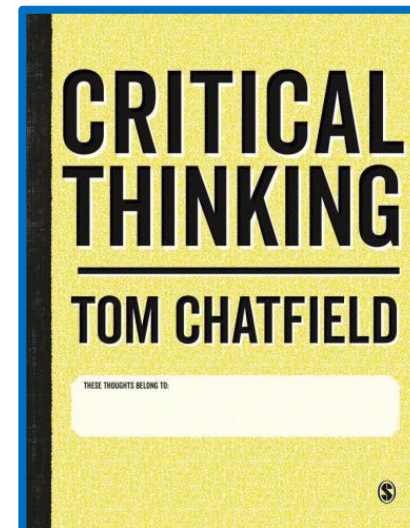
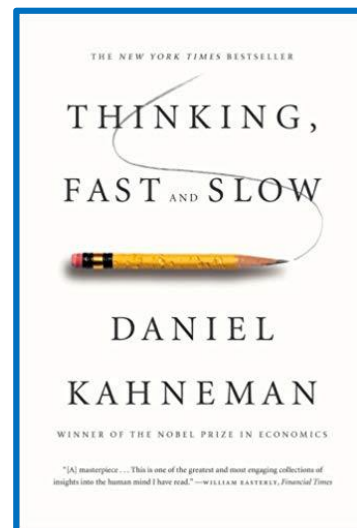




# Conclusions



- Thinking slowly helps us avoid being misled
- It is *deceptively* hard! – but practice helps
- As a research leader, you should understand *every step* in your analysis – get help if you need it
- Slides and more at <https://tinyurl.com/ahastats>
- Some great, non-technical books:





American  
**Heart**  
Association

American  
**Stroke**  
Association®

life is why™

# Thank You