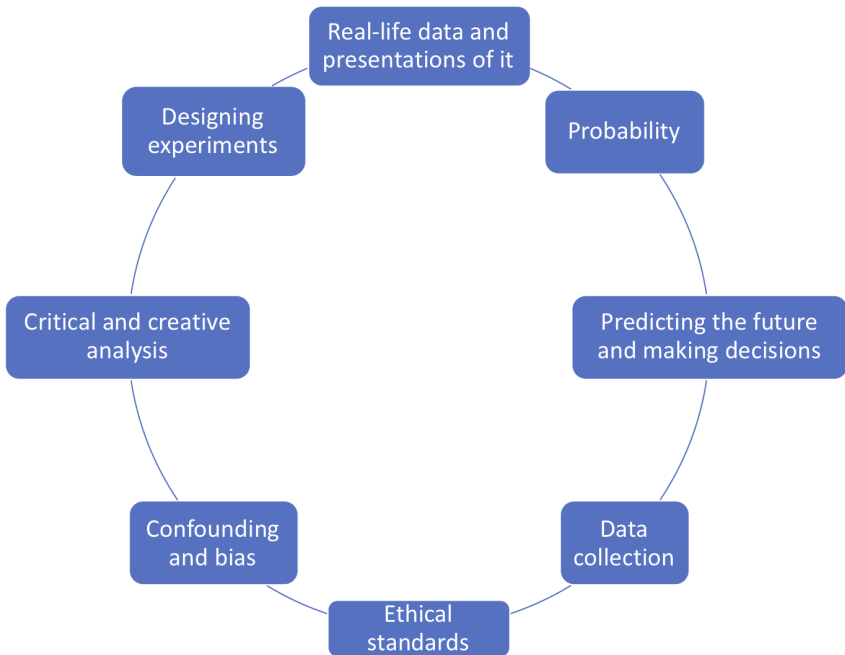


Case Studies

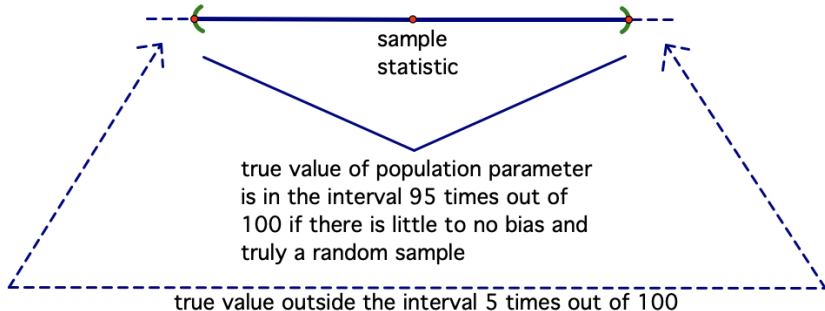


Confidence Levels

- If there is little to no bias and truly a random sample, then $x\%$ **confidence interval** is a numerical interval generated by a procedure that x times out of 100 will produce an interval that contains the true value for the entire population.

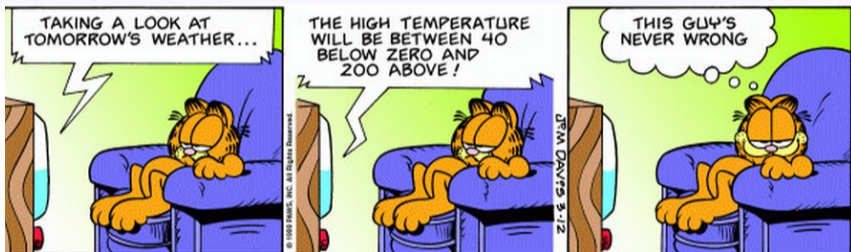
-margin of error=lower boundary

+margin of error=upper boundary



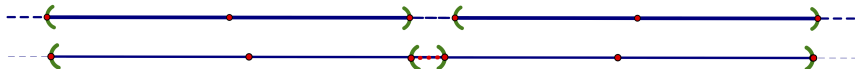
- Likelihood of the sample outcome—no way to know which intervals contain the true percentage and which don't

Margin of Error



Garfield by Jim Davis <https://garfield.com/comic/1999/03/12>

- **margin of error** gives a range the actual percentage is likely to be within if the sample size is large enough. Higher confidence level has a wider interval.
- For a 95% confidence interval, a sample of size n will have margin of error approximately $\frac{1}{\sqrt{n}}$ (**conservative estimate**).
- We check for overlaps in the intervals in order to evaluate the statistical validity of headlines and statements in polls



Statistically Accurate Claim?

“Desire to Migrate Rises in North Africa”

2017 lower boundary: $32 - 2 = 30\%$

2016 upper boundary: $28 + 2 = 30\%$

WORLD APRIL 24, 2018

Desire to Migrate Rises in North Africa

BY IMAN BERRACHED AND RJ REINHART

NORTH AFRICANS WHO WOULD LIKE TO
MIGRATE TO ANOTHER COUNTRY

2016

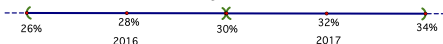
2017

28%

32%

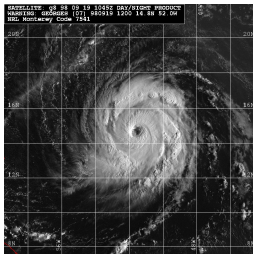
GALLUP WORLD POLL

it could have stayed the same!



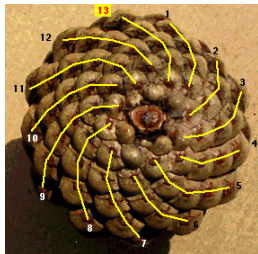
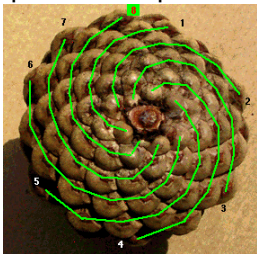
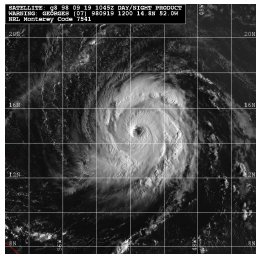
Statistics from Nature

Benford's Law and the likely frequency of the first digit applied to many data sets. Is there a pattern to spirals in nature?



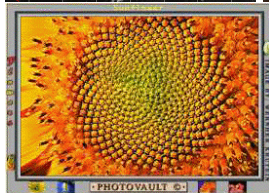
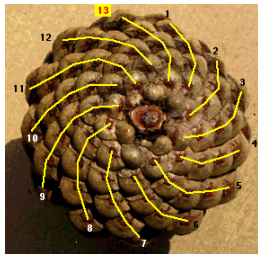
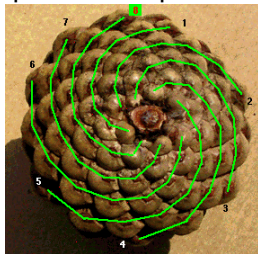
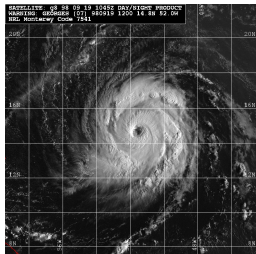
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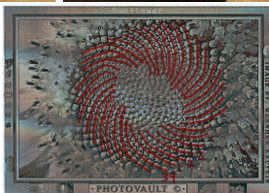
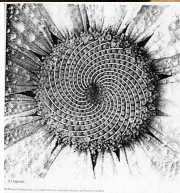
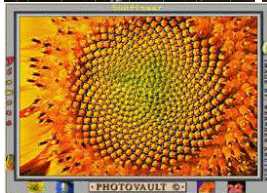
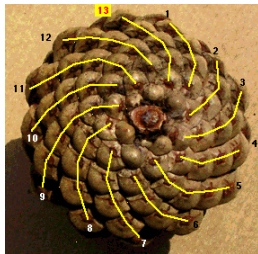
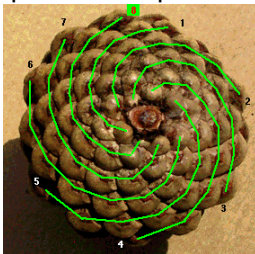
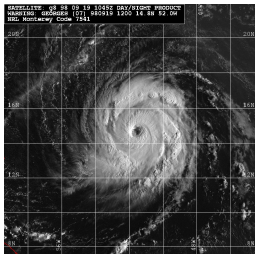
Statistics from Nature

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Picture credits:

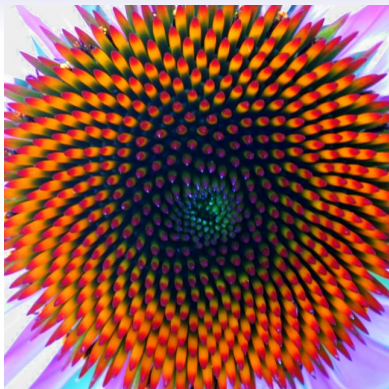
1. Clockwise hurricane Georges originated in southern hemisphere:

http://www.aoml.noaa.gov/hrd/Storm_pages/georges1998/sat.html

2-3. Ron Knott <http://www.maths.surrey.ac.uk/hosted-sites/R.Knott/Fibonacci/fibnat.html>

4 and 6. Wernher Krutein

5. *The Heart of Mathematics*





Picture credit:

Ron Knott <http://www.maths.surrey.ac.uk/hosted-sites/R.Knott/Fibonacci/fibnat.html>

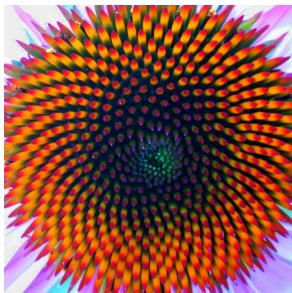
- Explore ideas systematically
- Look for a pattern
- Create abstract ideas by modeling nature
- Unexpected patterns are often a sign of hidden, underlying structure [and Excel can help us find it]
- Explore the consequences of new ideas



Picture credit:

Ron Knott <http://www.maths.surrey.ac.uk/hosted-sites/R.Knott/Fibonacci/fibnat.html>

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Picture credit:

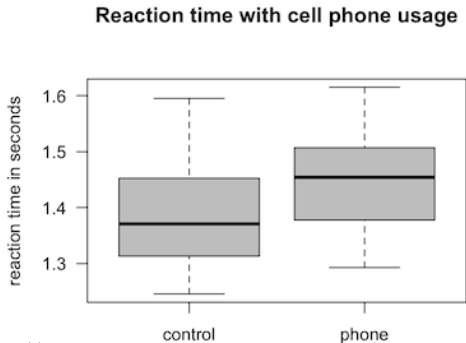
Ron Knott <http://www.maths.surrey.ac.uk/hosted-sites/R.Knott/Fibonacci/fibnat.html>

$$\frac{1+\sqrt{5}}{2} \approx 1.618033988749894848204586834365638117720$$

Why is it plausible that there is a pattern to spirals in nature? Where else do we find the same pattern?

http://www.youtube.com/watch?v=lOIP_Z_-0Hs

In the following we see two side-by-side boxplots on reaction times of control group vs cell users



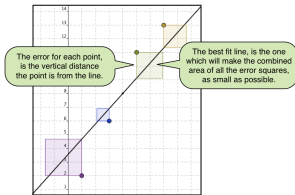
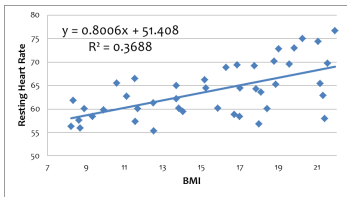
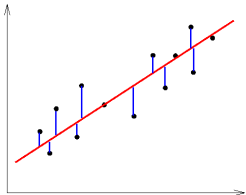
Picture: http://digitheadslabnotebook.blogspot.com/2010_06_01_archive.html

What can you say about the data from the median to Q3, the third quartile, of the reaction times?

- a) cell phone users did better because the data is more tightly clustered together
- b) control group did better because the data is lower
- c) neither

Strength of the Relationship: r^2 percent

- 0 to 10% **no**
- 10% to 25% **weak**
- 25% to 65% **moderate**
- above 65% **strong**
- NOT a probability for correct nor a likelihood of on the line
- measures the y-values distances via sum of squares as variation in the dependent variable explained by linearity



Picture citations:

1. <http://cs.wellesley.edu/~cs199/lectures/35-correlation-regression.html>
2. <http://www2.nau.edu/mat114-c/ch3a.php>
3. <http://math.maine121.org/welcome/chapter-5/>

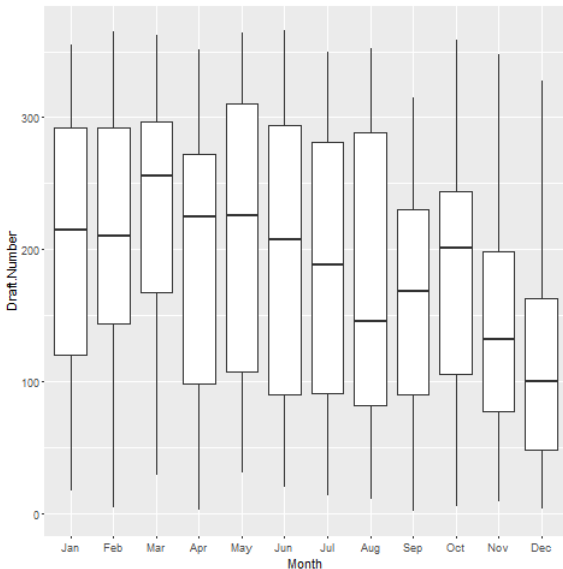
Would you have been drafted for Vietnam in 1969? Is there anyone in the class with the same birthday?

December 1, 1969 Vietnam Draft Lottery

https://www.youtube.com/watch?v=-p5X1FjyD_g

December 1, 1969 Vietnam Draft Lottery

https://www.youtube.com/watch?v=-p5X1FjyD_g



Joan Rosenblatt's 1970 Improvements

A truly unbiased military draft



January 01, 1970

Statisticians roundly criticized the 1969 draft lottery as unfair, so the Selective Service System asked NIST to devise an unquestionably random method for the 1970 draft. NIST mathematician Joan Rosenblatt and colleagues developed a method to randomly choose calendars and priority permutations for the draft. The new draft method was praised as fair, and Rosenblatt won the 1971 Federal Women's Award for her efforts on this and other projects.

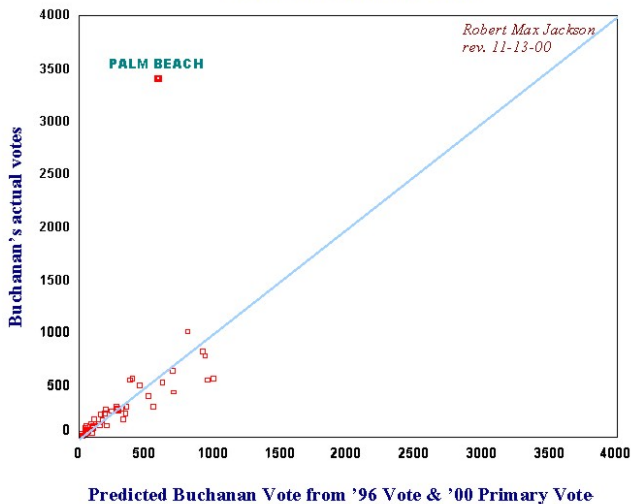
<https://www.nist.gov/node/774336>

Lottery procedure was improved the next year with a two-drum system. The 365 birthdates (for those born in 1951) were written down, placed in capsules, and put in a drum in the order dictated by random permutations. Similarly, the numbers from 1 to 365 were written down and placed into capsules. One drum was rotated for an hour and the other for a half-hour (its rotating mechanism failed). Pairs of capsules were then drawn, one from each drum, one with a 1951 birthdate and one with a number 1 to 365.

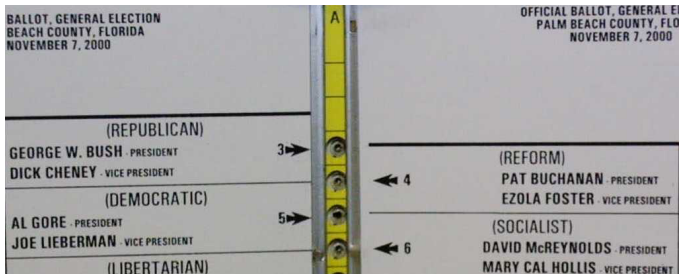
2000 Presidential Election—Bush, Gore, Buchanan

Florida Buchanan Vote by County Actual vs. Predicted

*Based Only on '96 Presidential Votes and
'00 Presidential Primary Votes*



2000 Presidential Election—Bush, Gore, Buchanan

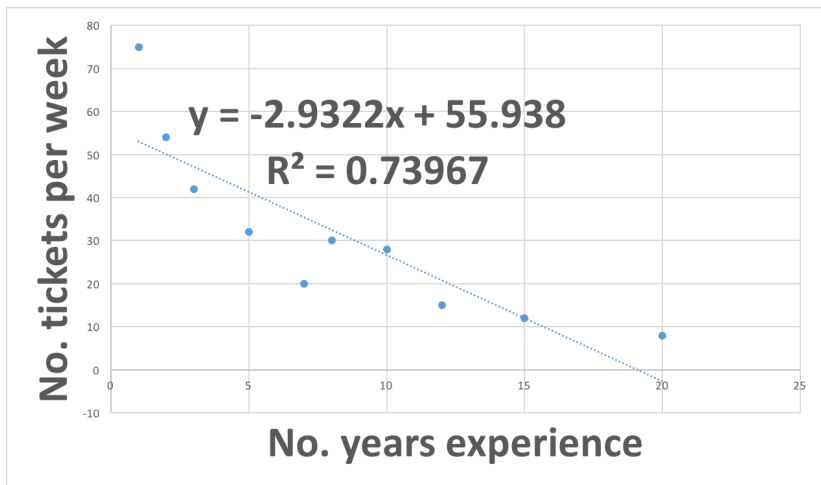


What does the y -intercept mean when x =#years and y =#tickets and the best fit line is $y = -2.932x + 55.038$?

- a) police give out 55 tickets as they start the job
- b) tickets are going down by about 3 with every extra year of experience
- c) neither

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$r = -.86$, so $r^2 = 73.96\%$, and this tells us that

- a) If you use the line to predict you'd get it right 74% of the time
- b) The y -value distances of the data to the best fit line are small so experience in this data is a statistically strong predictor of tickets

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The r^2 value is strong but the line $y = -2.932(25) + 55.038$ predicts that the police receives tickets after 25 years. Resolve the apparent conflict.

- a) There is a typo—the actual r^2 value should be weak
- b) The mathematics of the r^2 value and the prediction are correct: the police gets sloppy as they get older, causing them to be penalized
- c) There are other reasons why the prediction doesn't hold up like extrapolation

How to Get Rich Quick as a Stock Whiz

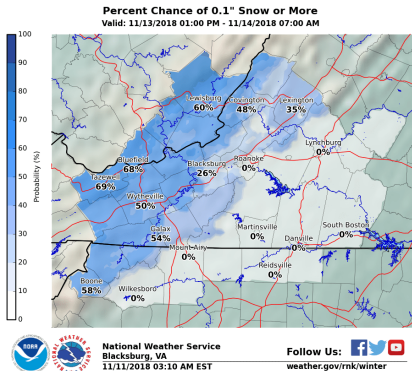
If the r^2 value was 100%, would you be assured to make money by using the best fit line to predict the future performance?

- a) yes
- b) no

How to Get Rich Quick as a Stock Whiz

If the r^2 value was 100%, would you be assured to make money by using the best fit line to predict the future performance?

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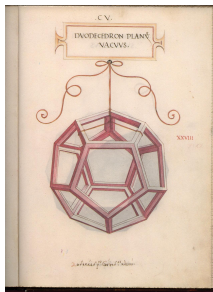
Picture and data: <https://www.weather.gov/rnk/winter>

$\geq .1''$	$\geq 1''$	$\geq 2''$	$\geq 4''$	$\geq 6''$	$\geq 8''$	$\geq 12''$	$\geq 18''$
58%	3%	0%	0%	0%	0%	0%	0%

The weather, stocks and more are chaotic dynamical systems with uncertainty within expected values

As a researcher, was it ethical to remove the armspan/height points that I eliminated and keep the remaining points?

- a) yes
- b) no
- c) did not complete



Picture credit: <https://www.maa.org/press/periodicals/convergence/leonardo-da-vincis-geometric-sketches-dodecahedron>

[//www.maa.org/press/periodicals/convergence/leonardo-da-vincis-geometric-sketches-dodecahedron](https://www.maa.org/press/periodicals/convergence/leonardo-da-vincis-geometric-sketches-dodecahedron)

We thank the Pennsylvania State University Libraries for allowing Convergence to publish the images above of Da Vinci's illustrations from their copy of the beautiful facsimile of Pacioli's De divina proportione...

In the egg bungee experiment the similarity of the rubber bands led to an almost constant slope = $\frac{\Delta y}{\Delta x} = \frac{\Delta \text{distance dropped}}{\Delta \text{rubber bands}}$

- a) egg-sactly
- b) egg-stremely close
- c) somewhat
- d) not at all
- e) did not complete

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- a) egg-sactly
- b) egg-stremely close
- c) somewhat
- d) not at all
- e) did not complete

My group used less than or equal to the number of rubber bands that the line predicted for 200 cm:

- a) true
- b) false
- c) did not complete

Even without r^2 in front of us, we can visually inspect and categorize relationships. From Gapminder did you think that recent Income is at least a statistically moderate predictor of Life expectancy (i.e. moderate/strong versus a no/weak correlation)?

- a) yes
- b) no
- c) did not complete

[http://www.gapminder.org/tools/#\\$chart-type=bubbles](http://www.gapminder.org/tools/#$chart-type=bubbles)

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What did you find interesting or surprising, or that you had a question on, in the Gapminder exploration.

Upcoming case studies