Course Reminders

- A1 due Friday (11:59 PM)
- Project Proposals due next Friday (11:59 PM)
  - **By this Friday**: http://bit.ly/groups_wi20
    - One entry per group
    - Will create a GH repo for each group
    - Will give access to group members
    - Please type GH usernames into form correctly

Data Wrangling & Intuition

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"Good data scientists understand, in a deep way, that the heavy lifting of cleanup and preparation isn't something that gets in the way of solving the problem: it is the problem." - DJ Patil

untidy data

Australian Bureau of Statistics

Table junk

1800.0 Australian Marriage Law Postal Survey, 2017

Released on 15 November 2017

Table 5 Participation by Federal Electoral Division(a), Males and Age — Gender apartheid

Yeah NA

		18-19 years	20-24 years	25-29 years	30-34 years	35-39 years	40-44 years	45-49 years	50-54 years	55-59 years	60-64 years
Lingiari(c)	Total participants	292	1,068	1,465	1,653	1,515	1,516	1,710	1,730	1,753	1,574
	Eligible participants	572	2,910	3,789	3,996	3,607	3,506	3,645	3,331	2,960	2,456
	Participation rate (%)	51.0	36.4	38.7	41.4	42.0	43.2	46.9	51.9	59.2	64.1
Solomon	Total participants	442	1,461	2,066	2,357	2,188	2,057	2,224	2,108	2,134	1,772
	Eligible participants	750	2,991	3,994	4,155	3,634	3,398	3,427	3,066	2,931	2,355
	Participation rate (%)	58.9	48.8	51.7	56.7	60.2	60.5	64.9	68.8	72.8	75.2
Northern Territory (Total)	Total participants	734	2,519	3,531	4,010	3,703	3,573	3,934	3,838	3,887	3,346
	Eligible participants	1,322	5,901	7,783	8,151	7,241	6,904	7,072	6,397	5,891	4,811
	Participation rate (%)	55.5	42.7	45.4	49.2	51.1	51.8	55.6	60.0	66.0	69.5
Australian Capital Territory Divisions											
Canberra(d)	Total participants	1,764	4,789	4,817	4,973	4,626	4,453	5,074	4,826	5,169	4,394
	Eligible participants	2,260	6,471	6,448	6,509	5,983	5,805	6,302	5,902	6,044	5,057
	Participation rate (%)	78.1	74.0	74.7	76.4	77.3	76.7	80.5	81.8	85.5	86.9
Fenner(e)	Total participants	1,477	4,687	5,178	5,786	6,025	5,463	5,191	4,208	3,948	3,465
	Eligible participants	1,904	6,354	7,121	7,822	7,960	7,155	6,480	5,206	4,692	3,945
	Participation rate (%)	77.6	73.8	72.7	74.0	75.7	76.4	80.1	80.8	84.1	87.8
Australian Capital Territory (Total)	Total participants	3,241	9,476	9,995	10,759	10,651	9,916	10,265	9,034	9,117	7,859
	Eligible participants	4,164	12,825	13,569	14,331	13,943	12,960	12,782	11,108	10,736	9,002
	Participation rate (%)	77.8	73.9	73.7	75.1	76.4	76.5	80.3	81.3	84.9	87.3
Australia											
Total	Total participants	151,297	438,166	441,658	460,548	462,206	479,360	524,620	517,693	543,449	506,799
	Eligible participants	201,439	635,909	646,916	665,250	656,446	660,841	693,850	659,150	664,720	597,386
	Participation rate (%)	75.1	68.9	68.3	69.2	70.4	72.5	75.6	78.5	81.8	84.8

(a) The Federal Electoral Divisions are current as at 24 August 2017
(b) Includes those whose age is unknown
(c) Includes Christmas Island and the Cocos (Keeling) Islands
(d) Includes Norfolk Island
(e) Includes Jervis Bay

Primary keynotes

Merged cells

Comma on

Covariate as Subheading

Summary of data inside data

NA Yeah

Return of the table junk

MS Excel or Die

data wrangling

tidy data

	area	gender	age	State	Area (sq km)	Eligible participants	Participation rate (%)	Total participants	Total Paticipants
2	Adelaide	Female	18-19 years	SA	76	1341	83.5	1120	1120
3	Adelaide	Female	20-24 years	SA	76	4620	81.2	3750	3750
4	Adelaide	Female	25-29 years	SA	76	4897	81.8	4004	4004
5	Adelaide	Female	30-34 years	SA	76	4784	79.8	3820	3820
6	Adelaide	Female	35-39 years	SA	76	4319	79	3411	3411
7	Adelaide	Female	40-44 years	SA	76	4310	80.6	3472	3472
8	Adelaide	Female	45-49 years	SA	76	4579	81.4	3728	3728
9	Adelaide	Female	50-54 years	SA	76	4475	84.7	3791	3791
10	Adelaide	Female	55-59 years	SA	76	4622	87.3	4033	4033
11	Adelaide	Female	60-64 years	SA	76	4342	89.3	3879	3879
12	Adelaide	Female	65-69 years	SA	76	3970	90.7	3602	3602
13	Adelaide	Female	70-74 years	SA	76	3009	90.3	2716	2716
14	Adelaide	Female	75-79 years	SA	76	2156	88.5	1908	1908
15	Adelaide	Female	80-84 years	SA	76	1673	85.1	1423	1423

https://medium.com/@miles.mcbain/tidying-the-australian-same-sex-marriage-postal-survey-data-with-r-5d35cea07962

Tidy Data

1. Each variable you measure should be in a single column

	A	B	C	D	E	F	G
1	ID	LastName	FirstName	Sex	City	State	Occupation
2	1004	Smith	Jane	female	Frederick	MD	Welder
3	4587	Nayef	Mohammed	male	Upper Darby	PA	Nurse
4	1727	Doe	Janice	female	San Diego	CA	Doctor
5	6879	Jordan	Alex	male	Birmingham	AL	Teacher

2. Every observation of a variable should be in a different row

	A	B	C	D	E	F	G
1	ID	LastName	FirstName	Sex	City	State	Occupation
2	1004	Smith	Jane	female	Frederick	MD	Welder
3	4587	Nayef	Mohammed	male	Upper Darby	PA	Nurse
4	1727	Doe	Janice	female	San Diego	CA	Doctor
5	6879	Jordan	Alex	male	Birmingham	AL	Teacher

3. There should be one table for each type of data

Demographic Survey Data

	A	B	C	D	E	F	G
1	ID	LastName	FirstName	Sex	City	State	Occupation
2	1004	Smith	Jane	female	Frederick	MD	Welder
3	4587	Nayef	Mohammed	male	Upper Darby	PA	Nurse
4	1727	Doe	Janice	female	San Diego	CA	Doctor
5	6879	Jordan	Alex	male	Birmingham	AL	Teacher

Doctor's Office Measurements Data

	A	D	E	F	G
1	ID	Height_inches	Weight_lbs	Insulin	Glucose
2	1004	65	180	0.60	163
3	4587	75	215	1.46	150
4	1727	62	124	0.72	177
5	6879	77	160	1.23	205

4. If you have multiple tables, they should include a column in each *with the same column label* that allows them to be joined or merged

	A	B	C	D	E	F	G
1	ID	LastName	FirstName	Sex	City	State	Occupation
2	1004	Smith	Jane	female	Frederick	MD	Welder
3	4587	Nayef	Mohammed	male	Upper Darby	PA	Nurse
4	1727	Doe	Janice	female	San Diego	CA	Doctor
5	6879	Jordan	Alex	male	Birmingham	AL	Teacher

	A	D	E	F	G
1	ID	Height_inches	Weight_lbs	Insulin	Glucose
2	1004	65	180	0.60	163
3	4587	75	215	1.46	150
4	1727	62	124	0.72	177
5	6879	77	160	1.23	205

Tidy data == rectangular data

A

	A	B	C	D	E
1	id	sex	glucose	insulin	triglyc
2	101	Male	134.1	0.60	273.4
3	102	Female	120.0	1.18	243.6
4	103	Male	124.8	1.23	297.6
5	104	Male	83.1	1.16	142.4
6	105	Male	105.2	0.73	215.7

Broman KW, Woo KH. (2017) Data organization in spreadsheets. *PeerJ Preprints* 5:e3183v1 https://doi.org/10.7287/peerj.preprints.3183v1

Tidy Data Benefits

1. consistent data structure
2. foster tool development
3. require only a small set of tools to be learned
4. allow for datasets to be combined

Common Problems with Messy Data Sets

1. Column headers are values but should be variable names.

2. A single column has multiple variables.

3. Variables have been entered in both rows and columns.

4. Multiple "types" of data are in the same spreadsheet.

5. A single observation is stored across multiple spreadsheets.

Tabular Data Time

A

ID	Last	First	height_m	height_f
1004	Smith	Jane	NA	65
4587	Nayef	Mohammed	72	NA
1727	Doe	Janice	NA	60
6879	Jordan	Alex	55	NA

B

ID	Last	First	height_m	height_f
1004	Smith	Jane		65
4587	Nayef	Mohammed	72	
1727	Doe	Janice		60
6879	Jordan	Alex	55	

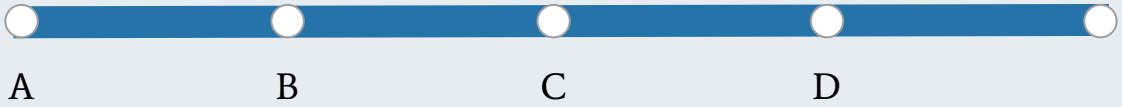
C

ID	Last	First	sex	height
1004	Smith	Jane	female	65
4587	Nayef	Mohammed	male	72
1727	Doe	Janice	fem	60
6879	Jordan	Alex	male	55

D

ID	Last	First	sex	height
1004	Smith	Jane	F	65
4587	Nayef	Mohammed	M	72
1727	Doe	Janice	F	60
6879	Jordan	Alex	M	55

Which of these tables stores data best?

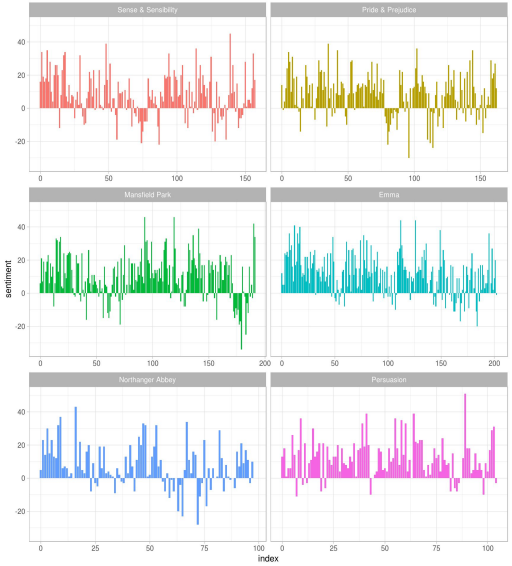


text

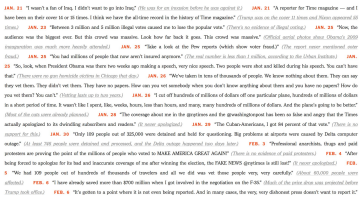
tidy dataset

Word	Novel	Frequency
good	Emma	359
young	Emma	192
friend	Emma	166

results



website

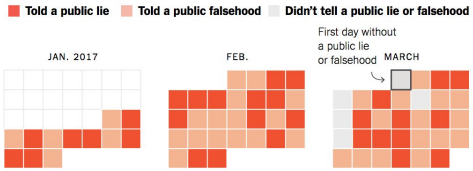


JAN. 21 "I wasn't a fan of Iraq. I didn't want to go into Iraq." *(He was for an invasion before he was against it.)* JAN. 21 "A reporter for Time magazine — and I have been on their cover 14 or 15 times. I think we have the all-time record in the history of Time magazine." *(Trump was on the cover 11 times and Nixon appeared 55 times.)* JAN. 23 "Between 3 million and 5 million illegal votes caused me to lose the popular vote." *(There's no evidence of illegal voting.)* JAN. 25 "Now, the audience was the biggest ever. But this crowd was massive. Look how far back it goes. This crowd was massive." *(Official aerial photos show Obama's 2009 inauguration was much more heavily attended.)* JAN. 25 "Take a look at the Pew reports (which show voter fraud.)" *(The report never mentioned voter fraud.)* JAN. 25 "You had millions of people that now aren't insured anymore." *(The real number is less than 1 million, according to the Urban Institute.)* JAN. 25 "So, look, when President Obama was there two weeks ago making a speech, very nice speech. Two people were shot and killed during his speech. You can't have that." *(There were no gun homicides victims in Chicago that day.)* JAN. 26 "We've taken in tens of thousands of people. We know nothing about them. Then can say they vet them. They didn't vet them. They have no papers. How can you vet somebody when you don't know anything about them and you have no papers? How do you vet them? You can't." *(Nothing lasts up to two years.)* JAN. 26 "I cut off hundreds of millions of dollars off one particular plane, hundreds of millions of dollars in a short period of time. It wasn't like I spent, like, weeks, hours, less than hours, and many, many hundreds of millions of dollars. And the plane's going to be better." *(Most of the cuts were already planned.)* JAN. 28 "The coverage about me in the @nytimes and the @washingtonpost has been so false and angry that the Times actually apologized to its dwindling subscribers and readers." *(It never apologized.)* JAN. 29 "The Cuban-Americans, I got 84 percent of that vote." *(There is no support for this.)* JAN. 30 "Only 109 people out of 325,000 were detained and held for questioning. Big problems at airports were caused by Delta computer outage." *(At least 500 people were detained and processed, and the Delta outage happened two days later.)* FEB. 3 "Professional anarchists, thugs and paid protesters are proving the point of the millions of people who voted to MAKE AMERICA GREAT AGAIN!" *(There is no evidence of paid protesters.)* FEB. 4 "After being forced to apologize for its bad and inaccurate coverage of me after winning the election, the FAKE NEWS @nytimes is still lost!" *(It never apologized.)* FEB. 5 "We had 109 people out of hundreds of thousands of travelers and all we did was vet those people very, very carefully." *(About 60,000 people were affected.)* FEB. 6 "I have already saved more than $700 million when I got involved in the negotiation on the F-35s" *(Much of the price drop was negotiated before Trump took office.)* FEB. 6 "It's gotten to a point where it is not even being reported. And in many cases, the very, very dishonest press doesn't want to report it."

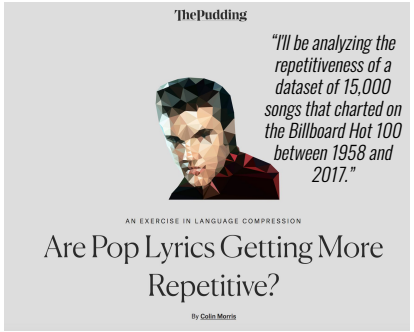
tidy dataset

	date	lie	explanation	url
0	Jan. 21, 2017	I wasn't a fan of Iraq. I didn't want to go in...	He was for an invasion before he was against it.	https://www.buzzfeed.com/andrewkaczynski/in-20...
1	Jan. 21, 2017	A reporter for Time magazine — and I have been...	Trump was on the cover 11 times and Nixon appe...	http://nation.time.com/2013/11/06/10-things-yo...
2	Jan. 23, 2017	Between 3 million and 5 million illegal votes ...	There's no evidence of illegal voting.	https://www.nytimes.com/2017/01/23/us/politics...
3	Jan. 25, 2017	Now, the audience was the biggest ever. But th...	Official aerial photos show Obama's 2009 inaug...	https://www.nytimes.com/2017/01/21/us/politics...
4	Jan. 25, 2017	Take a look at the Pew reports (which show vot...	The report never mentioned voter fraud.	https://www.nytimes.com/2017/01/24/us/politics...

results



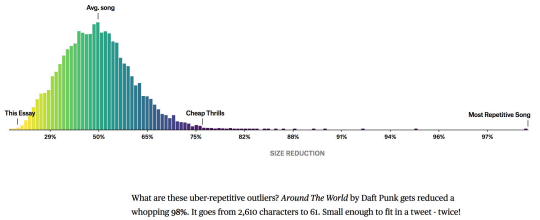
text (lyrics)



tidy dataset

song	Artist	Released	Reduction
Cheap Thrills	Sia	2016	76
Around The World	Daft Punk	1997	98
Everybody Dies	J. Cole	2018	27

results



https://pudding.cool/2017/05/song-repetition/

Data Intuition

1011

1375

In today's pattern recognition class my professor talked about PCA, eigenvectors and eigenvalues.

I understood the mathematics of it. If I'm asked to find eigenvalues etc. I'll do it correctly like a machine. But I didn't **understand** it. I didn't get the purpose of it. I didn't get the feel of it.

I strongly believe in the following quote:

> You do not really understand something unless you can explain it to your grandmother. -- Albert Einstein

Well, I can't explain these concepts to a layman or grandma.

1. Why PCA, eigenvectors & eigenvalues? What was the *need* for these concepts?
2. How would you explain these to a layman?

https://stats.stackexchange.com/questions/2691/making-sense-of-principal-component-analysis-eigenvectors-eigenvalues

Theory vs. Practice: “Tai’s model”

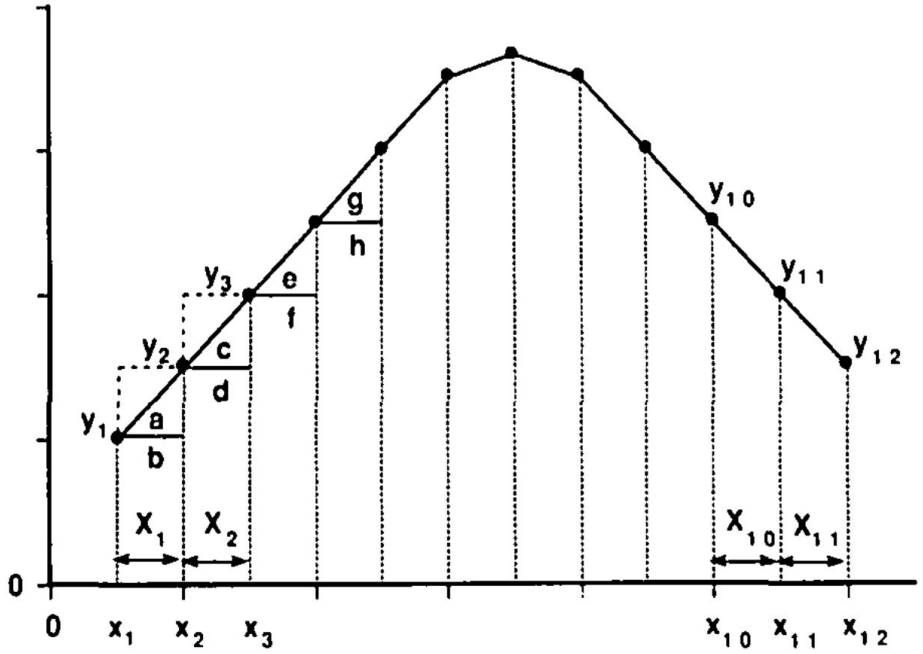
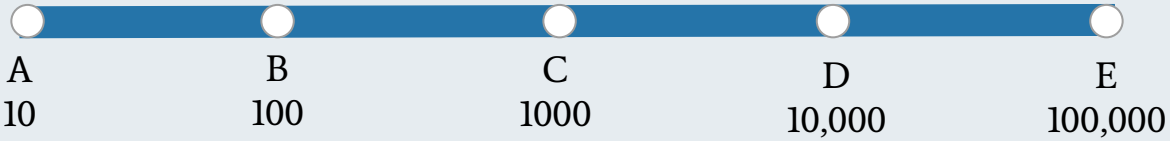


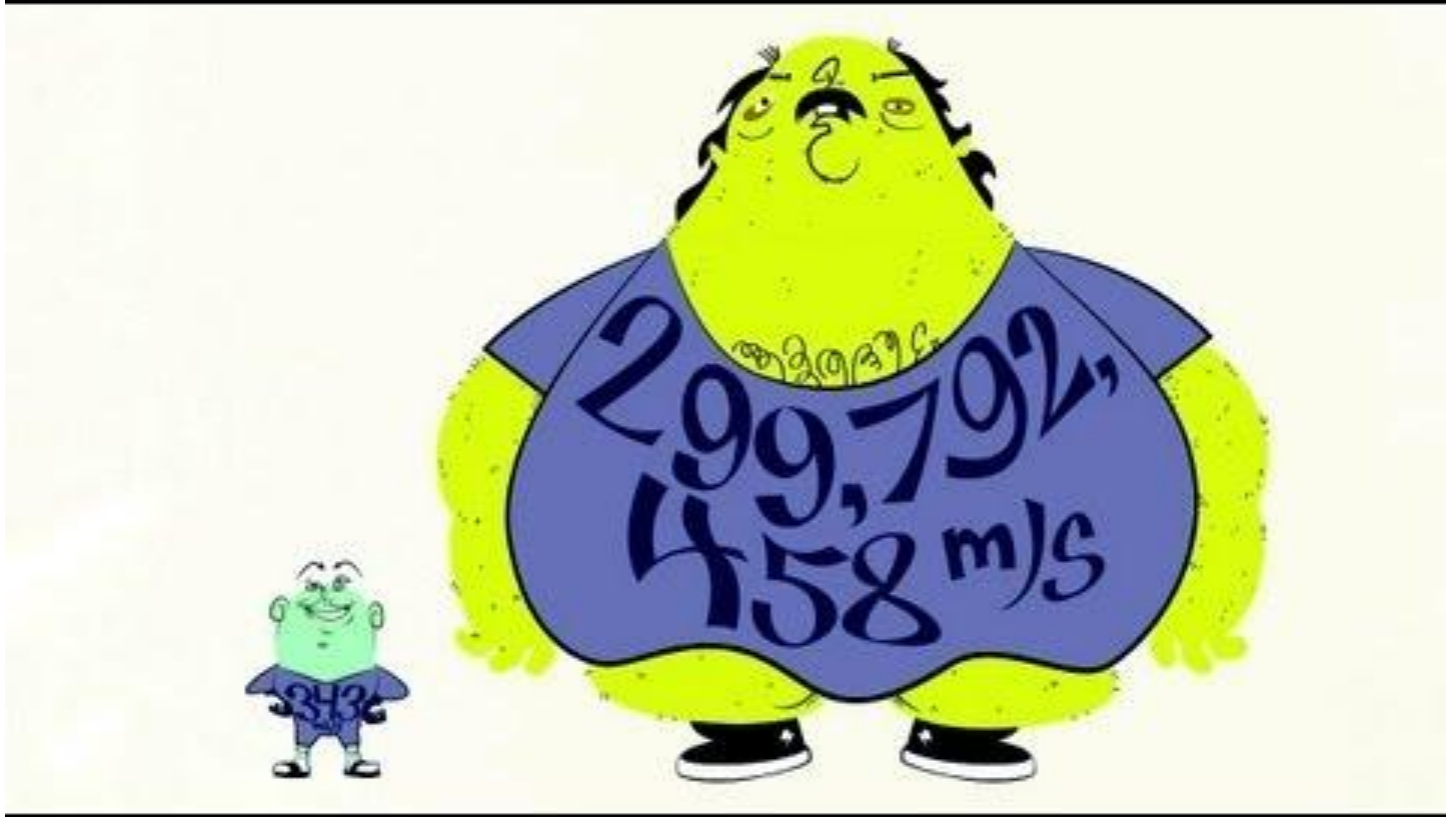
Figure 1—*Total area under the curve is the sum of individual areas of triangles a, c, e, and g and rectangles b, d, f, and h.*

Tai, *Diabetes Care* (1994)

Fermi Estimation

Approximately how many piano tuners do you think there are in the city of Chicago?





https://www.youtube.com/watch?v=0YzvupOX8Is

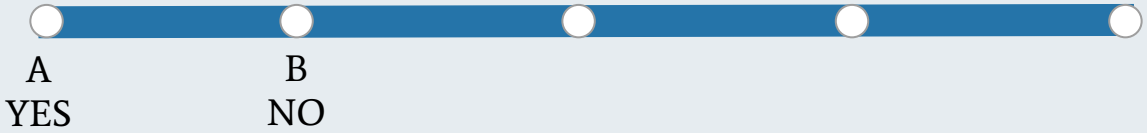
Has humanity produced enough paint to cover the entire land area of the Earth?

—Josh (Bolton, MA)

https://what-if.xkcd.com/84/

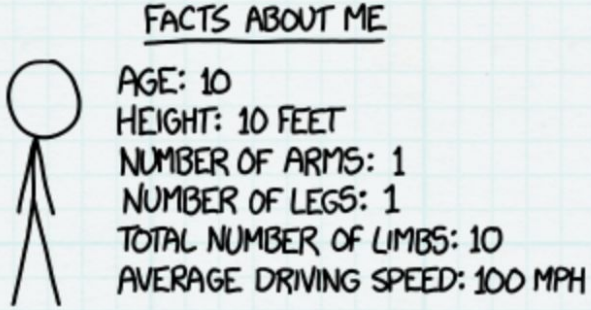
Fermi Estimation

Has humanity produced enough paint to cover the entire land area of the Earth?

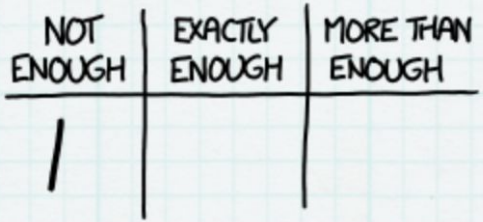


This answer is pretty straightforward. We can look up the size of the world's paint industry, extrapolate backward to figure out the total amount of paint produced. We'd also need to make some assumptions about how we're painting the ground. Note: When we get to the Sahara desert, I recommend not using a brush.

But first, let's think about different ways we might come up with a guess for what the answer will be. In this kind of thinking—often called **Fermi estimation**—all that matters is getting in the right ballpark; that is, the answer should have about the right number of digits. In Fermi estimation, you can round [1] all your answers to the nearest order of magnitude:



Let's suppose that, on average, everyone in the world is responsible for the existence of two rooms, and they're both painted. My living room has about 50 square meters of paintable area, and two of those would be 100 square meters. 7.15 billion people times 100 square meters per person is a little under a trillion square meters—an area smaller than Egypt.

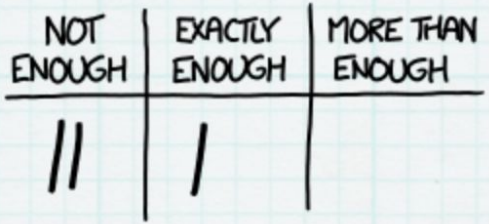


Let's make a wild guess that, on average, one person out of every thousand spends their working life painting things. If I assume it would take me three hours to paint the room I'm in, [2] and 100 billion people have ever lived, and each of them spent 30 years painting things for 8 hours a day, we come up with 150 trillion square meters ... just about exactly the land area of the Earth.

How much paint does it take to paint a house? I'm not enough of an adult to have any idea, so let's take another Fermi guess.

Based on my impressions from walking down the aisles, home improvement stores stock about as many light bulbs as cans of paint. A normal house might have about 20 light bulbs, so let's assume a house needs about 20 gallons of paint.[3] Sure, that sounds about right.

The average US home costs about $200,000. Assuming each gallon of paint covers about 300 square feet, that's a square meter of paint per $300 of real estate. I vaguely remember that the world's real estate has a combined value of something like $100 trillion, [4] which suggests there's about 300 billion square meters of paint on the world's real estate. That's about one New Mexico.



Of course, both of the building-related guesses could be overestimates (lots of buildings are not painted) or underestimates (lots of things that are not buildings [5] are painted) But from these wild Fermi estimates, my guess would be that there probably isn't enough paint to cover all the land.

So, how did Fermi do?

According to the report **The State of the Global Coatings Industry**, the world produced 34 billion liters of paints and coatings in 2012.

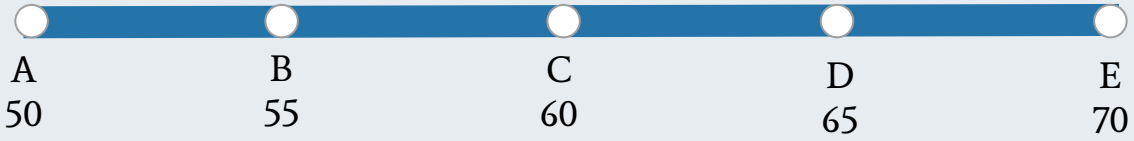
There's a neat trick that can help us here. If some quantity—say, the world economy—has been growing for a while at an annual rate of **n**—say, 3% (0.03)—then the most recent year's share of the whole total so far is $1 - \frac{1}{1+n}$, and the whole total so far is the most recent year's amount times $1 + \frac{1}{n}$.

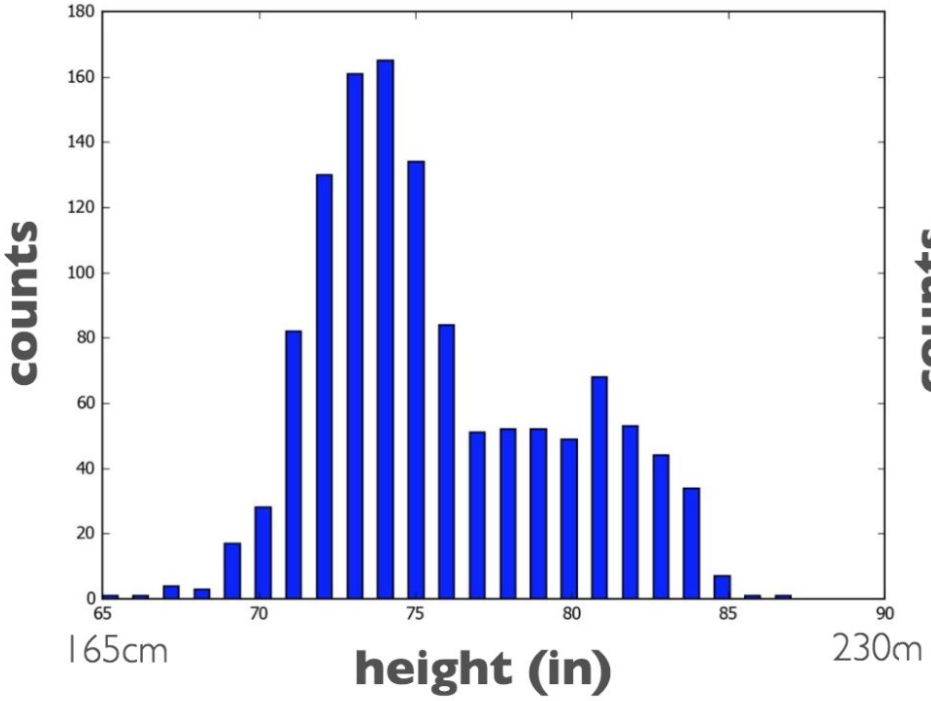
If we assume paint production has, in recent decades, followed the economy and grown at about 3% per year, that means the total amount of paint produced equals the current yearly production times 34. [6] That comes out to a little over a trillion liters of paint. At 30 square meters per gallon, [7] that's enough to cover 9 trillion square meters—about the area of the United States.

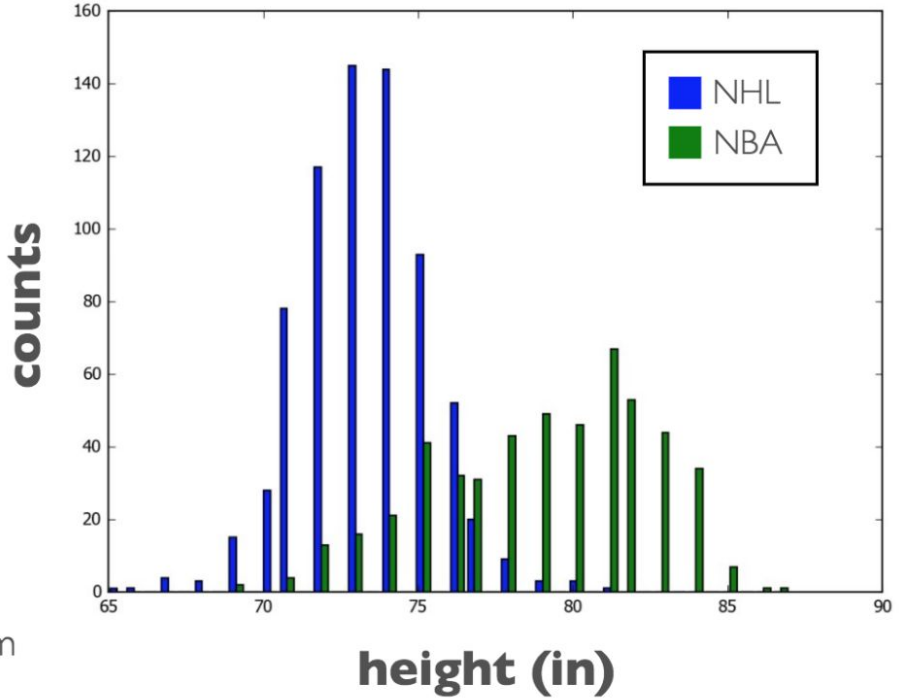
So the answer is no; there's not enough paint to cover the Earth's land, and—at this rate—probably won't be enough until the year 2100.

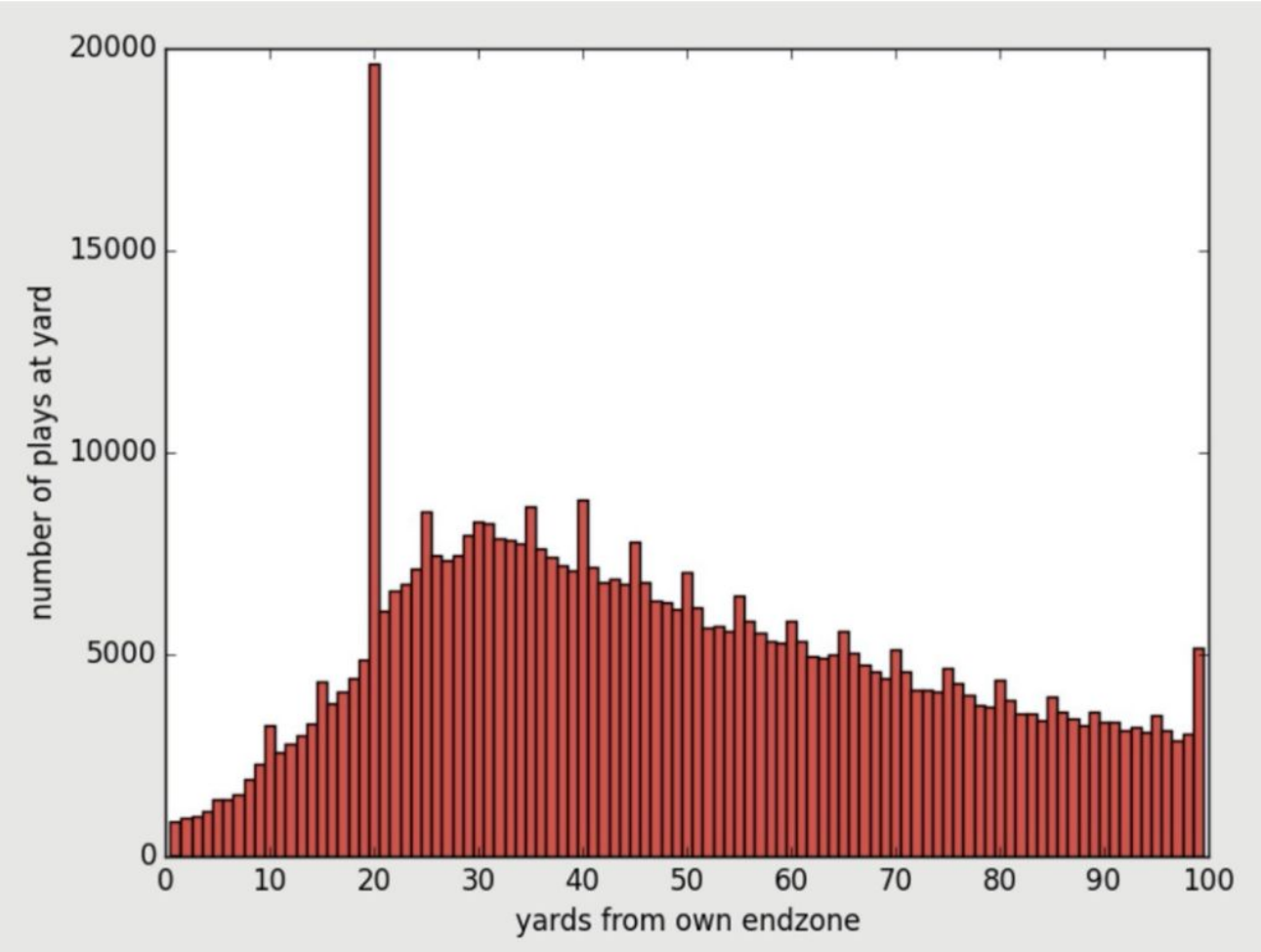
Wisdom of the crowds

What is the average height (in inches) of adult Americans?




counts
height (in)
165cm
230m


NHL
NBA
counts
height (in)

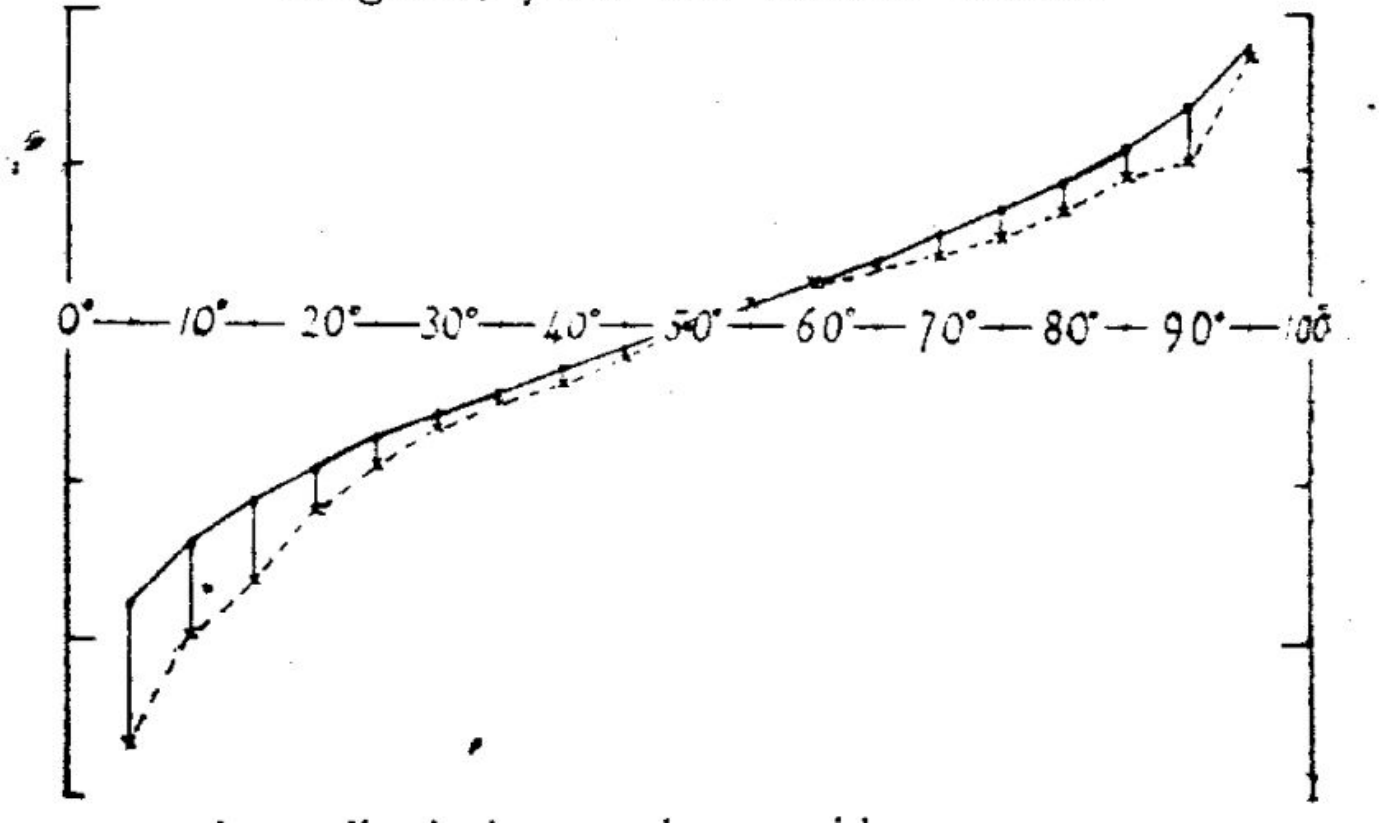

20000
15000
10000
5000
0
number of plays at yard
0
10
20
30
40
50
60
70
80
90
100
yards from own endzone

Data Intuition

1. Think about your question and your expectations
2. Do some Fermi (back of the envelope calculations)
3. Write code & look at outputs <- think about those outputs
4. Use your gut instinct / background knowledge to guide you
5. Review code & fix bus

Vox Populi

Diagram, from the tabular values.



Galton, *Nature* (1907)

The Wisdom of the Crowds

- Diversity of opinion: Each person should have private information....even if it's just an eccentric interpretation of the known facts
- Independence: People's opinions aren't determined by the opinions of those around them
- Decentralization: People are able to specialize and draw on local knowledge
- Aggregation: Some mechanism exists for turning private judgements into a collective decision