

A Short Course in Numeric Self Defense

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Oil futures

"Perhaps the Bush administration could use the 660-billion-barrel Strategic Petroleum Reserve to push prices down."

Newsweek, 5/24/04 (when gas was under \$2/gallon)

"The average vehicle uses 550 gallons/year."

How long will the Strategic Petroleum Reserve last?



Oil futures (2)

- How many vehicles are there?
 - about one per person?
 - so about 300 million



- How big is a barrel?
 - bigger than a beer keg?
 - like a 55 gallon drum?
 - call it 50 gallons



Oil futures (3)

$$\begin{aligned} 500 \text{ gallons/year} &= 10 \text{ barrels/year} \\ 300 \text{ million cars} \times 10 \text{ barrels/car} \\ &= 3 \text{ billion barrels/year} \end{aligned}$$

The Reserve contains 660 billion barrels.
We use 3 billion barrels a year.
It will last over 200 years.

Why are we worried about oil??

Oil futures (4)

"...we said that the size of the Strategic Petroleum Reserve is 660 billion barrels.
It is actually 660 million barrels."

Newsweek, 6/7/04

In case you were wondering...

"A barrel holds 42 gallons, not 42,000 gallons."
(New York Times, 6/9/10)

Millions, billions, zillions

The bailout will cost \$700 billion, not million.

(New York Times, 9/25/08)

The U.S. budget deficit is projected to total \$1.2 trillion this year, not \$1.2 billion.

(Wall Street Journal, 1/13/09)

Total credit limits are \$3.4 trillion, not billion.

(New York Times, 11/11/09)

The rescue package for ailing European economies is 750 billion euros, not 750 million.

(New York Times, 5/25/10)

Cutting big numbers down to size

"The yearly budget deficit stands at \$1.3 billion."
(New York Times, 10/24/10)

How much is that per person?

\$1.3 billion / 300 million is about \$4 / person

Does that seem a bit low?

The deficit is \$1.3 trillion, not billion

or about \$4,000 / person

Kilo, mega, giga, tera, peta, ...

A petaflop is a **thousand trillion instructions per second, not a million trillion.**

(New York Times, 3/25/08)

A teravolt or TeV is a **million million electron volts, not a billion billion.**

(theusdaily.com, 3/30/10)

..., exa, zetta, yotta, ...

The Nook e-book reader has 2 GB of memory, "enough to hold about 1,500 digital books."

(Wall Street Journal, 12/9/09)

A zettabyte (10^{21} bytes) "is equivalent to 100 billion copies of all the books in the Library of Congress."

(New York Times, 12/10/09)

How many books are there in the Library of Congress?

How many books in the Library of Congress?

WSJ: a book is 2×10^9 / 1.5×10^3 bytes
~ 10^6 bytes/book

NYT: 10^{21} bytes in 100 billion copies
= 10^{21} bytes / 100×10^9 copies
= 10^{10} bytes in 1 copy of all the books

So: 10^{10} bytes in 1 copy / 10^6 bytes/book
= 10^4 books

The Library of Congress has 10,000 books.

Numeric triage: is the number likely to be much too high, much too low, or plausible?

"Americans receive almost 2 million tons of junk mail daily."

Dear Abby, 1/3/96

2 million tons = 4 billion pounds
300 million Americans

~ 13 pounds / person / day

Much too high, much too low, or plausible?

"Each person eats about sixty tons of food in a lifetime."

Microcosm, Carl Zimmer, 2008

60 tons/lifetime ~ 1 ton / year
~ 2000 lb / 365 days
~ 5 pounds / day

Much too high, much too low, or plausible?

"Shutting down your computer and monitor overnight rather than running them 24 hours a day will save \$88 a day."

(Newark Star Ledger, 12/08)

Plausibility and common sense

- does the number make sense?
- does it agree with your experience, or run counter to it?
- what would be the implications if the number were accurate?

Faster than a speeding bullet...

The Times

November 16, 2004

Nasa jet travels 850 miles in 10 seconds

FROM CHRIS AYRES IN LOS ANGELES

AN AIRCRAFT that can fly at ten times the speed of sound will be tested over the Pacific Ocean today — possibly leading to "hypersonic" cruise missiles that could travel from Los Angeles to Pyongyang in less than an hour.

The aircraft was designed by Nasa to travel 850 miles in just ten seconds, or 7,000mph.

www.timesonline.co.uk
TIMESONLINE
The best of The Times and The Sunday Times, in real time.

(London Times)

White water?

"The Passaic River was traveling about 200 miles per hour, about five times faster than average." (Newark Star Ledger, 6/10/92)



Know some basic facts and conversions

- 6.8 billion people (China 1.3B, India 1.2B, USA 300M, NYC 9M)
- 1 gallon of water weighs ~ 8 lb
 - 1 cubic foot of water weighs ~ 60 lb (rock 200, steel 500)
- 1 liter is just over 1 quart
- 1 kilogram is ~ 2.2 lb (28 gms in an ounce)
- 1 ton is 2000 lb (a metric ton is 1000 kg ~ 2200 lb)
- 1 meter is a little over 3 feet or 1 yard
- MP3 music is 1 MB/minute
- electricity costs 15-20 cents/KWH
- 100K seconds in a day, 500K minutes (30M seconds) in a year
- speed of light: 1 foot/nanosecond, speed of sound: 1000 feet/sec
- 250 working days/year, 2000 hours/year,
- ...

Learn to estimate

How many golf balls can fit in a school bus?



How many petabytes could you fit in this room?



Milestones

"Every day, 10,000 Americans turn 50 years old."

Gambling Magazine, 12/31/05

Little's Law: a "conservation law"

number in process = arrival rate x service time

- **6600 Harvard undergrads** (number in process)
- **each spends 4 years** (service time)
- **1650 arrive each year** (arrival rate)
1650 leave each year (departure rate)

Little's Law

number in process = arrival rate x service time

- **300 million Americans** (number in process)
- **if each lives to 100** (service time)
 - **3 million die each year** (departure rate)
 - **3 million reach any given milestone each year**
- **if each lives to 75**
 - **4 million reach any given milestone each year**
 - **about 10,000 reach any milestone each day**

Milestones

"Every day, 10,000 Americans turn 50 years old."

Gambling Magazine, 12/31/05

"Every week for the next 18 years, some 88,500 baby boomers will turn 59½."

Newsweek, 9/12/05

"350,000 Americans turn 50 every month."

Forbes, 1/10/05

"4 million students graduate from high school each year."

New York Times, 7/9/10

Some things to watch out for

- errors of dimensionality
- oddly precise numbers
- graphical trickery
- flaky data
- advocacy bias

The screenshot shows a news article titled "N.J. Fish and Game Council approves 6-day black bear hunt". The article is dated Tuesday, July 13, 2010, and was updated on Wednesday, July 14, 2010. The author is Brian T. Murray. The article text describes a public hearing where the council approved a six-day bear hunt. A photograph shows Patrick Carr, a wildlife biologist, presenting a slide that compares "Adult survival rate 86%" and "High cub survival First year cub survival 95%".

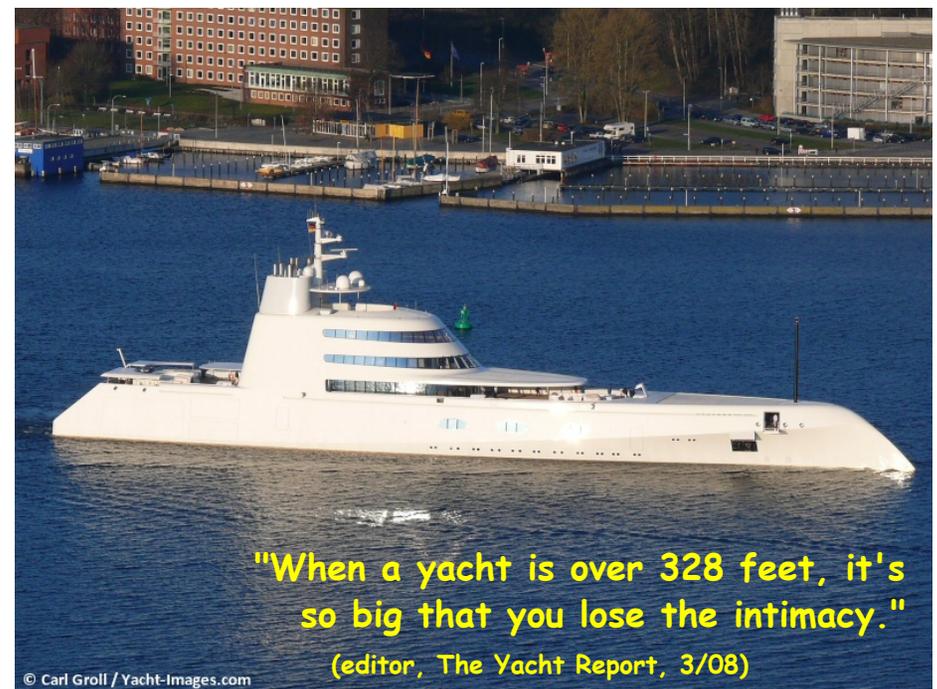
Bears in the woods

"Young males can roam 60 to 100 square miles looking for food and mates, but females stay close to the cave, foraging within a 10-mile radius."
Newark Star-Ledger (7/9/99)

How does the area that males cover compare to the more stay-at-home females?

10 mile radius for females:

$$\begin{aligned} \text{area} &= \pi r^2 \\ &= 314 \text{ square miles!} \end{aligned}$$



"When a yacht is over 328 feet, it's so big that you lose the intimacy."
(editor, The Yacht Report, 3/08)



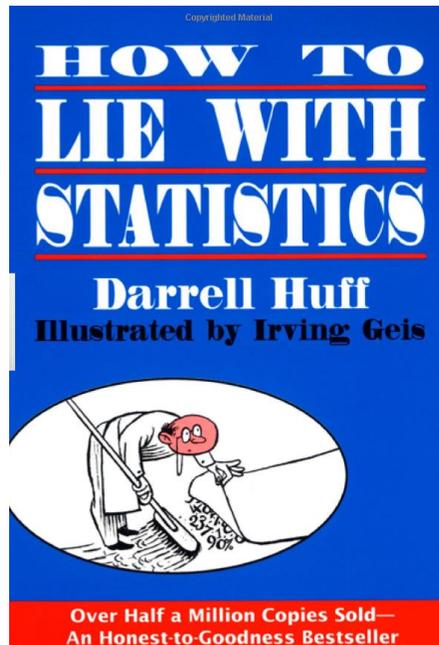
"You know what they say, son --
28.35 grams of prevention is worth
.45 kilograms of cure..."

Specious precision

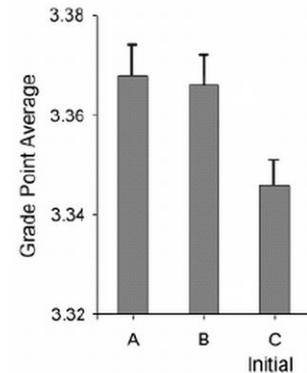
93,754,333 Examples of Data Nonchalance

By TOM ZELLER Jr.
Published: September 25, 2006

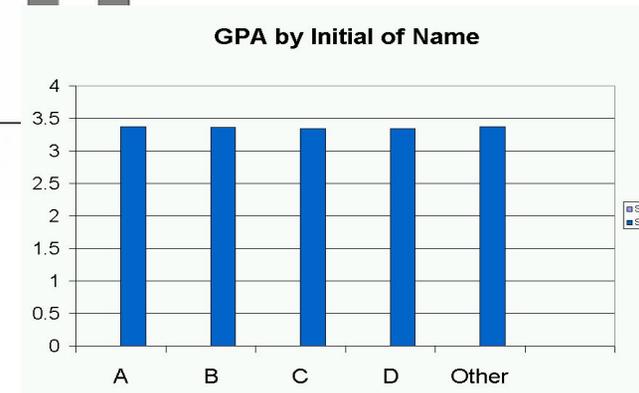
Less than two years into the great cultural awakening to the vulnerability of personal data, companies and institutions of every shape and size — like the data broker [ChoicePoint](#), the credit card processor CardSystems Solutions, media companies like [Time Warner](#) and dozens of colleges and universities across the land — have collectively fumbled 93,754,333 private records. Or at least that's the rough figure the Privacy Rights Clearinghouse, a consumer advocacy organization in San Diego, has tallied thus far.



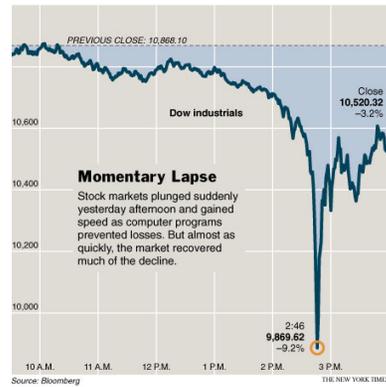
Gee-whiz graphs



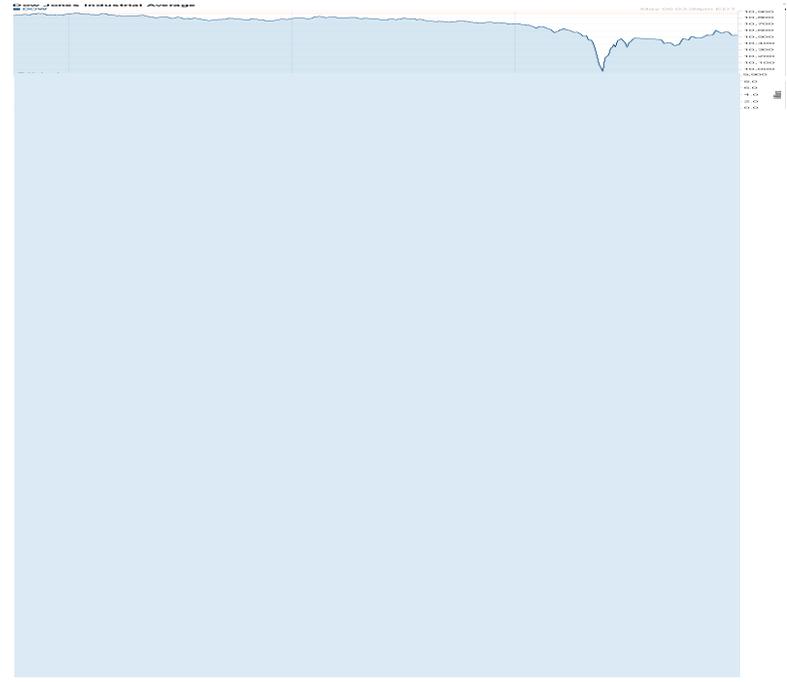
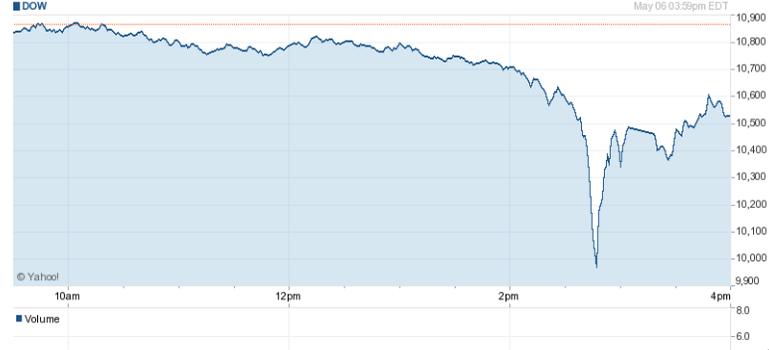
"Despite the pervasive desire to achieve high grades, students with the initial C or D, presumably because of a fondness for these letters, were slightly less successful at achieving their conscious academic goals than were students with other initials."



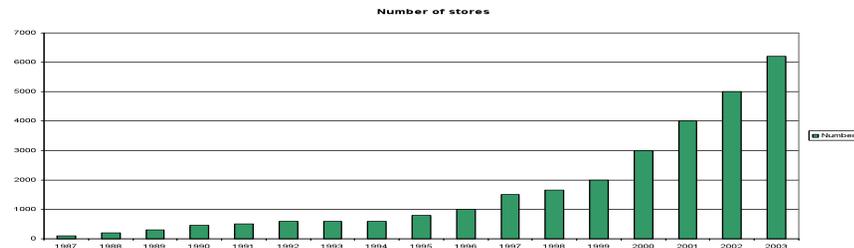
Gee-whiz graphs (2)



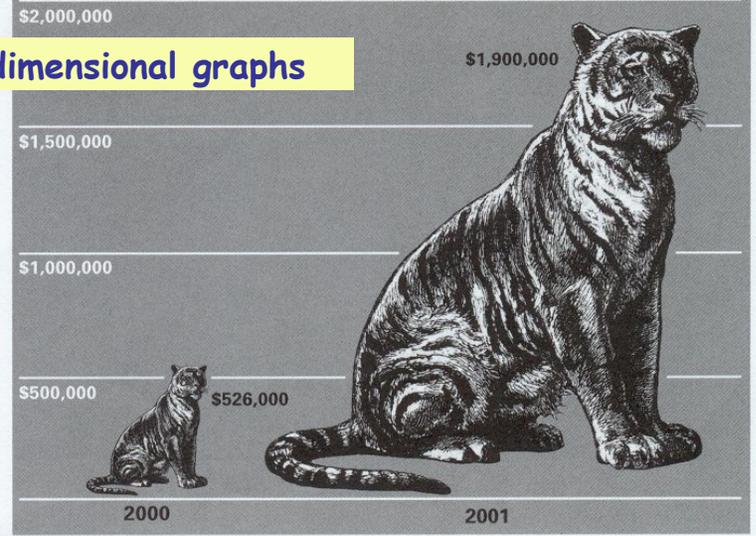
Dow Jones Industrial Average



One-dimensional graphs



One-dimensional graphs



Between 2000 and 2001, the Graduate School almost quadrupled summer stipends for students in the humanities and the social sciences.

Who's number 1?

National Universities—Doctoral: Top 50
 Click on the variable that interests you, and the table will resort.

Rank	School (State)	Overall score	Graduation rank	2000 predicted grad rate	2000 overperf. (+) underperf. (-)	% of classes under 20	Student/faculty ratio	Selectivity rank	Freshmen in top 10% of HS class	Financial resources rank	Alumni giving rate									
		Reputation score (5.0 highest)	Freshman retention rate	2000 actual grad rate	Faculty resources rank	% with 50 or more	% of full-time faculty	SAT/ACT 25th-75th percentile	Acceptance rate	Alumni giving rank										
Sort by: Rank																				
1	Princeton University (NJ)	100.0	4.9	1	99%	92%	97%	+5	4	71%	11%	6/1	92%	4	1350-1540	92%	12%	13	1	66%
2	Harvard University (MA)	99.0	4.9	2	96%	91%	97%	+6	7	69%	13%	8/1	91%	1	1410-1580	90%	11%	8	6	46%
3	Yale University (CT)	99.0	4.9	3	98%	93%	95%	+2	10	75%	8%	7/1	90%	2	1350-1550	95%	16%	2	5	46%
4	California Institute of Technology	96.0	4.7	25	94%	95%	82%	-13	2	76%	5%	3/1	96%	5	1460-1580	98%	13%	1	13	39%
5	Massachusetts Inst. of Technology	95.0	4.9	10	98%	93%	91%	-2	19	58%	16%	7/1	89%	3	1410-1560	97%	16%	3	9	41%
6	Stanford University (CA)	95.0	4.9	7	98%	91%	93%	+2	15	69%	14%	7/1	99%	6	1360-1560	89%	13%	9	11	40%
7	University of Pennsylvania	95.0	4.5	15	97%	87%	91%	+4	1	70%	8%	7/1	89%	8	1310-1490	92%	23%	6	10	41%
8	Duke University (NC)	93.0	4.6	8	97%	91%	93%	+2	8	69%	7%	9/1	98%	12	1300-1500	86%	26%	10	7	45%
9	Columbia University (NY)	89.0	4.6	14	98%	86%	88%	+2	14	68%	9%	7/1	93%	7	1310-1510	87%	13%	18	21	32%
10	Dartmouth College (NH)	89.0	4.4	5	96%	91%	92%	+1	20	57%	11%	9/1	88%	10	1330-1520	86%	21%	11	3	48%
11	University of Chicago	89.0	4.7	24	94%	86%	85%	-1	3	68%	3%	4/1	95%	22	1280-1490	82%	44%	15	20	33%

Much too high, much too low, or plausible?

"Each year, according to the [American Anorexia and Bulimia] Association, 150,000 American women die of anorexia."

Naomi Wolf, *The Beauty Myth*, 1990, p 148

Who says so? How do they know? Why do they care? What are they selling?

"Four thousand teens will try their first cigarette today."

advertisement, *New York Times* (11/18/05)

"Endorsed by American Academy of Pediatrics, American Heart Assoc, American Lung Assoc, American Medical Assoc, National PTA."

"Every day 5000 teenagers try pot for the first time."

advertisement, *New York Times* (11/4/05)

Coalition for a Drug-Free America

Much too high, much too low, or plausible?

"The number of American children killed by guns has doubled every year since 1950."

Nancy Day, *Violence in Schools: Learning in Fear* (1996)

Defenses

- **recognize the enemy**
 - flaky numbers / excessive precision
 - arithmetic errors/ wrong units / wrong dimensions
 - bad statistics / deceptive presentation / suspect motives
- **beware of the source**
 - how do they know? how could they know?
 - why do they care? what are they trying to sell you?
- **learn some useful numbers, facts, shortcuts**
 - populations, rates, sizes, areas, conversions, etc.
 - approximate arithmetic, Little's Law, Rule of 72, powers of 2
- **use your common sense and experience**
 - much too big? much too small?
 - does it make sense? what would it imply?

Good reading

- Darrell Huff, *How to Lie with Statistics*
- Joel Best, *Damned Lies and Statistics, More Damned Lies and Statistics, ...*
- John Allen Paulos, *Innumeracy, A Mathematician Reads the Newspaper*
- **Web sites**
 - innumeracy.com
 - megapenny.com
 - math.temple.edu/~paulos/