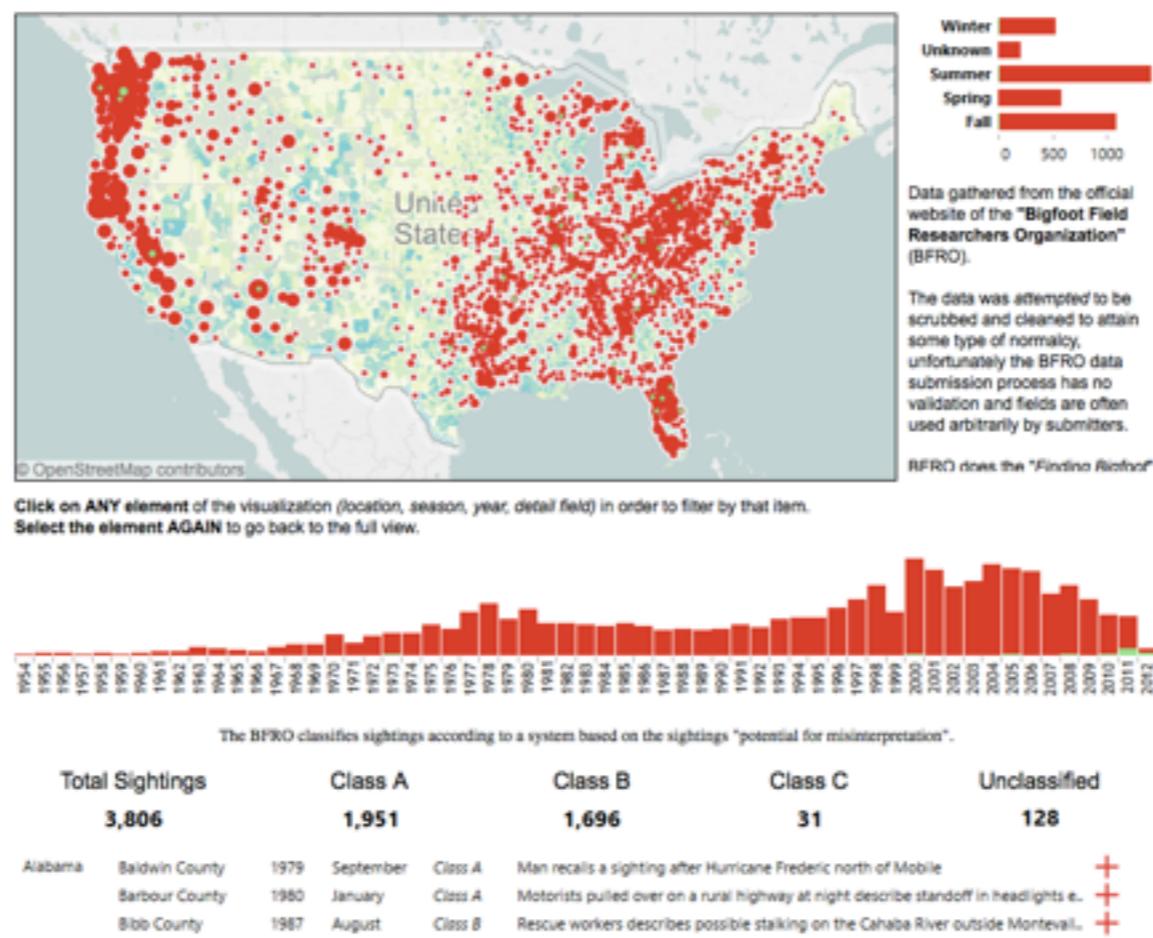


CS I 09/Stat I 2I/AC209/E- I 09

Data Science Communication and Storytelling

Hanspeter Pfister, Joe Blitzstein, and Verena Kaynig



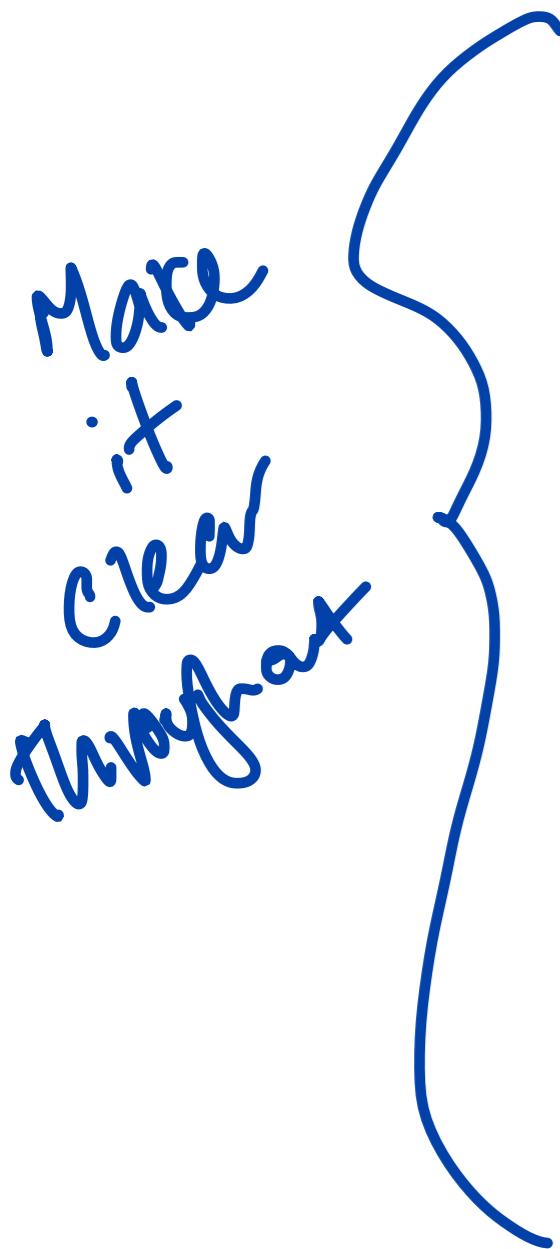
This Week

- HWI is due this Thursday (September 24) at 11:59 pm (Eastern Time)
- Remember to attend section. If you need to change sections, try to swap with someone (there is a Piazza thread for this).
- Make sure you have read the homework policies on the syllabus, and follow the homework submission procedure carefully. See <https://piazza.com/class/icf0cypdc3243c?cid=451>
- Always check your submission.
- Late days are calculated based on the time stamp of the *last* push to your repository.

Two Fundamental Questions

I.What is the goal?

- predict future data?
- explain and understand a phenomenon?
- test a hypothesis?
- compare two groups?
- dimension reduction?
- build a good recommendation system?
- decide on a course of action or a policy?



Two Fundamental Questions

2. Who cares?

↳ Relate to who the audience is.

IMAC

*'Iterative', but
starts w/ Q.*

I: inferential goal (scientific question of interest)
M: model (all models are wrong, some are useful)
A: algorithms
C: conclusions and checking
*↳ Does it make sense?
↳ Go back to motivating problem.*

The C is crucial: what did we learn? Was the model useful, and how well does it fit? How do we know whether the method is working? Do we need to iterate and improve the model? What are the limitations and future directions?

Some Key Principles

- remember **The Golden Rule**
- know your audience
- tell a story
- choose and use notation carefully
- read great writers
- create good sense of direction (with the help of signposts), with clear flow of logic

Don't assume people understand.

begin → AIC → going.

Notation, notation, notation

It was said of Jordan's writings that if he had four things on the same footing (as a, b, c, d) they would appear as $a, M'_3, \epsilon_2, \Pi''_{1,2}$.

- J.E. Littlewood

Halmos' nightmare: $n_\varepsilon \rightarrow 0$ as $\varepsilon \rightarrow \infty$.

Use conventions; parallel.

bizarre notation
n. usually
small
integer

Four useful references on scientific writing

Marie Davidian: http://www4.stat.ncsu.edu/~davidian/st810a/written_handout.pdf

Rod Little: <http://sitemaker.umich.edu/rlittle/files/styletips.pdf>

Paul Halmos: <http://www.matem.unam.mx/ernesto/LIBROS/Halmos-How-To-Write%20Mathematics.pdf>

George Gopen and Judith Swan: <http://engineering.missouri.edu/civil/files/science-of-writing.pdf>

The Science of Scientific Writing (Gopen-Swan)

<http://engineering.missouri.edu/civil/files/science-of-writing.pdf>

BAD Example.

The smallest of the URF's (URFA6L), a 207-nucleotide (nt) reading frame overlapping out of phase the NH₂-terminal portion of the adenosinetriphosphatase (ATPase) subunit 6 gene has been identified as the animal equivalent of the recently discovered yeast H⁺-ATPase subunit 8 gene. The functional significance of the other URF's has been, on the contrary, elusive. Recently, however, immunoprecipitation experiments with antibodies to purified, rotenone-sensitive NADH-ubiquinone oxido-reductase [hereafter referred to as respiratory chain NADH dehydrogenase or complex I] from bovine heart, as well as enzyme fractionation studies, have indicated that six human URF's (that is, URF1, URF2, URF3, URF4, URF4L, and URF5, hereafter referred to as ND1, ND2, ND3, ND4, ND4L, and ND5) encode subunits of complex I. This is a large complex that also contains many subunits synthesized in the cytoplasm.

But what about structure, not just jargon?

Still hard to follow the thread.
How are the sentences related?

The smallest of the URF's, an [A] has been identified as a [B] subunit 8 gene. The functional significance of the other URF's has been, on the contrary, elusive. Recently, however, [C] experiments, as well as [D] studies, have indicated that six human URF's [1-6] encode subunits of Complex I. This is a large complex that also contains many subunits synthesized in the cytoplasm.

How are these sentences connected?
What is the emphasis?

The Science of Scientific Writing (Gopen-Swan)

<http://engineering.missouri.edu/civil/files/science-of-writing.pdf>

Subject and verb are far apart.

Recently, however, immunoprecipitation experiments with antibodies to purified, rotenone-sensitive NADH-ubiquinone oxido-reductase [hereafter referred to as respiratory chain NADH dehydrogenase or complex I] from bovine heart, as well as enzyme fractionation studies, have indicated that six human URF's (that is, URF1, URF2, URF3, URF4, URF4L, and URF5, hereafter referred to as ND1, ND2, ND3, ND4, ND4L, and ND5) encode subunits of complex I.

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Linda the Bank Teller (Kahneman-Tversky)

Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

Which is more probable?

- ① Linda is a bank teller. ← *fewer conditions*.
2. Linda is a bank teller and is active in the feminist movement.

85% of Stanford Business School students participating in the study said option 2 is more probable.

Ipl don't remember the theory; they remember the example.

THE EVOLUTION OF A PROBLEM

Henry S. Baird and Colin L. Mallows

Bell Laboratories, AT & T Laboratories

*Dedicated to Herbert Robbins on the occasion of his 80th
birthday*

way too vague. ↗

Abstract: This paper describes several problems, all arising from one real-world problem. Some of these problems have been solved, others offer interesting challenges.

Abstract MadLibs!!

This paper presents a _____ method for _____
(synonym for new) (sciencey verb)
the _____. Using _____, the
(noun few people have heard of) (something you didn't invent)
_____ was measured to be _____ +/- _____
(property) (number) (number)
_____. Results show _____ agreement with
(units) (sexy adjective)
theoretical predictions and significant improvement over
previous efforts by _____, et al. The work presented
(Loser)
here has profound implications for future studies of
_____ and may one day help solve the problem of
(buzzword)
_____.
(supreme sociological concern)

Keywords: _____, _____, _____
(buzzword) (buzzword) (buzzword)

Tell a Story!

Any story has a beginning, a middle, and an end.

- introduce interesting characters
- put them in a predicament
- resolve the predicament
- but leave room for sequels! (Limitations and future work)

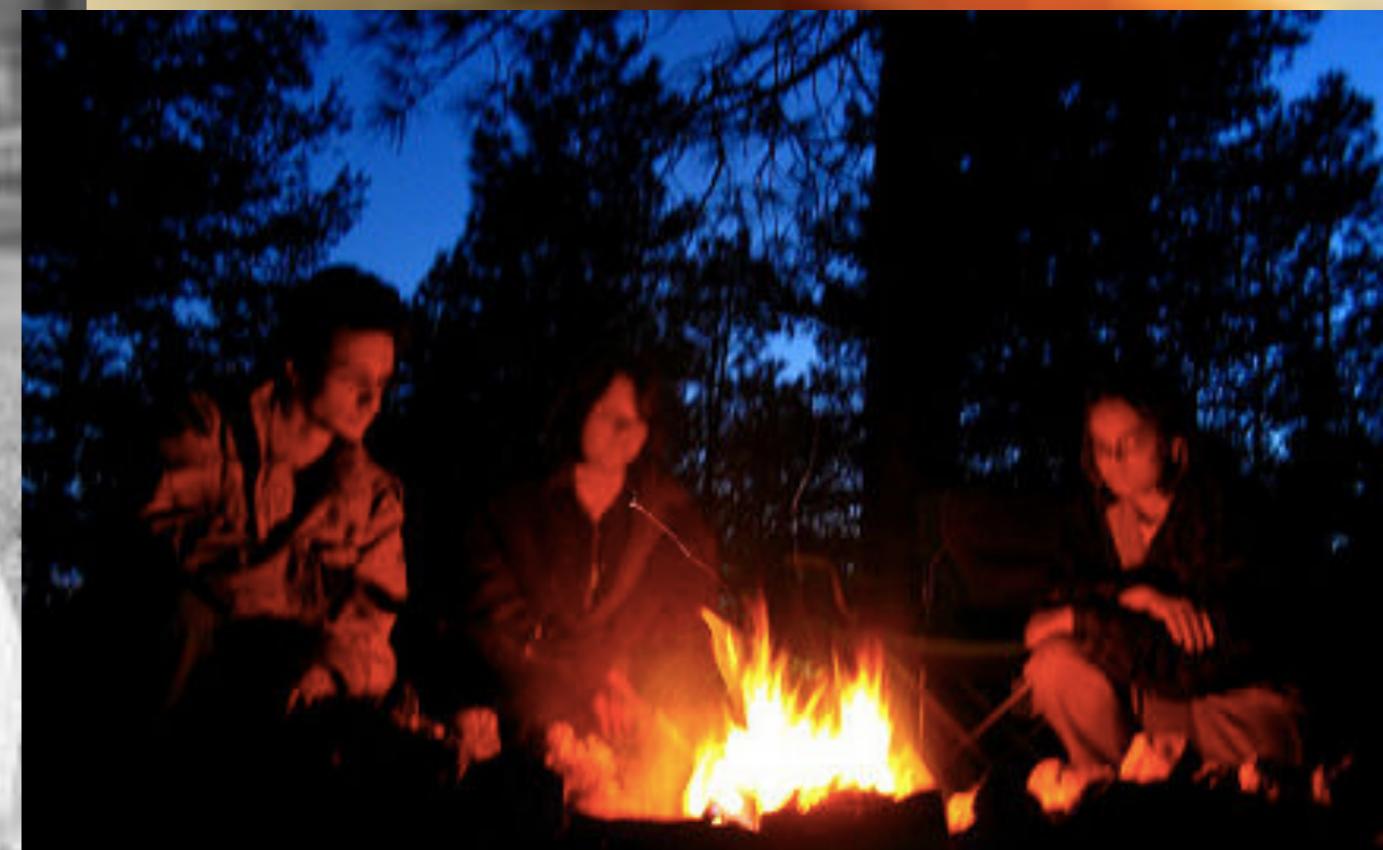
↳ Can't solve everything

Tell a Story with Data

Use a
lot of
visuals.

Stories

Stories are the most powerful delivery tool for information, more powerful and enduring than any other art form



Enduring + memorable.



Fun + informative

Key Considerations

- Who is your audience?
Can you make it accessible to everyone?
- What questions are you answering?
- Why should the audience care?
- What are your major insights and surprises?
↳ Should tie to Q; but also some surprises.
- What change do you want to affect?
↳ emotional.

Know Your Audience



People you don't know are difficult to influence

Know Your Audience

- What do they know? *What preconceived notion
do they have?*
- What motivates them? What do they desire?
↳ What will keep their attention?
- What experiences do you share? What are common goals?
- What insights can you give them? What tools and “magical gifts”?

Don't Make Them Think!

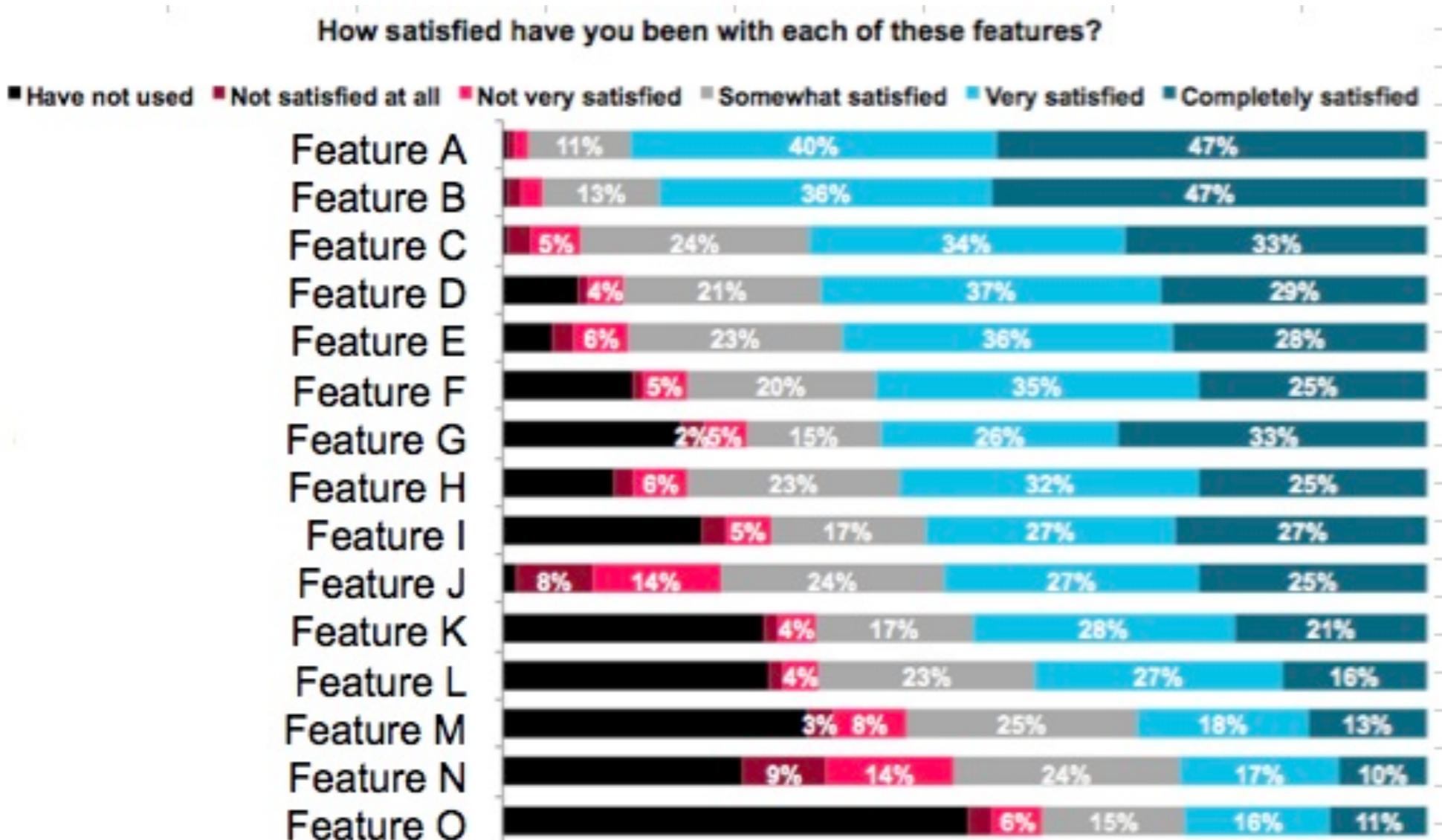
→ *easy notation*

- Your audience does not want to spend cognitive effort on things you know and can just show them
- Lead them through the major steps of your story
- Point out interesting key facts and insights using captions and annotations

↳ *Give an action step.*



Don't Bury the Lead

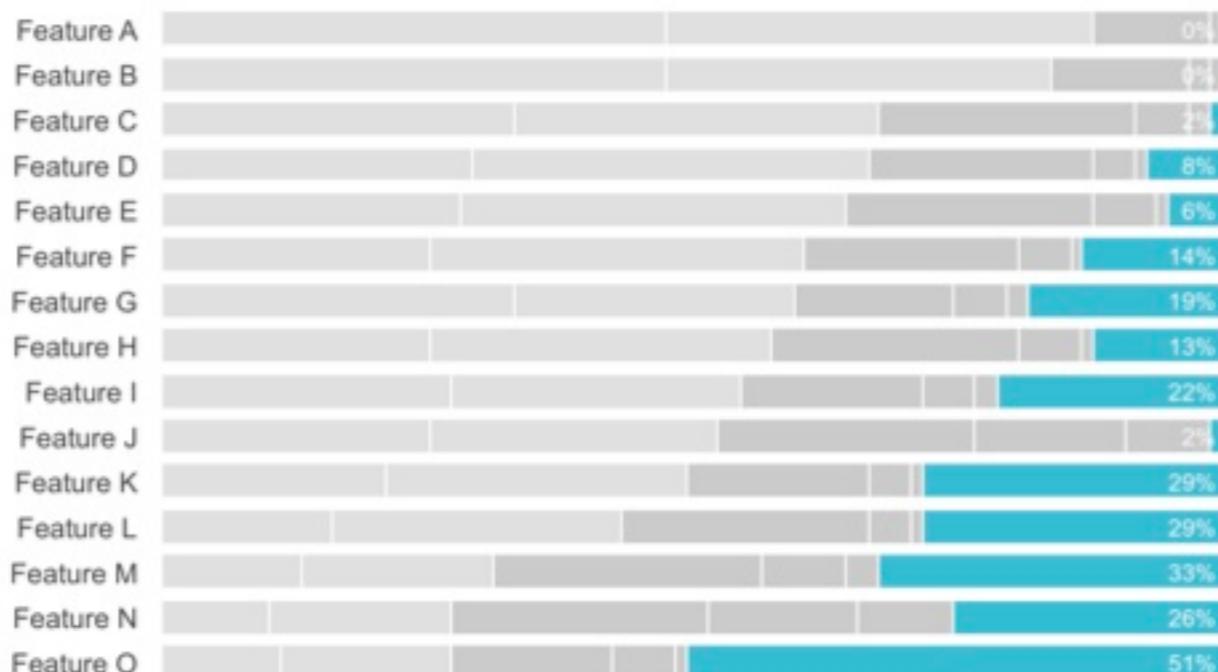


Don't Bury the Lead

User satisfaction varies greatly by feature

Product X User Satisfaction: Features

* Completely satisfied * Very satisfied * Somewhat satisfied * Not very satisfied * Not satisfied at all * Have not used



Feature O is least-used feature; what steps can we proactively take with existing users to increase use?

Message
is in
the
title.

Think of
this as
supporting
evidence.

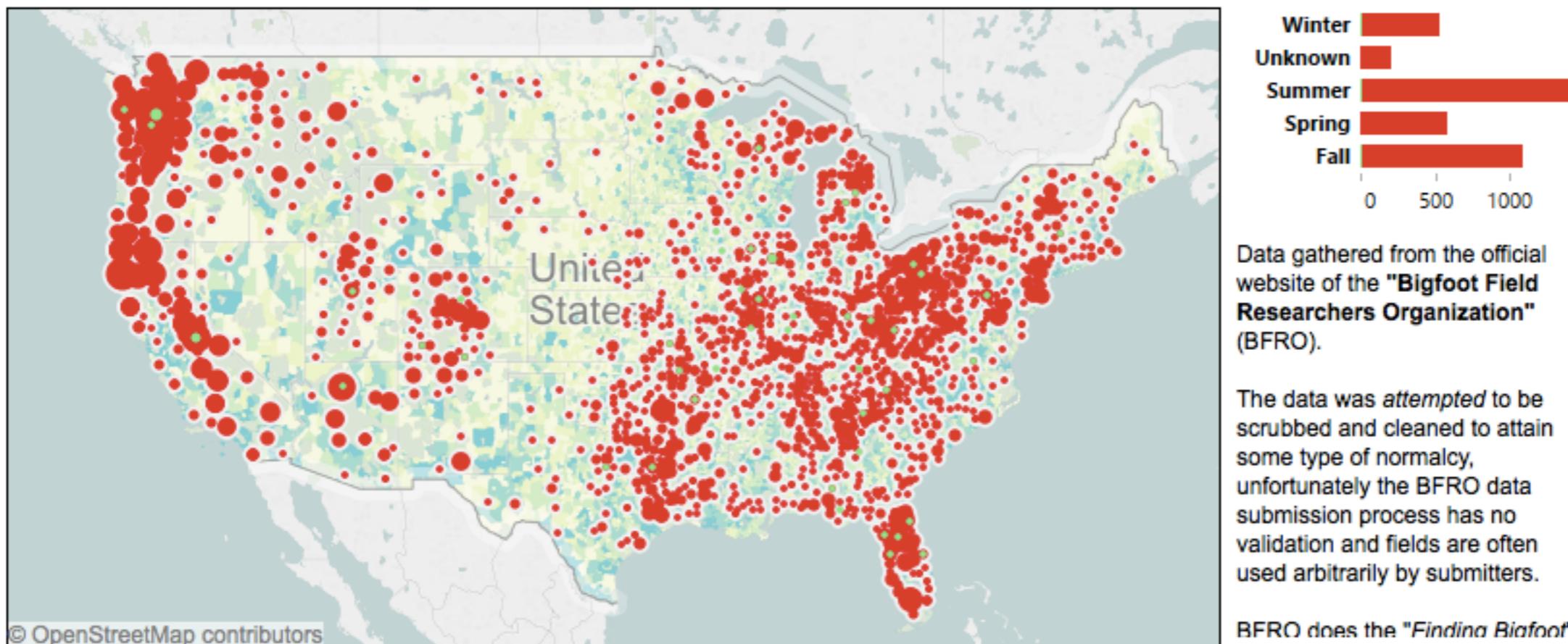
David Jacopille



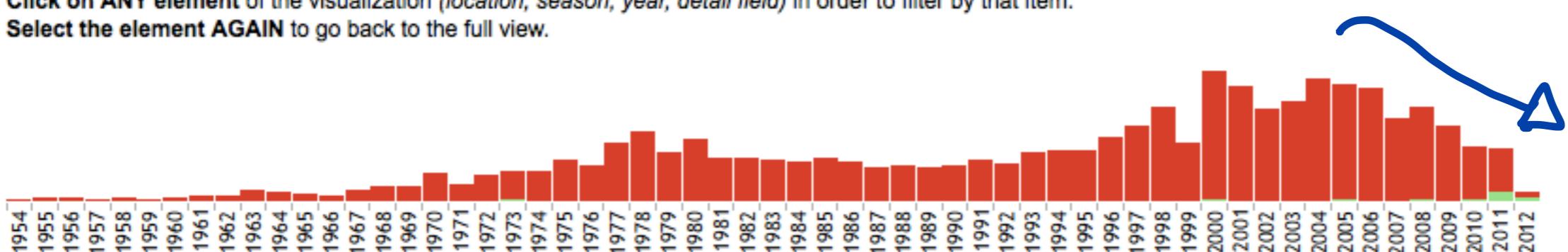
Ryan Robitaille

*Bigfoot sightings
in decline*

Where is Bigfoot seen in the USA?



Click on ANY element of the visualization (location, season, year, detail field) in order to filter by that item.
Select the element AGAIN to go back to the full view.

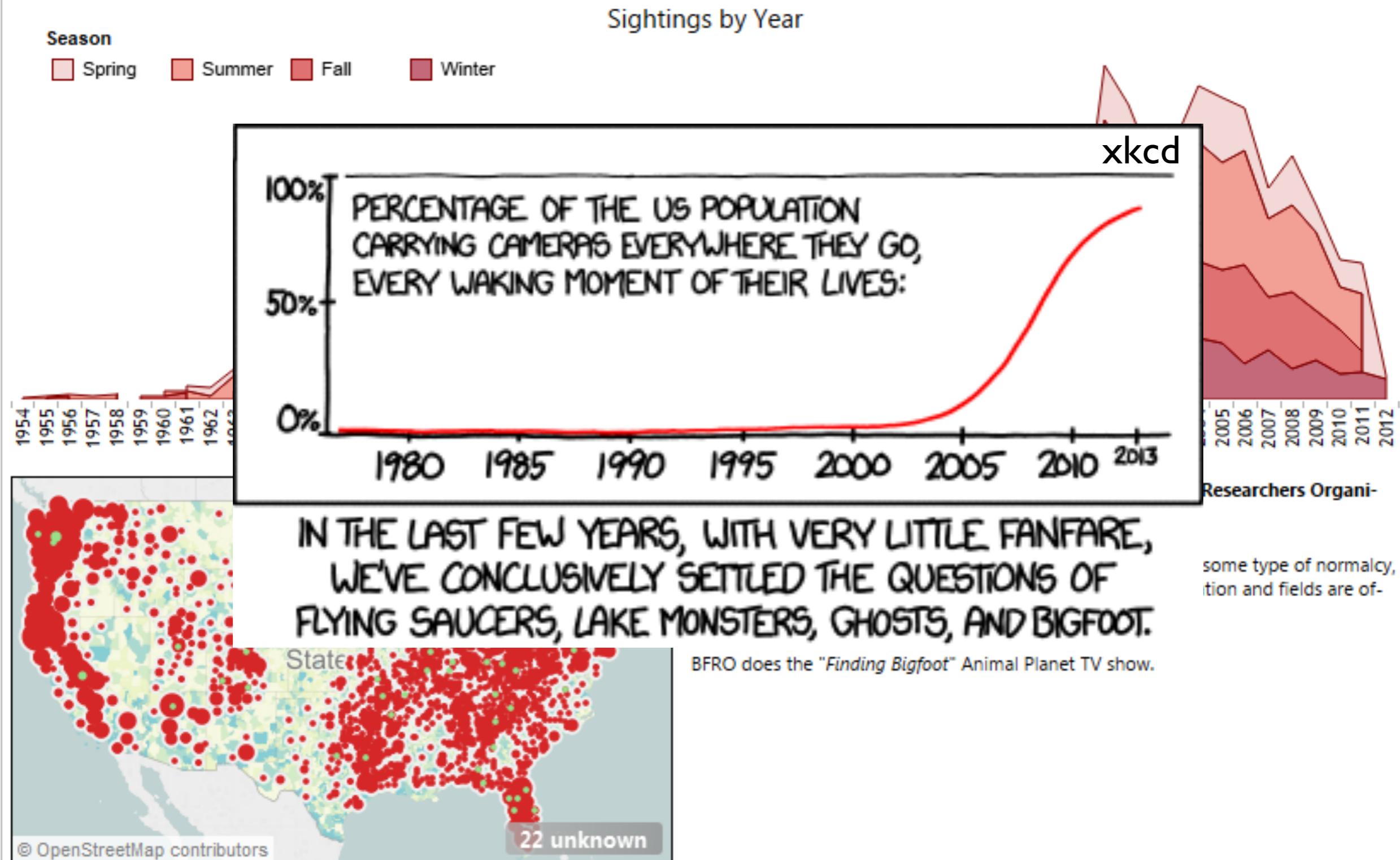


The BFRO classifies sightings according to a system based on the sightings "potential for misinterpretation".

Total Sightings	Class A	Class B	Class C	Unclassified
3,806	1,951	1,696	31	128

Alabama	Baldwin County	1979	September	Class A	Man recalls a sighting after Hurricane Frederic north of Mobile	+
	Barbour County	1980	January	Class A	Motorists pulled over on a rural highway at night describe standoff in headlights e..	+
	Bibb County	1987	August	Class B	Rescue workers describes possible stalking on the Cahaba River outside Monteval..	+

Bigfoot sightings are in decline



Ryan Robitaille

Unexpectedness

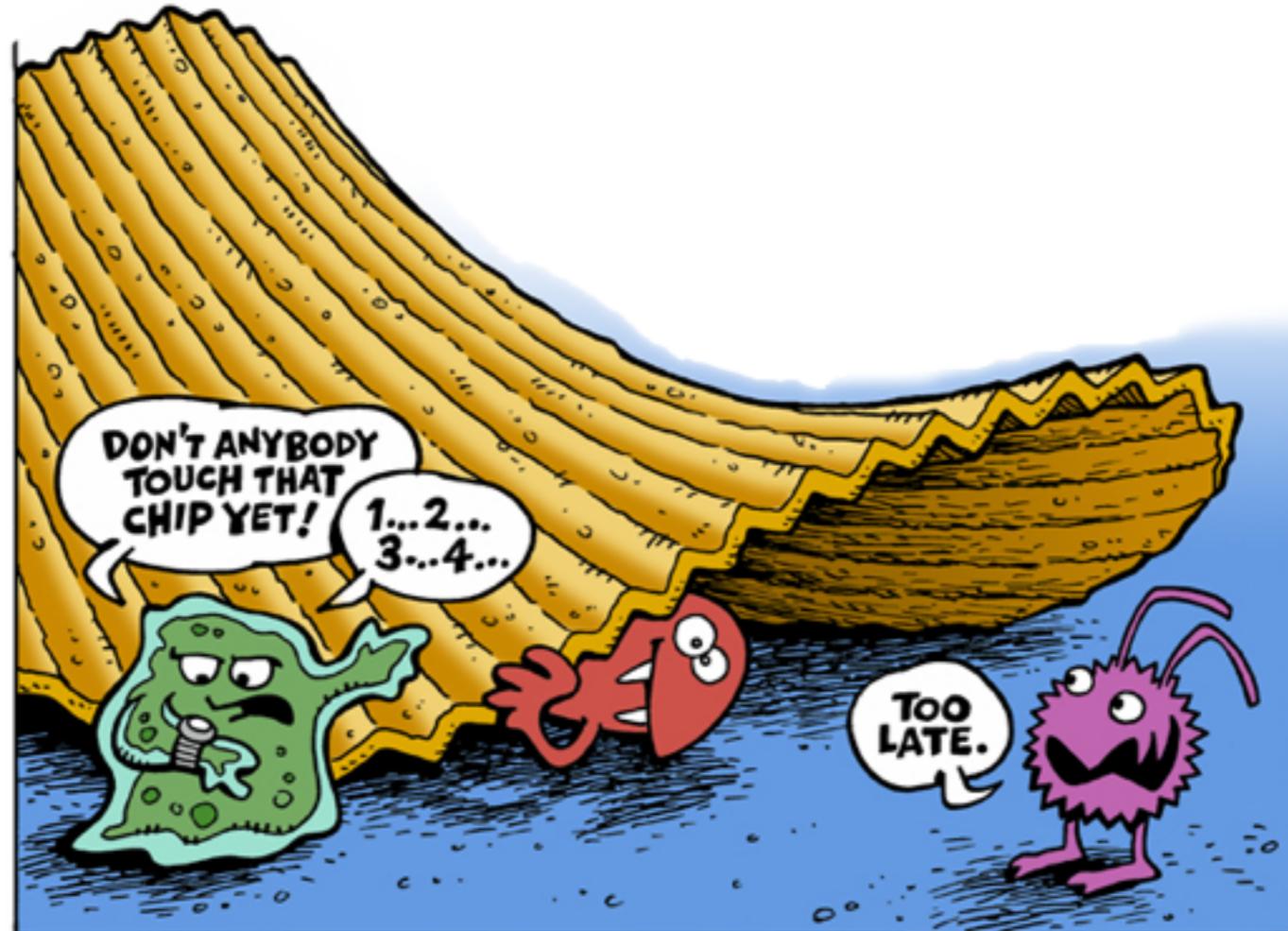
Might lead
to more Qs.

Make the audience aware that there is something they didn't know they didn't know

Use surprise to grab the audience's attention

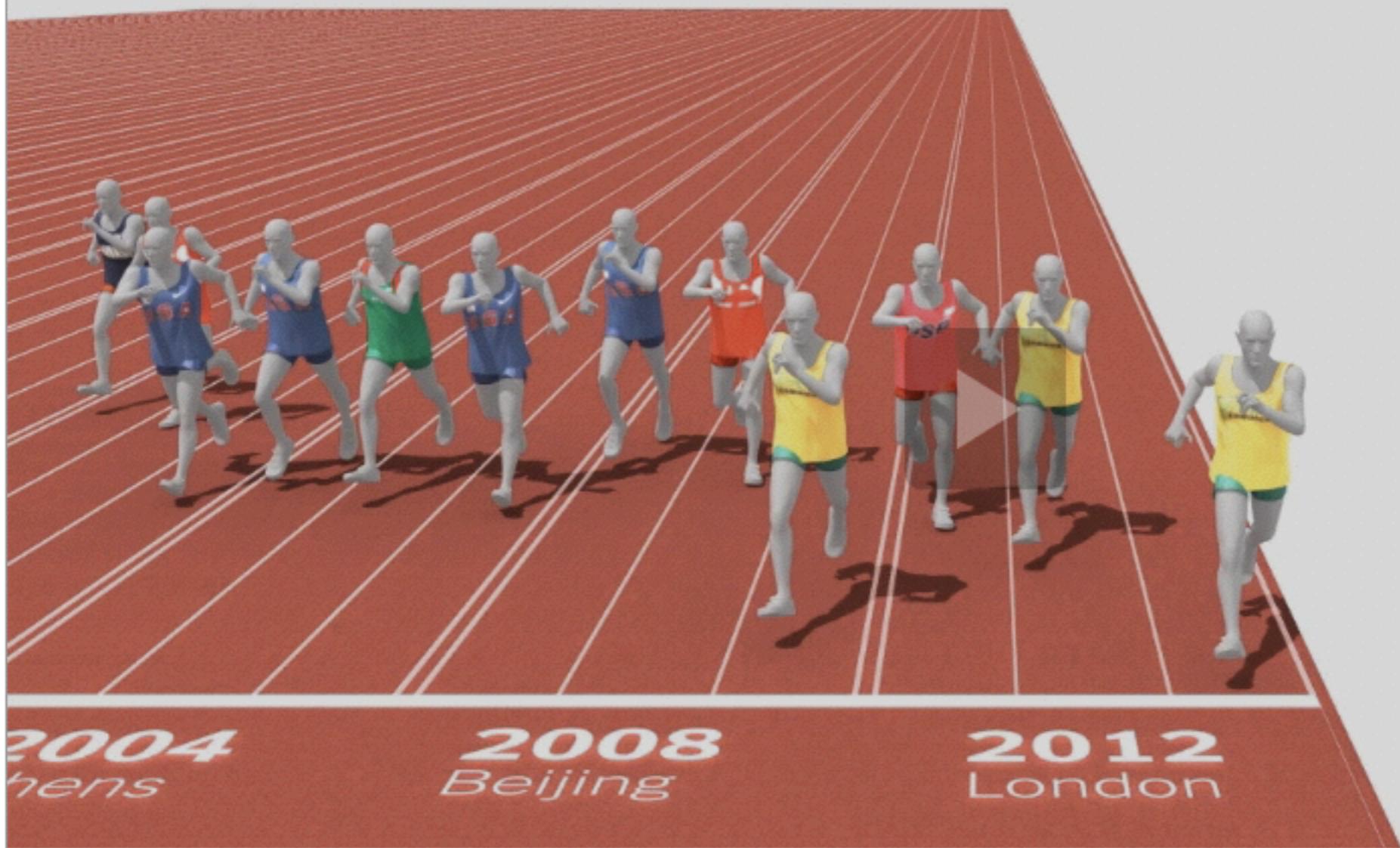
“You might think you know this, but here's a new angle on it”

Curiosity happens when we feel a gap in our knowledge



Not
gimicky.

All the Medalists: Men's 100-Meter Sprint



Sources: "The Complete Book of the Olympics" by David Wallechinsky and Jaime Loucky, International Olympic Committee; Amateur Athletic Association; Photographs: Chang W. Lee/The New York Times, Getty Images, International Olympic Committee

[FACEBOOK](#) [TWITTER](#) [GOOGLE+](#) [E-MAIL](#) [SHARE](#)

Messaging

Framing - Why should I care?

Parkular to your pov. Fit within frame.

- Tell the audience: “Here is the right way to think about the problem I was trying to solve.”
- Catch the audience’s attention and frame the story using captions and annotations
- If done well, your insights will seem obvious given this framing. And that’s a good thing!

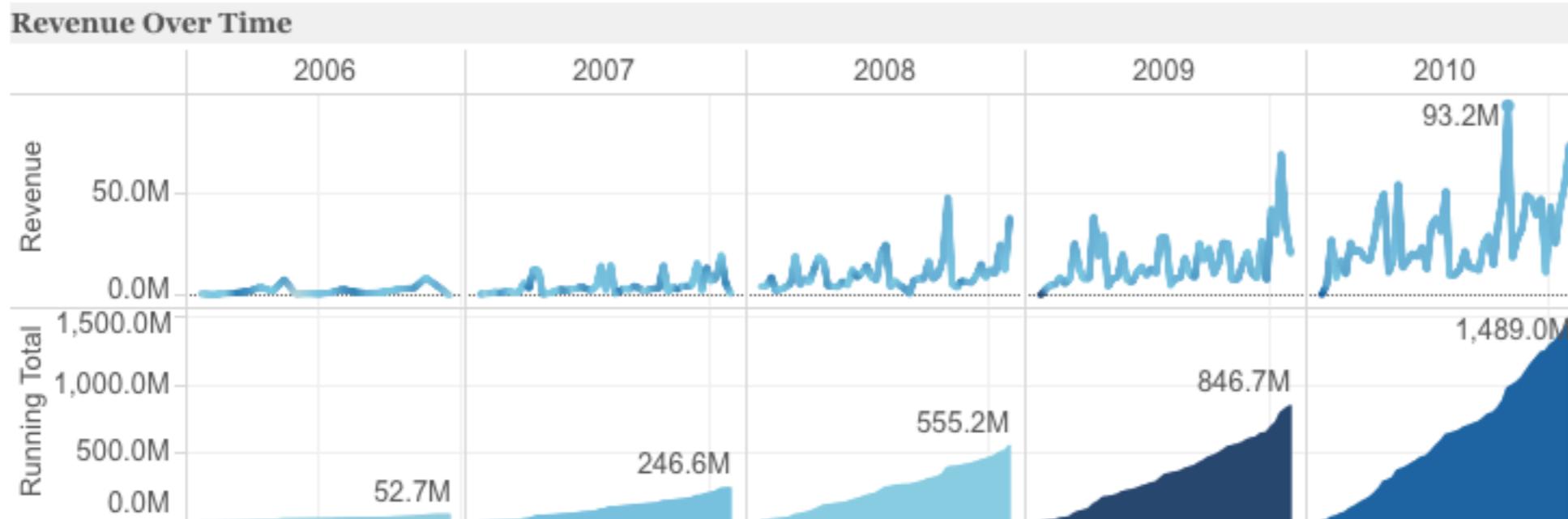


Opportunity Dashboard

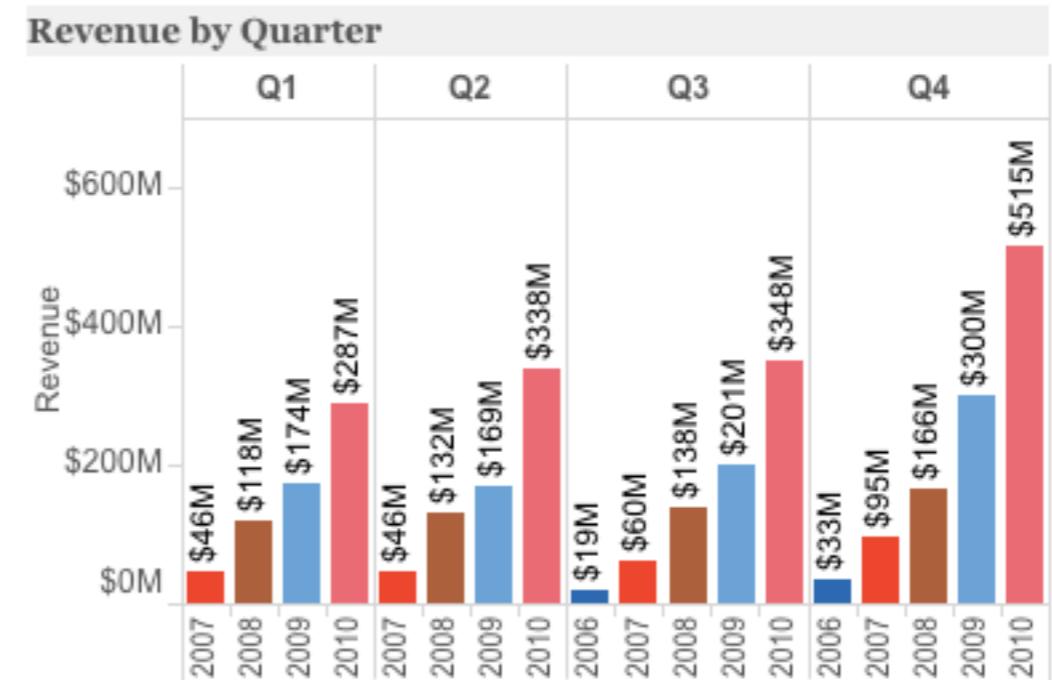
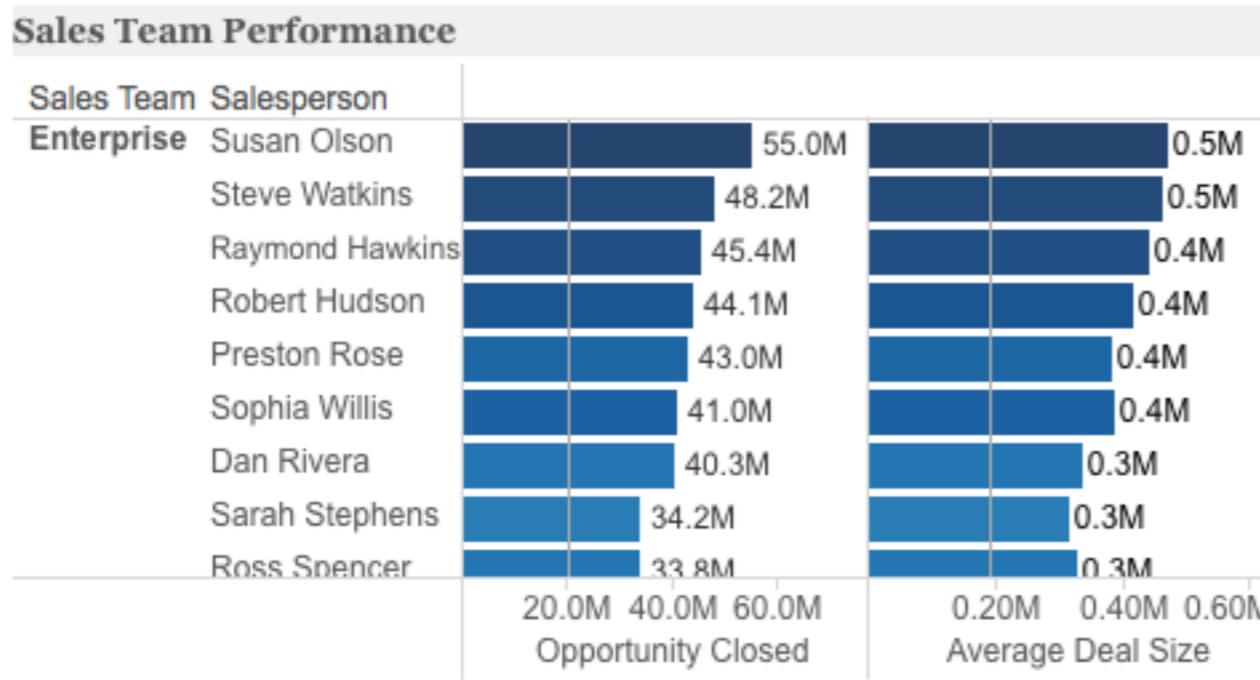
Sales Dashboard

Sales Dashboard

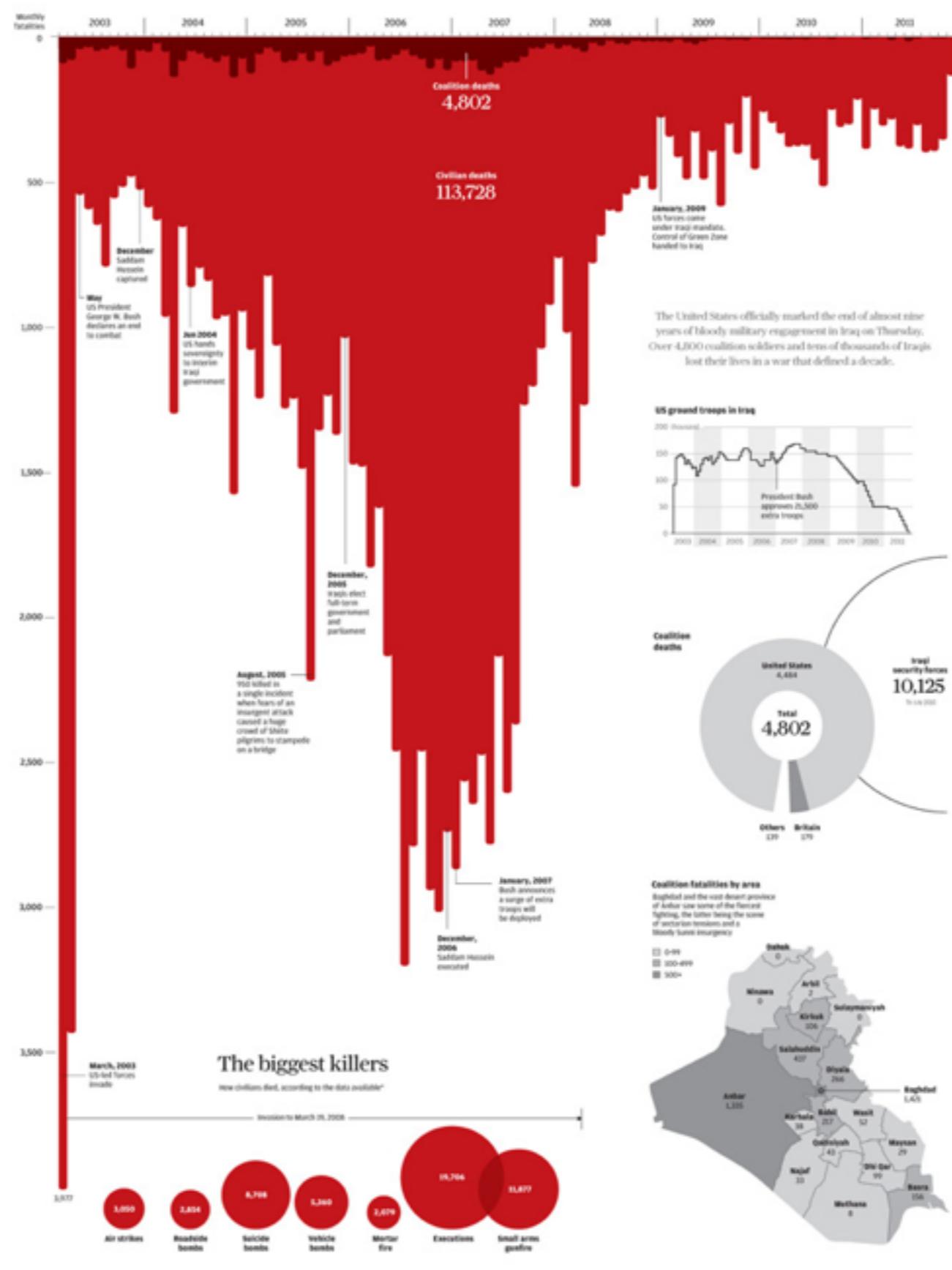
Total Sales	Number of Deals	Avg Deal Size	Rev. per Salesperson
\$3,190.2M	16,610	\$189,545	\$20.1M



Date Closed	8/7/2006	12/31/2010
<input type="text"/>	<input type="text"/>	<input type="text"/>
Region	(All)	<input type="button" value="▼"/>
Country	(All)	<input type="button" value="▼"/>
Sales Team	(All)	<input type="radio"/>
Small and Midmarket	<input type="radio"/>	<input type="radio"/>
Enterprise	<input type="radio"/>	<input type="radio"/>
Avg Deal Size/Salespe...	\$130,922	\$336,519



Iraq's bloody toll



Clea Pol.
Lucky, but
fits their
frame.
Much more
emotionally
engaging.
Don't lose
your integrity.

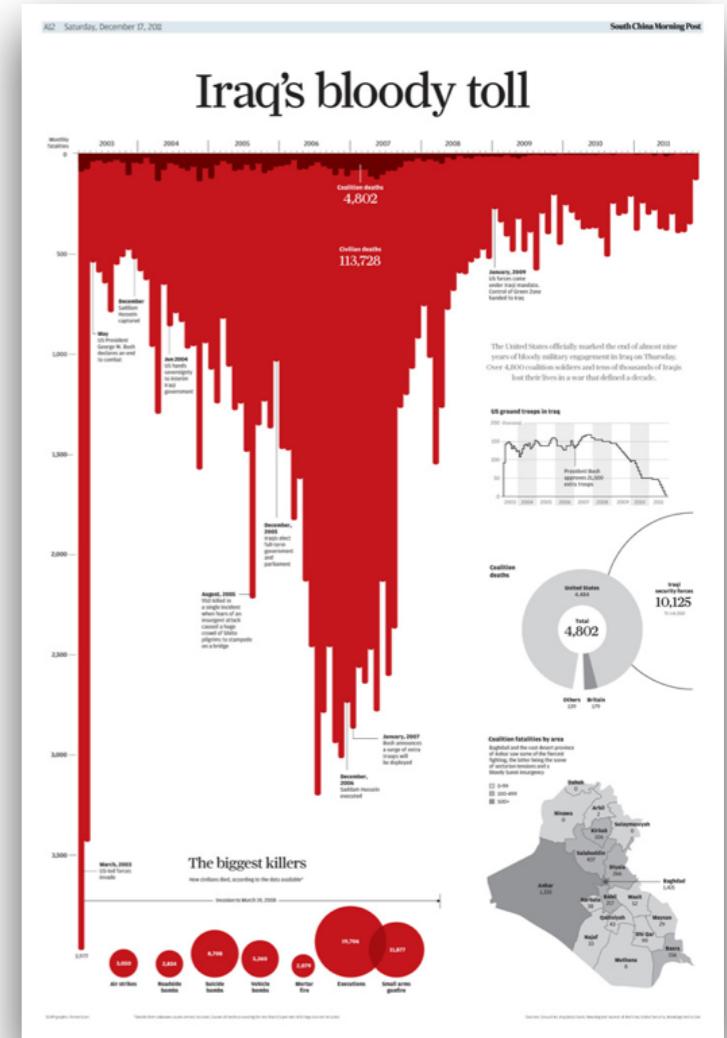
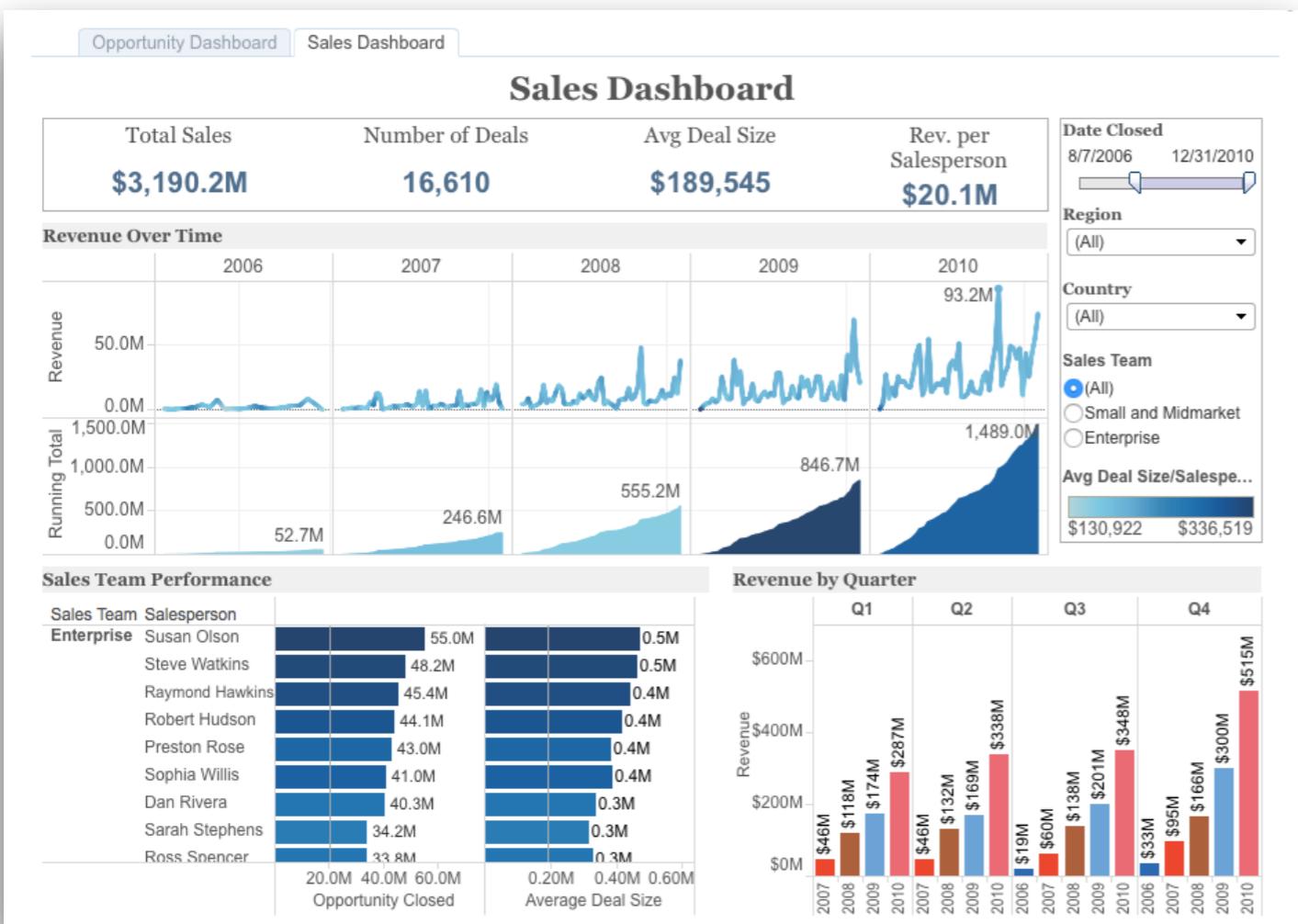
What is the message?

Exploratory

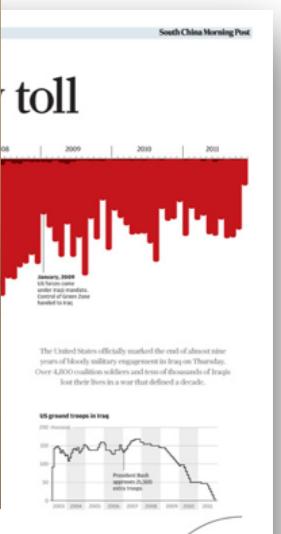
Neutral

know your audience.

- Explanatory
Opinionated

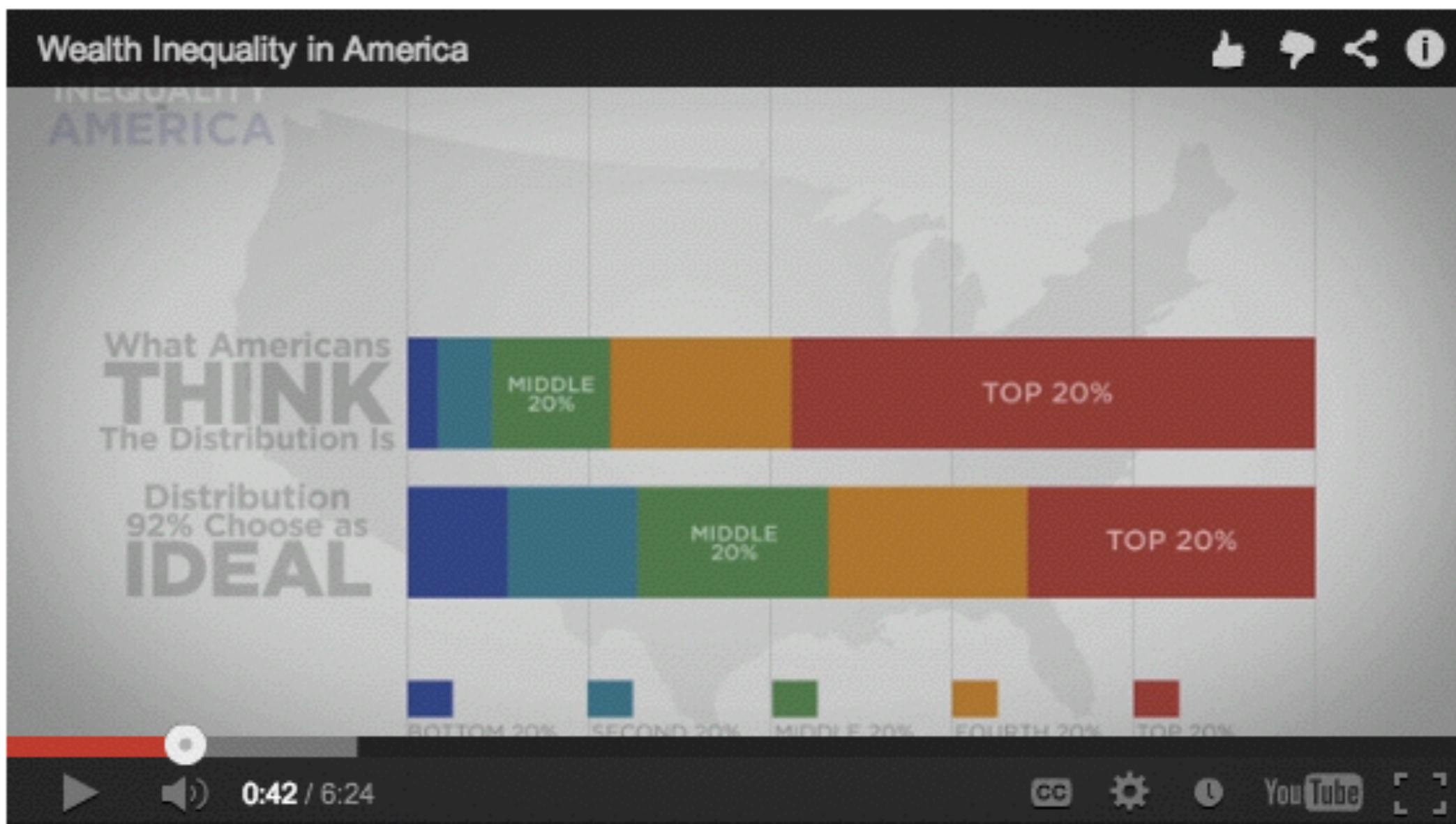


Know Your Audience



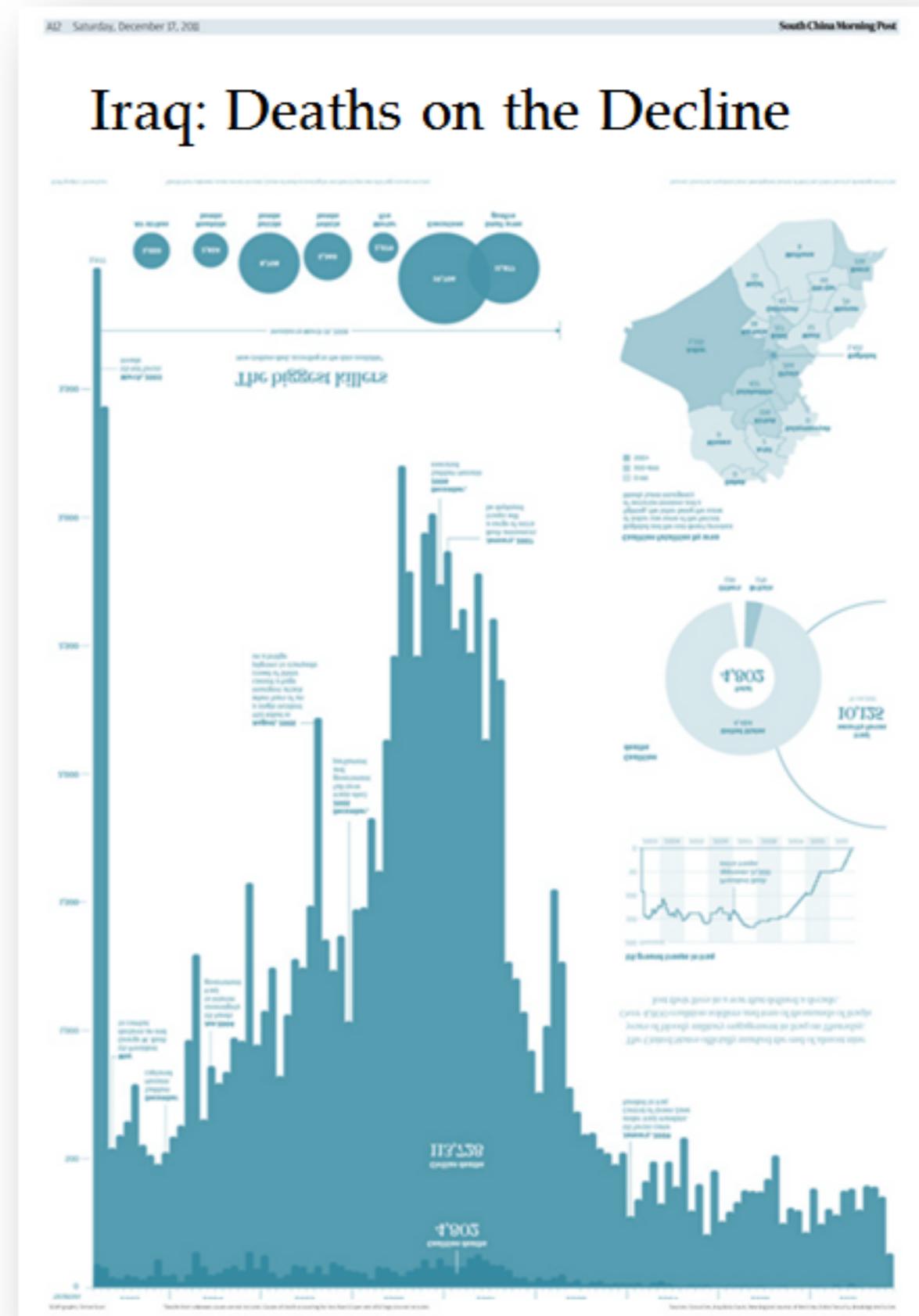
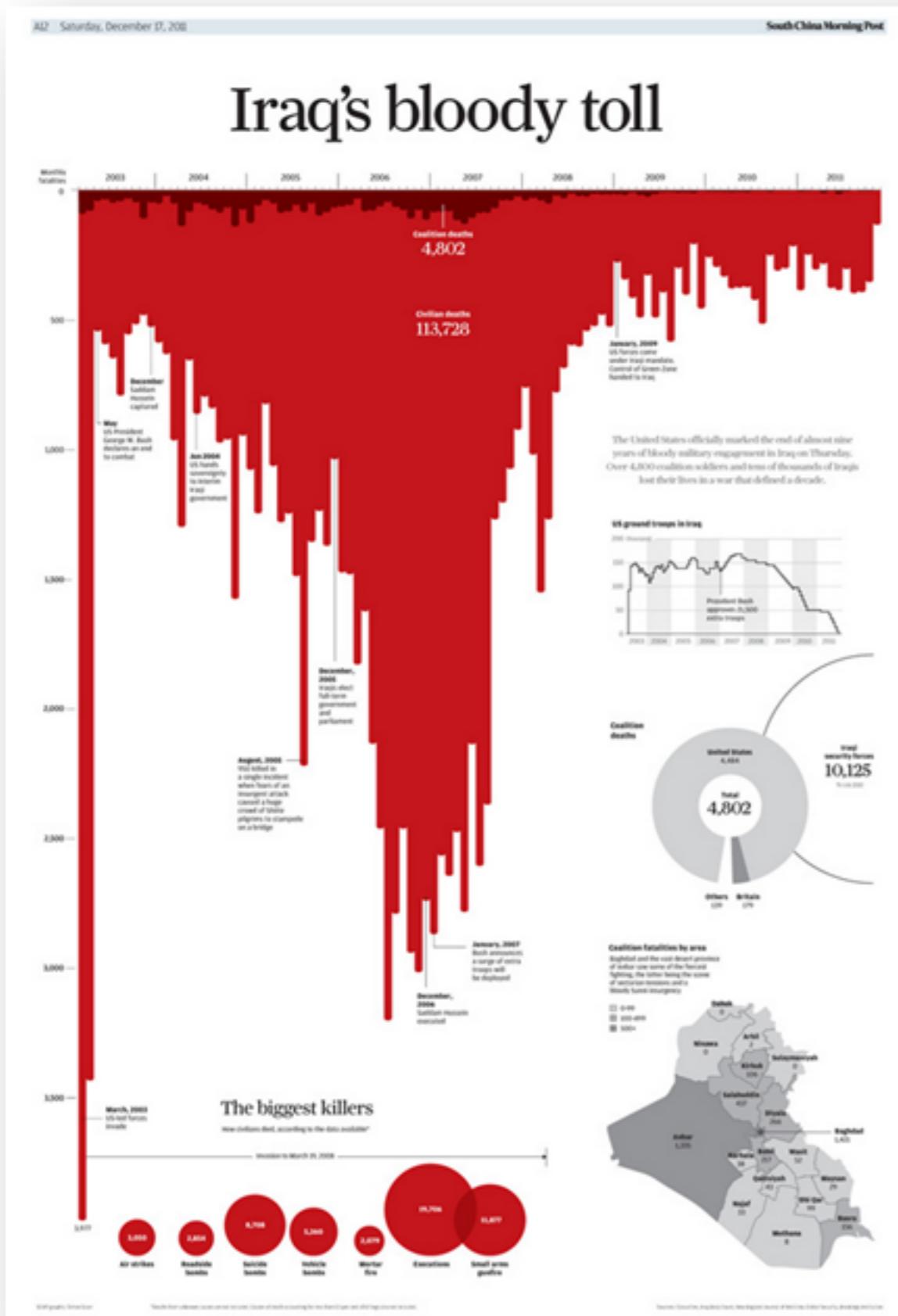
Wealth Inequality in America

RANDY | MONDAY, MARCH 11, 2013 AT 8:08AM [PERMALINK](#)



Visual Story Design

Color, correct attach, title.



Andy Cotgreave, Tableau

755



Steroids or Not, the Pursuit Is On

Babe Ruth is taking aim at the career home run record. He needs only six more to tie Babe Ruth and 47 to equal Hank Aaron.

Lines are cumulative home runs.



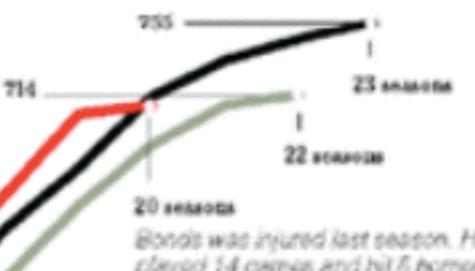
Bonds takes lead
Home runs:
after 16 seasons

Bonds	587
Aaron	554
Ruth	516

600

14th season

According to allegations in a book about Bonds, he began taking steroids before the 1999 season, his 14th in the league. Two seasons later, he hit 73 home runs, surpassing Aaron's career pace.

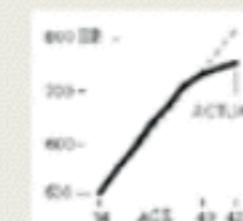


Homer Pace After Age 34

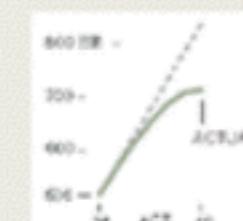
If the accusations are correct, Bonds was 34 in his first season on steroids. Here are projected home run paces for each player after age 34.

PROJECTION BASED ON AVERAGE OF PREVIOUS FIVE SEASONS

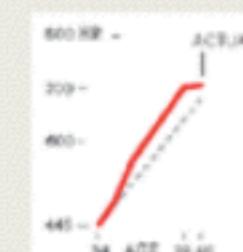
Aaron
Actual homers slightly outpace projected homers for five seasons



Ruth
Averaged 46.4 homers a season from age 30 to 34. Averaged 42.5 for next four seasons

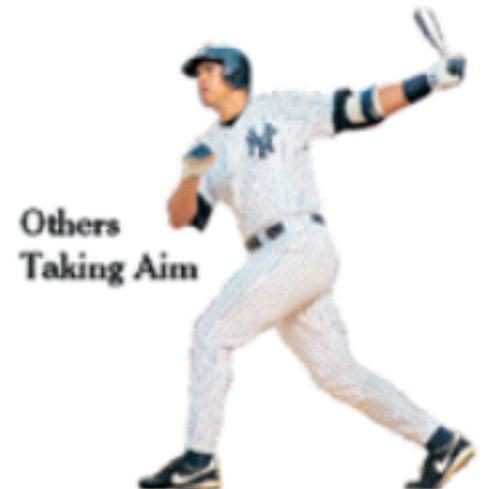


Bonds
From age 35 to 39, he averaged 14 more homers a season than projected



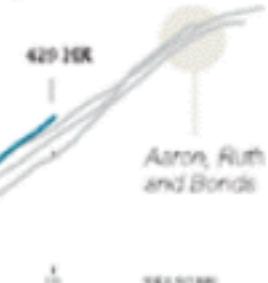
Note: Ages as of July 1 of each season

Others Taking Aim



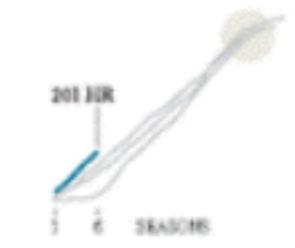
Alex Rodriguez

Is ahead of the pace set by all three home run leaders.



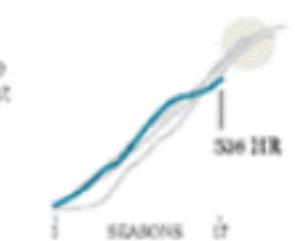
Albert Pujols

Averaging 40 homers a season, he has started stronger than the three leaders did.



Ken Griffey Jr.

Many thought he would be the first to catch Ruth and Aaron until injuries limited his output.

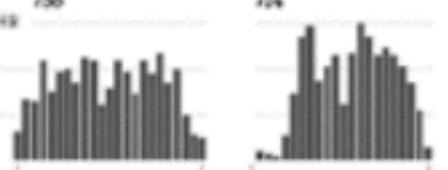


Differing Paths to the Top of the Charts

The top seven players on the career home run list, along with a look at Griffey (12th), Rodriguez (37th) and Pujols (5ed 257th).

Hank Aaron

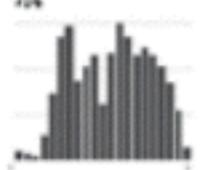
755



16 times hit 30 or more (M.L. most).

Babe Ruth

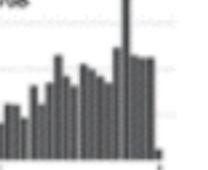
714



Hit only 20 over first five seasons.

Barry Bonds

708



Averaged 52 from 2000 to 2004.

Willie Mays

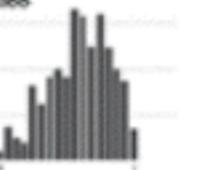
660



No one hit more than 1950-69.

Sunny Sosa

588



Three 60-homer seasons is record.

Frank Robinson

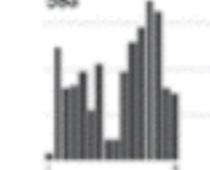
586



Triple Crown in '66 (49, 122, .316).

Mark McGwire

583



First to hit 70 in a season.

Ken Griffey Jr.

536



Only McGwire had more in the 90's.

Alex Rodriguez

429



Youngest to reach 400 homers.

Albert Pujols

261



Second most ever in first five seasons.

Source: The New York Times/National League

E. Segel

755

Steroids or Not, the Pursuit Is On

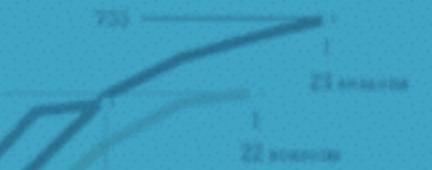
Every Bonds is being won at the career home run record. His record is only six more to tie Babe Ruth and 47 to equal Hank Aaron.

It's a remarkable home run



BEGINNING

According to accusations in a book about steroids, he began using steroids before the 1993 season. He hit 439 in the league two seasons after his 61 in 1994, then surpassing Aaron's career pace.



20 seasons
Bonds was accused last season. He already had 14 games and had 6 home runs.

Homer Pace After Age 34

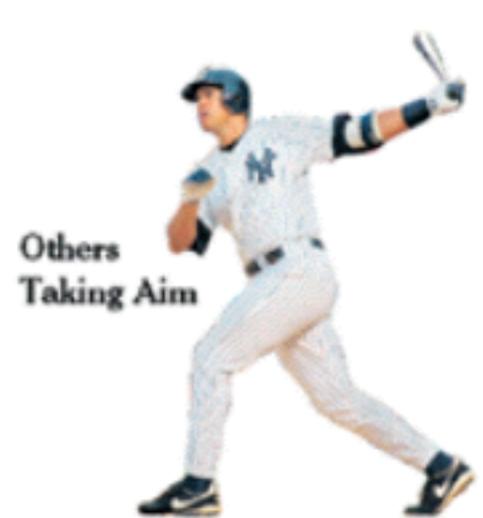
If the accusations are correct, Bonds was 24 in his first season on steroids. Here are projected home run paces for each player after age 34.

Accusations raised the number of previous five seasons



Note: Ages as of July 1 of each season

Others Taking Aim



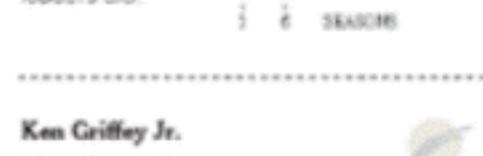
Alex Rodriguez

is ahead of the pace set by all three home run leaders.



Albert Pujols

Averaging 40 homers a season from age 20 to 34, he has started stronger than the three leaders did.



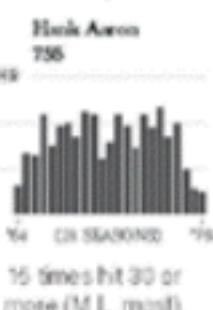
Ken Griffey Jr.

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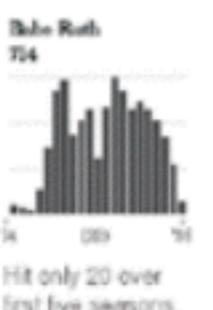


Differing Paths to the Top of the Charts

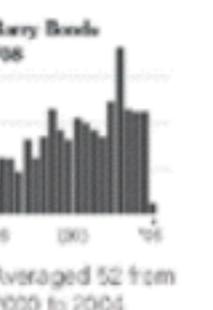
The top seven players on the career home run list, along with a look at Griffey (129), Rodriguez (37th) and Pujols (led 257th).



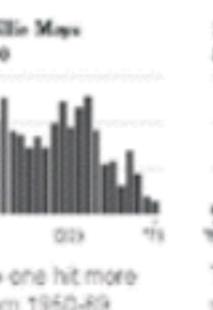
15 times hit 30 or more (M.L. most).



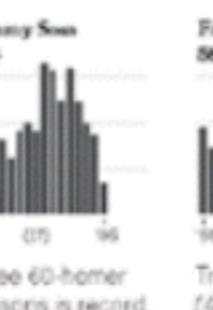
Hit only 20 over first five seasons.



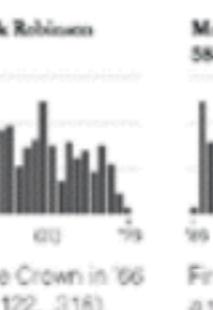
Averaged 52 from 2000 to 2004.



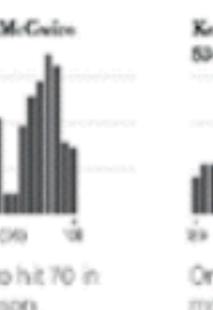
No one hit more from 1950-69.



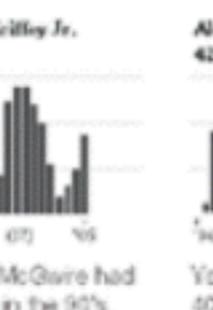
Three 60-homer seasons is record.



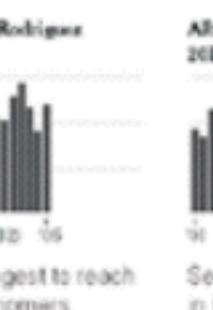
Triple Crown in '66 (49, 122, .316).



First to hit 70 in a season.



Only McGwire had more in the 90's.



Youngest to reach 400 homers.



Second most ever in first five seasons.

Source: The 2005 World Series New York Times

755

Steroids or Not, the Pursuit Is On

Every Bonds hit seems like the closer home run is scored. He needs only six more to tie Babe Ruth and 47 to equal Hank Aaron.

Line shows cumulative home runs.

Hank Aaron
755 home runs
23 seasons



Babe Ruth
714 home runs
22 seasons



Barry Bonds
709 home runs
20 seasons



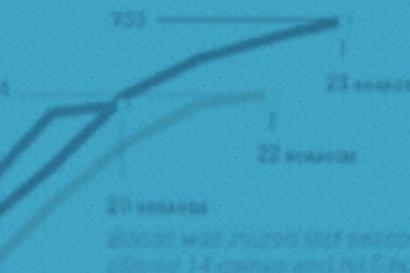
BEGINNING

According to accusations in a grand jury about steroids, he began hitting records before the 1990 season. The 400 in the major leagues was passed when he hit 70 home runs, surpassing Aaron's career pace.

670

1400 seasons

Bonds takes lead
1990-93
After 75 home runs
Bonds: 547
Aaron: 544
Ruth: 538



Homer Pace After Age 34

If the accusations are correct, Bonds was 26 in his first season on steroids. Here are projected home run paces for each player after age 34.

1990-2005 HOME RUNS BY AGE

Aaron
Actual home runs
Averaged 40.4
home runs per
season.
Projected home
runs for the
next five
years.

Ruth
Averaged 46.4
home runs
per season
from age 30
to 34.
Averaged 42.5
for next four
years.

Bonds
From age 35
to 39, he
averaged 51.4
more home
runs than
projected.

Note: Ages as of July 1 of each season.

Others Taking Aim

Alex Rodriguez
is ahead of
Babe Ruth
by all three
home run
records.

429 HR

MIDDLE

Albert Pujols
Averaging 40
home runs
per season, he has
surpassed Ruth
in three
years and
McGwire in
one.

364 HR

Ken Griffey Jr.
Many thought he
would be the first
to catch Ruth
and McGwire.
However, limited
by injury.

334 HR

Differing Paths to the Top of the Charts

The top seven players on the career home run list, along with a look at Griffey (129), Rodriguez (37th) and Pujols (led 257th).

Hank Aaron

755

40 HR

1954-74

Babe Ruth

714

40 HR

1914-34

Barry Bonds

709

40 HR

1982-2002

Willie Mays

660

40 HR

1951-71

Sunny Sosa

588

40 HR

1988-98

Frank Robinson

586

40 HR

1956-76

Mark McGwire

583

40 HR

1988-98

Ken Griffey Jr.

536

40 HR

1989-2001

Alex Rodriguez

429

40 HR

1994-2004

Albert Pujols

261

40 HR

1995-2005

15 times hit 30 or
more (M.L. most).

Hit only 20 over
first five seasons.

Averaged 52 from
2000 to 2004.

No one hit more
than 1950-69.

Three 60-home
seasons is record.

Triple Crown in '96
(49, 122, .316).

First to hit 70 in
a season.

Only McGwire had
more in the 90's.

Youngest to reach
400 homers.

Second most ever
in first five seasons.

AP/WIDEWORLD AND THE NEW YORK TIMES

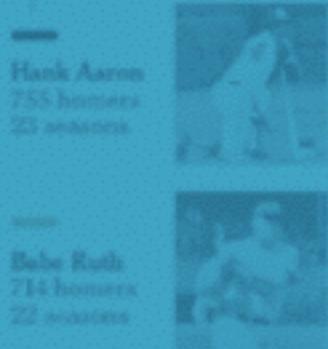
E. Segel

755

Steroids or Not, the Pursuit Is On

Barry Bonds is racing toward the career home run record. Perhaps only six more to be above Ruth and 47 to beat Hank Aaron.

It's been a cumulative pursuit.



BEGINNING

Important.

American League
in a book about steroids
he suggests that
Bonds' home run record
isn't the most impressive
achievement. Aaron's
home run record is
more impressive because
Aaron played longer.

0 to 1000

1000 to 1500

1500 to 2000

2000 to 2500

2500 to 3000

3000 to 3500

3500 to 4000

4000 to 4500

4500 to 5000

5000 to 5500

5500 to 6000

6000 to 6500

6500 to 7000

7000 to 7500

7500 to 8000

8000 to 8500

8500 to 9000

9000 to 9500

9500 to 10000

10000+

Bonds takes lead

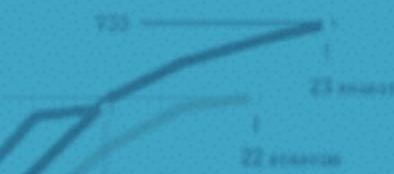
Home runs

after 16 seasons

Bonds: 567

Aaron: 554

Ruth: 516



Homer Pace After Age 34

If the accusations are correct, Bonds was 34 in his first season on the lists. Here are projected home run paths for each player after age 34.

Projecting home runs based on career home run rates per season.

Aaron

Ahead home runs

sixty

forty

thirty

twenty

ten

zero

negative

forty

sixty

eighty

one hundred

one hundred twenty

one hundred forty

one hundred sixty

one hundred eighty

two hundred

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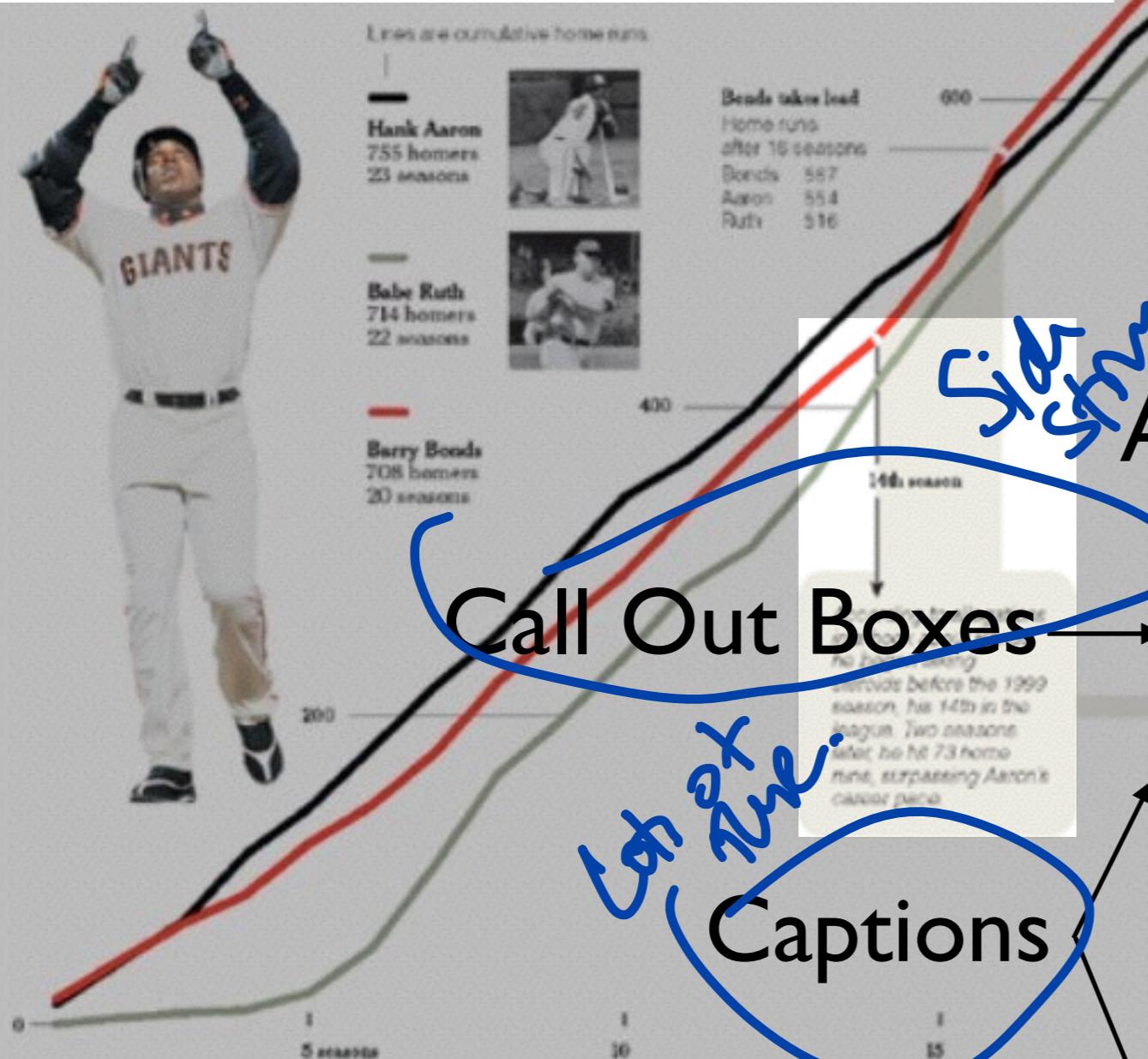
two hundred forty</

755

Headline *Most important insight*

Steroids or Not, the Pursuit Is On

Babe Ruth is taking aim at the career home run record. He needs only six more to tie Babe Ruth and 47 to equal Hank Aaron.



Call Out Boxes

Cir. 1990
1st 2x

Captions



Homer Pace After Age 34

If the accusations are correct, Bonds was 34 in his first season on steroids. Here are projected home run paces for each player after age 34.

PROJECTED PACE BASED ON AVERAGE OF PREVIOUS FIVE SEASONS

Aaron
Actual homers slightly outpace projected homers for five seasons.

Ruth
Averaged 46.4 homers a season from age 30 to 34. Averaged 42.5 for next four seasons.

Bonds
From age 35 to 39, he averaged 14 more homers a season than projected.

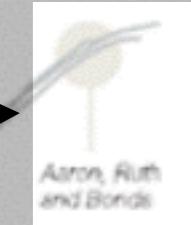
Note: Ages as of July 1 of each season.

Others Taking Aim

Alex Rodriguez
Is ahead of the pace set by all three home run leaders.

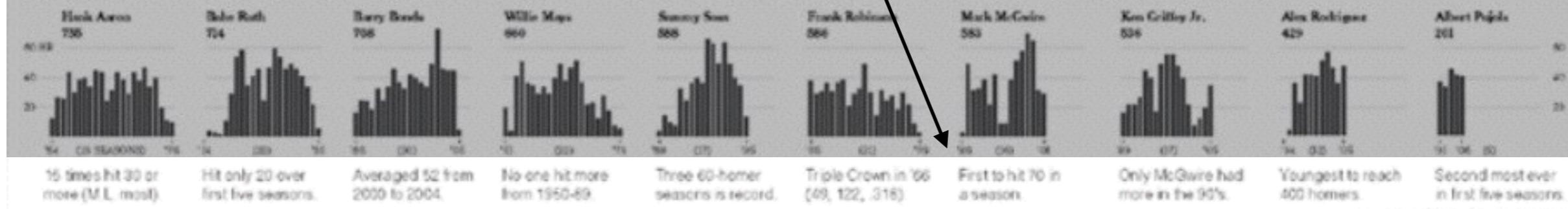
Albert Pujols
Averaging 40 homers a season, he has started stronger than the three leaders did.

Ken Griffey Jr.
Many thought he would be the first to catch Ruth and Aaron until injuries limited his output.



Differing Paths to the Top of the Charts

The top seven players on the career home run list, along with a look at Griffey (129), Rodriguez (37th) and Pujols (5ed 257th).



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Where the Power Is Out and Returning Across the Northeast

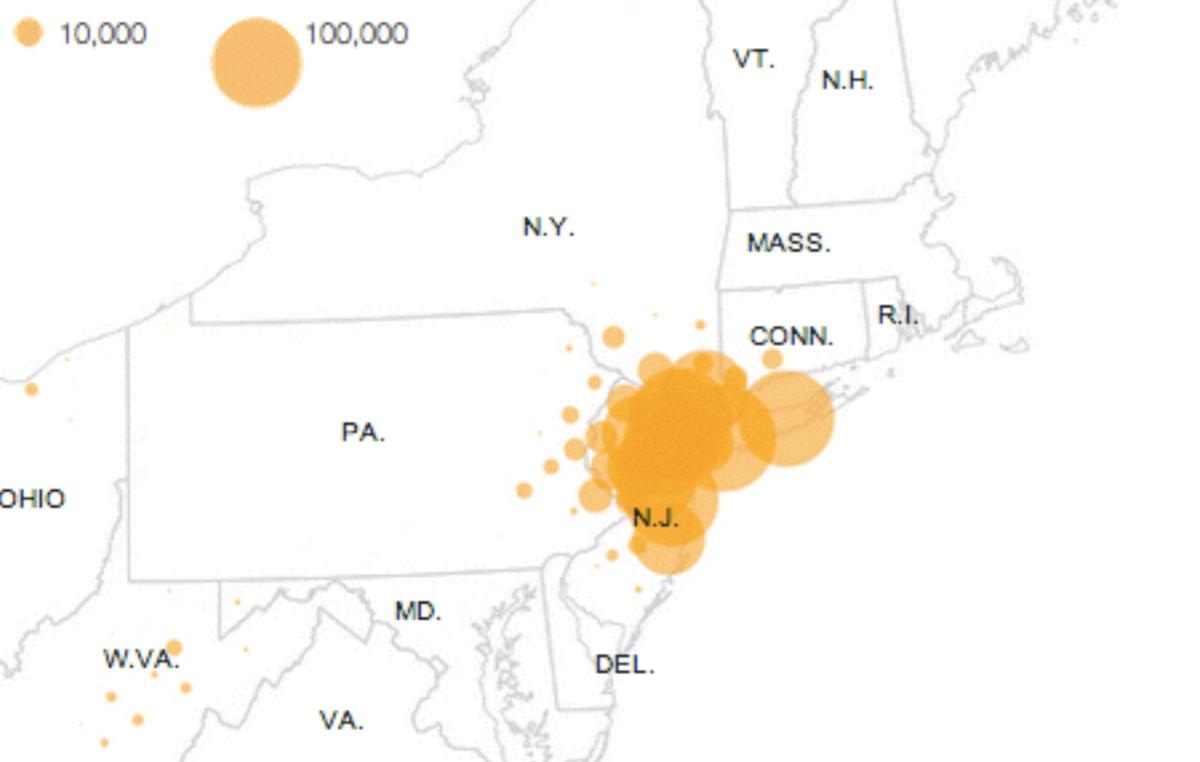
Updated Sunday, November 4 at 8:00 PM

Hurricane Sandy felled trees, downed power lines and flooded substations. The storm led to power failures in at least 17 states. Here's the restoration status in areas with significant power failures.

Power outages across the Northeast

Customers without power

● 10,000



TRI-STATE AREA

PSE&G

501,074 customers affected



Jersey Central Power & Light

405,816 customers affected



Long Island Power Authority

281,900 customers affected



WHERE THERE'S SMOKE—THERE'S CANCER

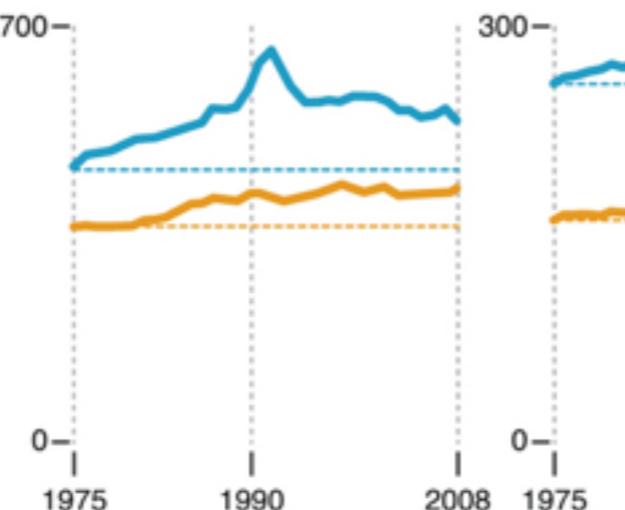
Cancer rates are up, but mortality is down. New diagnostics and treatments are responsible for part of this trend. But the greatest single contributing factor is the decline in smoking—rates are at their lowest level in 50 years.

Men Women

1 Increased incidence

An aging population contributes to rising incidence of cancer.

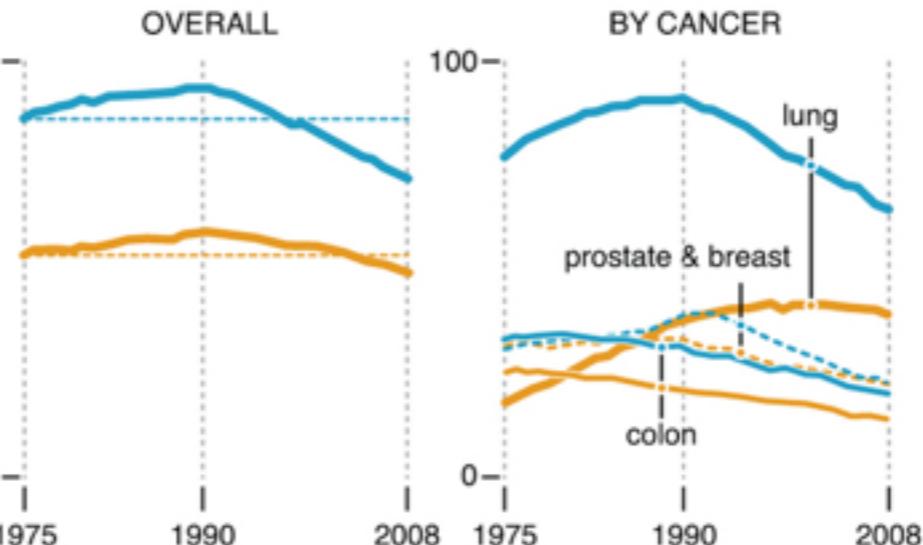
Cancer incidence rates (per 100,000)



2 Fewer deaths

Cancer deaths have been dropping since 1991, especially in males.

Cancer death rates (per 100,000)



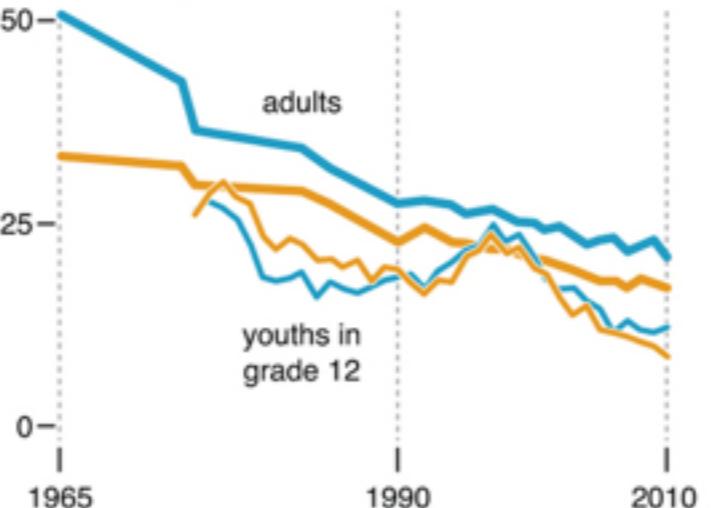
3 Decline of lung cancer

Drop in lung cancer deaths in males is the primary reason why death rates are down.

4 Decline in smoking

Since the 1964 first Surgeon General's report, smoking rates have been dropping. By 2010, the rate among males was down to 20%, from 50% at its peak. Among youths, rates have been on an even steeper decline since 1997.

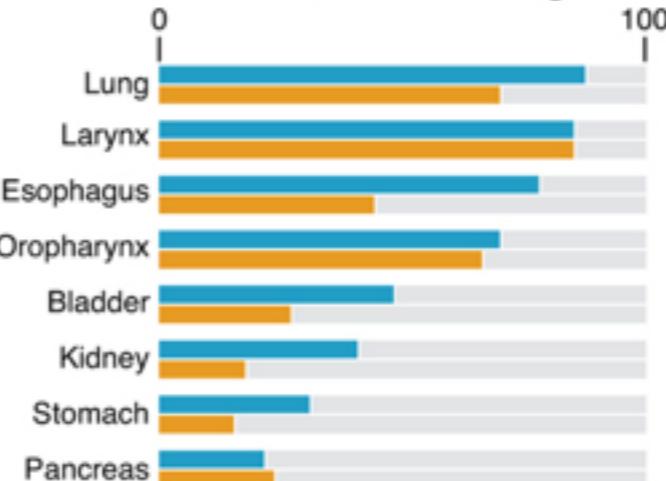
Smoking prevalence (%)



5 Impact of smoking on cancer deaths

Smoking is a major risk factor for many types of cancer and significant contributor to cancer-related deaths. It remains the single largest preventable cause of disease and premature death in the US.

Percentage of cancer deaths attributable to smoking



M. Krzywinski & A. Cairo

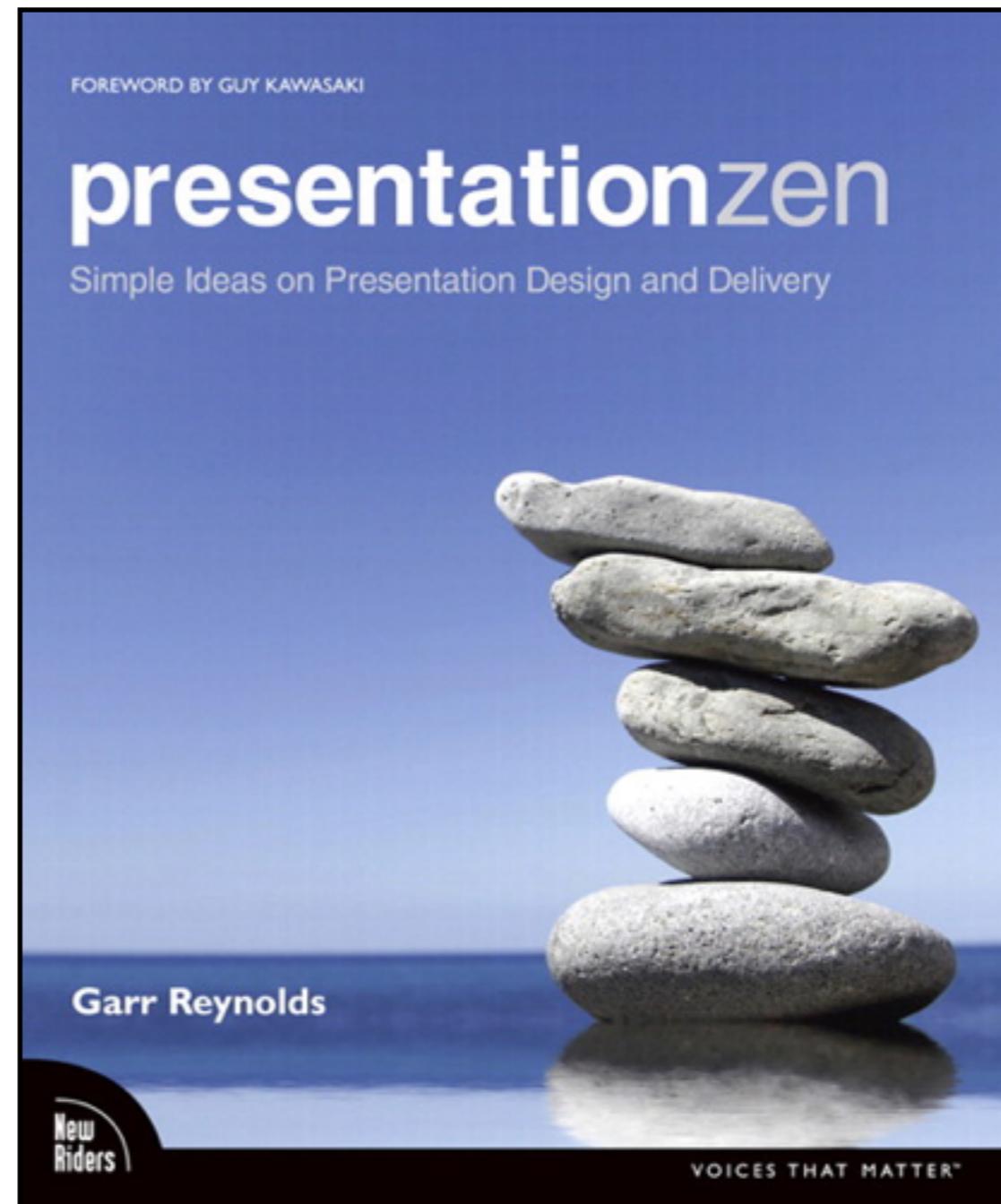
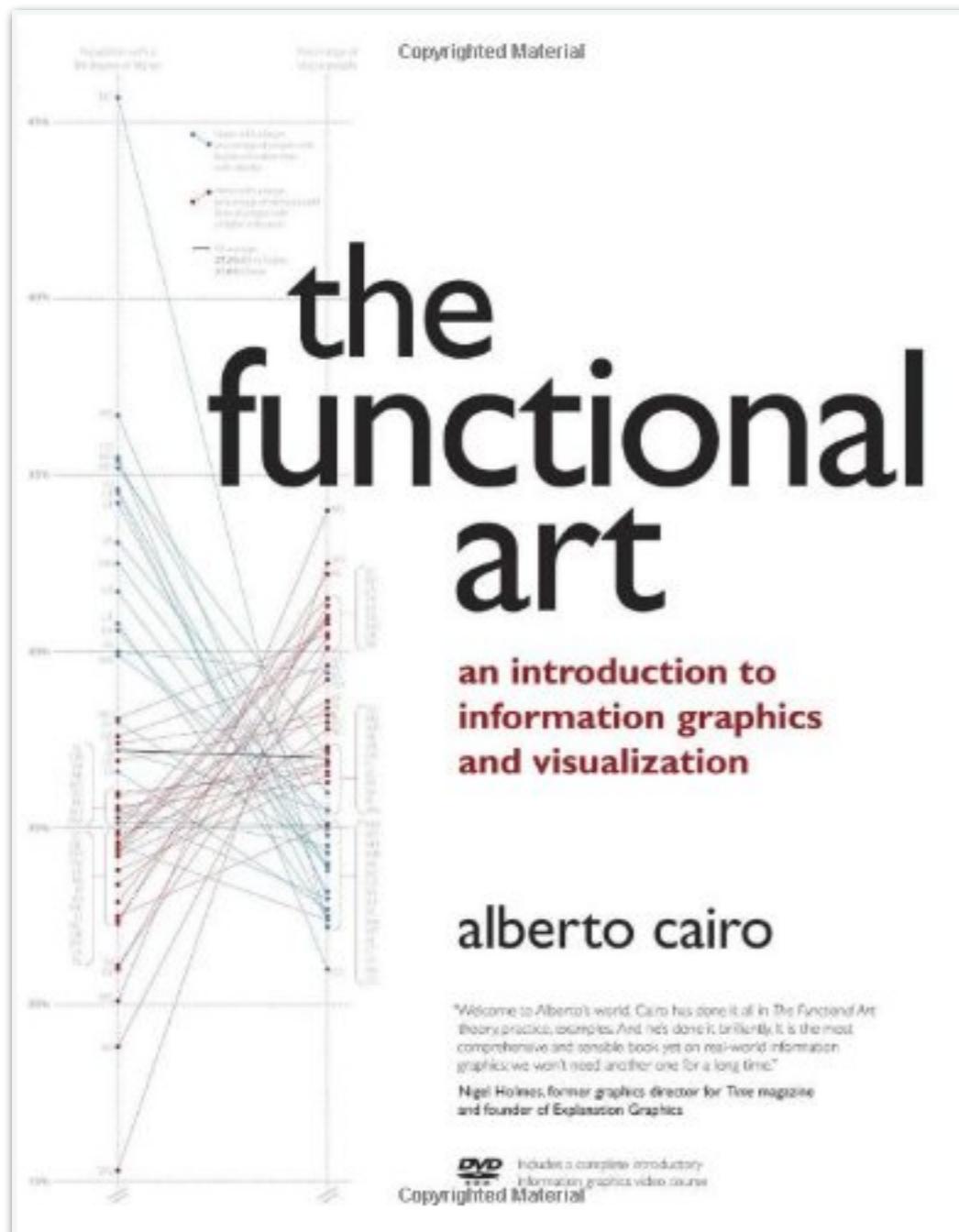
source: American Cancer Society Cancer Statistics 2012; Monitoring the Future (University of Michigan).

Take it
reade by
n hand.

Successful Data Stories...

-target the audience
- ...engage and are memorable
- ...answer concise questions
- ...are carefully designed
- ...move us to want to change the world

Further Reading



Further Reading

