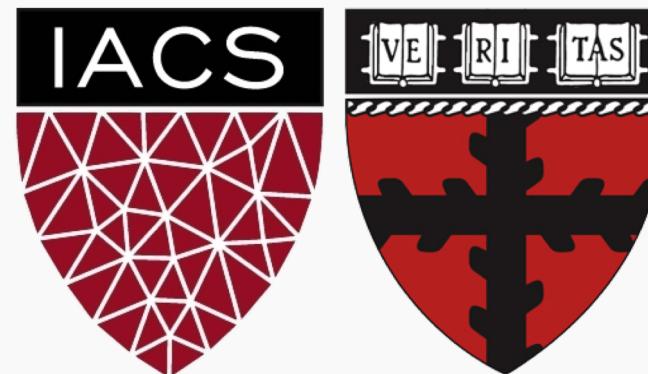


Lecture 8: EDA

CS109A Introduction to Data Science
Pavlos Protopapas, Kevin Rader and Chris Tanner



Lecture Outline

Data Science Process Example

- Dataset considerations
 - Comprehensive vs Sampled
 - Biases

Visualization

- Exploration (EDA)
- Communication

Lecture Outline

Data Science Process Example

- Dataset considerations
 - Comprehensive vs Sampled
 - Biases

Visualization

- Exploration (EDA)
- Communication

Example

Let's say that we are interested in the English Premier League (football/soccer) and want to build a model to predict a player's market value.

Question

Does age affect one's market value?

Example

What do we do?



Example

What do we do?

Ask an interesting question

Get the Data

Explore the Data

Model the Data

Communicate/Visualize the Results



Dataset Considerations

- What data is necessary to answer our question?
- Is the source credible/authoritative? (.com, .net, .org, .gov, .name)
- How difficult is it to analyze the dataset? (photos, videos, text?)
- What is the allowed usage of data under its license?
- Who collected the data?
- When was the data collected?

Dataset Considerations (continued)

- How was the data collected?
- How is the data formatted?
- Confidentiality concerns
- Does your data collection procedures need to be approved by an IRB?
- Comprehensive data vs sampled data?
- Biases

Dataset Considerations (continued)

- How was the data collected?
- How is the data formatted?
- Confidentiality concerns
- Does your data collection procedures need to be approved by an IRB?
- Comprehensive data vs sampled data?
- Biases

Lecture Outline

Data Science Process Example

- Dataset considerations
 - Comprehensive vs Sampled
 - Biases

Visualization

- Exploration (EDA)
- Communication

Dataset Considerations: Comprehensive Data

- We have access to all the data points that exist, which is usually a lot
- Collected and digitized as part of generalized procedures of an institution

having all the data is usually unrealistic

The New York Times

13 million articles



~500 million tweets per day

CONGRESS.GOV

100,000s votes per year

Dataset Considerations: Sampled Data

- When collecting individual data is relatively expensive
- Only a portion of the population is sampled
- Not just restricted to polling or surveys



1. [Clover Food Lab](#)



\$\$\$ · American (New),
Sandwiches, Cafes



nielsen
.....

Lecture Outline

Data Science Process Example

- Dataset considerations
 - Comprehensive vs Sampled
 - Biases

Visualization

- Exploration (EDA)
- Communication

Dataset Considerations: Biases

- **A bias in sampled data occurs when a procedure causes the sample to overrepresent a subpopulation**
- Biases may not necessarily be intentional
- Even if you don't think over-representation of a subpopulation will bias the dataset with regard to your question, it's still a bias
- Always strive to minimize any biases in your data collection procedures

Dataset Considerations: Biases

Gallup Polls

- Randomly calls two groups of ~500 people a day by sampling among all possible phone numbers
- For landlines, asks for household member who has the next birthday
- Calls people living in all 50 states
- Tries to assure 70% cellphone, 30% landlines
- Weights data to reflect the demographics of the general population

Dataset Considerations: Biases

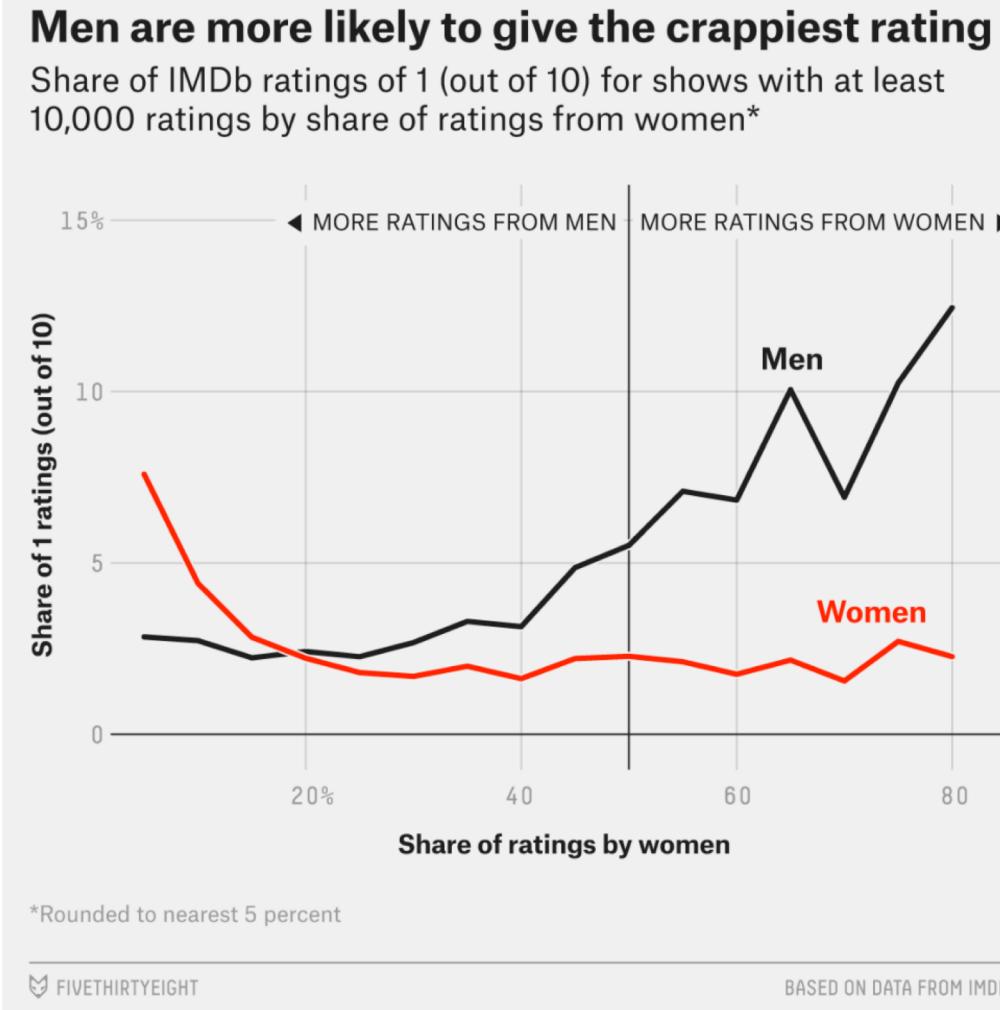
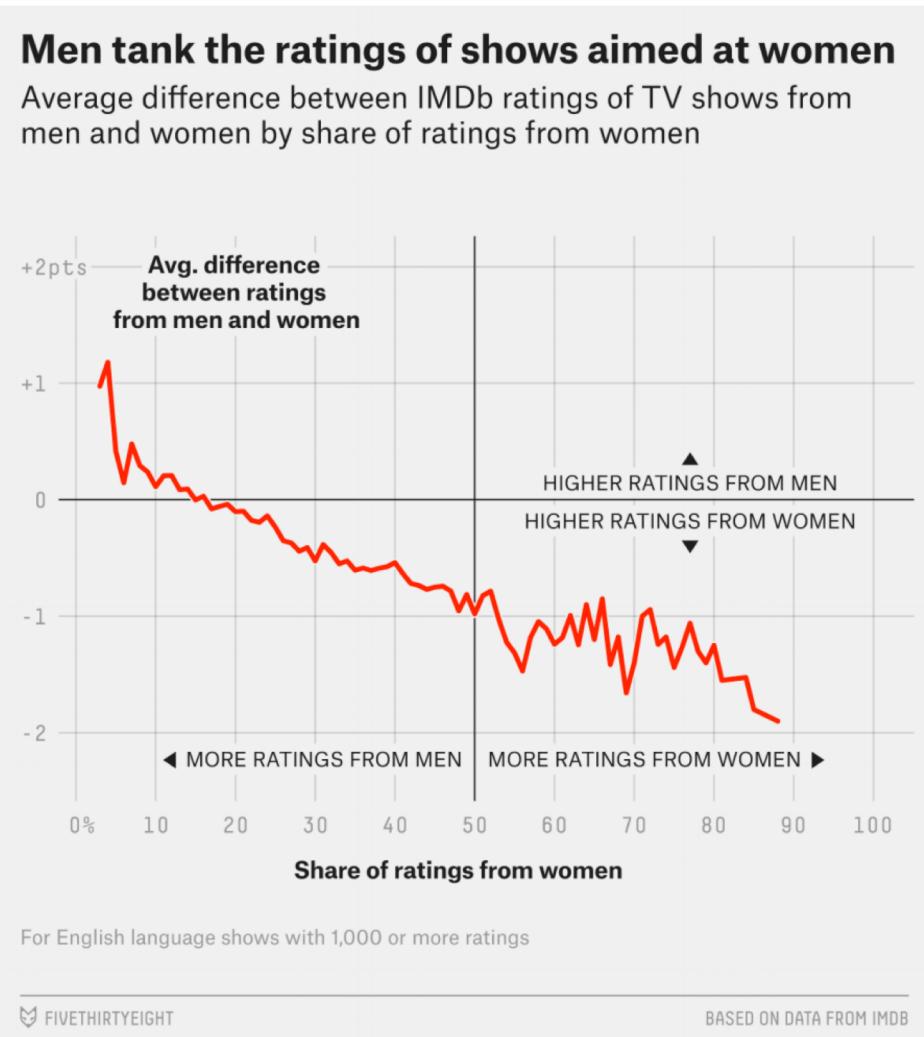
IMDb Movie Ratings

- Registered users rate films 1-10 stars; they are an overrepresented subpopulation relative to the general population
- Registered users who rate movies in their free time further over represents a specific segment of the general population
- *"Men Are Sabotaging The Online Reviews Of TV Shows Aimed At Women¹"*
 - 60% who rated Sex in the City were women. Women gave it a 8.1, men gave it 5.8.

¹ fivethirtyeight.com

Dataset Considerations: Biases

IMDb Movie Ratings



Dataset Considerations: Biases

Yelp Reviews

- Registered users rate businesses on a 1-5 star scale
- Registered users tend to represent a certain subset of the population (those who are more social media inclined and opinionated)
- Customers with extreme experiences are more likely to voice their opinions

Dataset Considerations: Biases

Yelp Reviews



6. Clover Food Lab

104 reviews

\$ · Sandwiches, Cafes,
American (New)



1. Clover Food Lab

821 reviews

\$\$ · American (New),
Sandwiches, Cafes

Dataset Considerations: Biases

Yelp Reviews



6. Clover Food Lab

104 reviews

\$ · Sandwiches, Cafes,
American (New)



1. Clover Food Lab

821 reviews

\$\$ · American (New),
Sandwiches, Cafes

Longwood Medical

Harvard Square

Back to our example...

Let's say that we are interested in the English Premier League (football/soccer) and want to build a model to predict a player's market value.

Question

Does age affect one's market value?

Example: Get the data

name	club	age	position	market value
Alexis Sanchez	Arsenal	28	LW	65
Mesut Ozil	Arsenal	28	AM	50
Petr Cech	Arsenal	35	GK	7
Theo Walcott	Arsenal	28	RW	20
Laurent Koscielny	Arsenal	31	CB	22

from www.transfermarkt.us

Example: Get the data

name	club	age	position	market value
Alexis Sanchez	Arsenal	28	LW	65
Mesut Ozil	Arsenal	28	AM	50
Thierry Henry	Arsenal	35	GK	7
Andrea Belotti	Arsenal	28	RW	20
Mathieu Debuchy	Arsenal	21	CB	22

- Credible/Trustworthy?
- Possibly subjective market values?
- Sampled data

from www.transfermarkt.us

Example

name	club	age	position	market value
Alexis Sanchez	Arsenal	28	LW	65
Mesut Ozil	Arsenal	28	AM	50
Petr Cech	Arsenal	35	GK	7
Theo Walcott	Arsenal	28	RW	20
Laurent Koscielny	Arsenal	31	CB	22

Example: Explore the Data

name	club	age	position	market value
Alexis Sanchez	Arsenal	28	LW	65
Mesut Ozil	Arsenal	28	AM	50
Petr Cech	Arsenal	35	GK	7
Theo Walcott	Arsenal	28	RW	20
Laurent Koscielny				22

Does it contain the necessary information?

Example: Explore the Data

name	club	age	position	market value
Alexis Sanchez	Arsenal	28	LW	65
Mesut Ozil	Arsenal	28	AM	50
Petr Cech	Arsenal	35	GK	7
Theo Walcott	Arsenal	28	RW	20
Laurent Koscielny	Arsenal	31	CB	22

Missing data? Imputation needed?

Example: Explore the Data

name	club	age	position	market value
Alexis Sanchez	Arsenal	28	LW	65
Mesut Ozil	Arsenal	28	AM	50
Petr Cech	Arsenal	35	GK	7
Theo Walcott	Arsenal	28	RW	20
Laurent Koscielny	Arsenal	31	CB	22

Are the data types okay (`df.dtypes`)? Should be casted?

Example: Explore the Data

name	club	age	position	market value
Alexis Sanchez	Arsenal	28	LW	65
Mesut Ozil	Arsenal	28	AM	50
Petr Cech	Arsenal	35	GK	7
Theo Walcott	Arsenal	28	RW	20
Laurent Koscielny	Arsenal	31	CB	22

Are the values reasonable? `DataFrame.describe()` ...

Example: Explore the Data

	age	page_views	fpl_value	fpl_points	market_value
count	461.000000	461.000000	461.000000	461.000000	461.000000
mean	26.804772	763.776573	5.447939	57.314534	11.012039
std	3.961892	931.805757	1.346695	53.113811	12.257403
min	17.000000	3.000000	4.000000	0.000000	0.050000
25%	24.000000	220.000000	4.500000	5.000000	3.000000
50%	27.000000	460.000000	5.000000	51.000000	7.000000
75%	30.000000	896.000000	5.500000	94.000000	15.000000
max	38.000000	7664.000000	12.500000	264.000000	75.000000

Are the values reasonable? `DataFrame.describe()` ...

Example: Explore the Data

	age	page_views	fpl_value	fpl_points	market_value
count	461.000000	461.000000	461.000000	461.000000	461.000000
mean	26.804772	763.776573	5.447939	57.314534	11.012039
std	3.961892	931.805757	1.346695	53.113811	12.257403
min	17.000000	3.000000	4.000000	0.000000	0.050000
25%	24.000000	220.000000	4.500000	5.000000	3.000000
50%	27.000000	460.000000	5.000000	51.000000	7.000000
75%	30.000000	896.000000	5.500000	94.000000	15.000000
max	38.000000	7664.000000	12.500000	264.000000	75.000000

Summary statistics can only reveal so much

Lecture Outline

Data Science Process Example

- Dataset considerations
 - Comprehensive vs Sampled
 - Biases

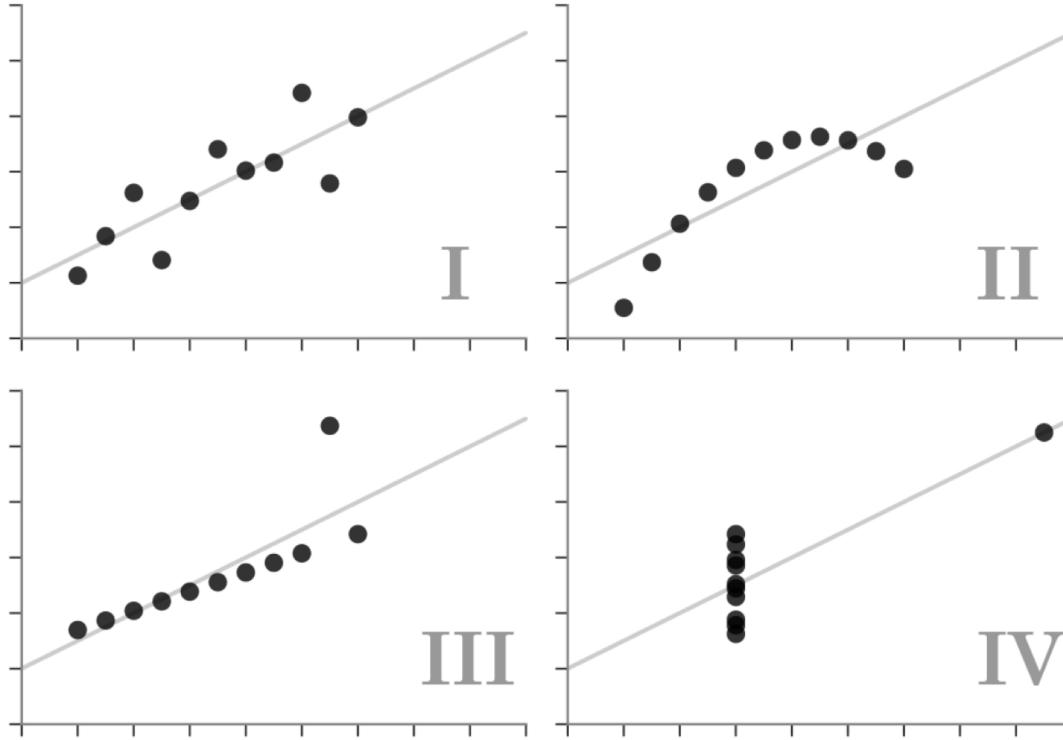
Visualization

- Exploration (EDA)
- Communication

Visualization

✓ Anscombe's Quartet

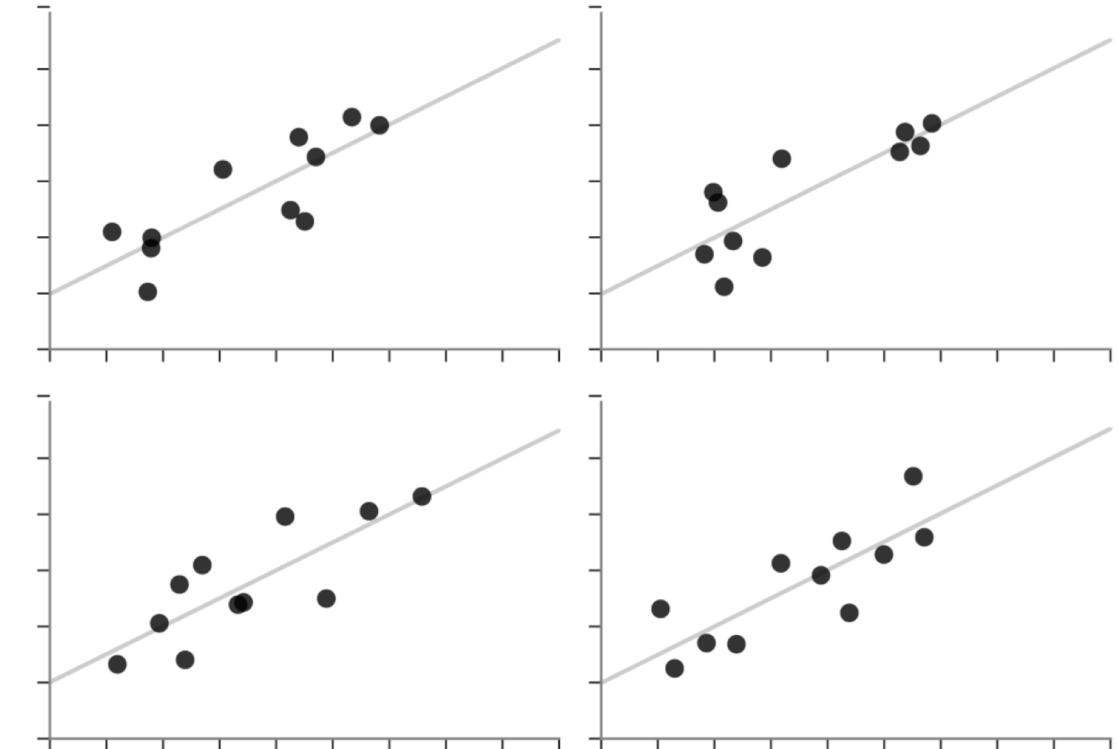
Each dataset has the same summary statistics (mean, standard deviation, correlation), and the datasets are *clearly different*, and *visually distinct*.



Same stats do not imply same graphs

✗ Unstructured Quartet

Each dataset here also has the same summary statistics. However, they are not *clearly different* or *visually distinct*.



Same graphs do not imply same stats

Visualization

Bacteria	Antibiotic			Gram Staining
	Penicillin	Streptomycin	Neomycin	
<i>Aerobacter aerogenes</i>	870	1	1.6	negative
<i>Brucella abortus</i>	1	2	0.02	negative
<i>Brucella anthracis</i>	0.001	0.01	0.007	positive
<i>Diplococcus pneumoniae</i>	0.005	11	10	positive
<i>Escherichia coli</i>	100	0.4	0.1	negative
<i>Klebsiella pneumoniae</i>	850	1.2	1	negative
<i>Mycobacterium tuberculosis</i>	800	5	2	negative
<i>Proteus vulgaris</i>	3	0.1	0.1	negative
<i>Pseudomonas aeruginosa</i>	850	2	0.4	negative
<i>Salmonella (Eberthella) typhosa</i>	1	0.4	0.008	negative
<i>Salmonella schottmuelleri</i>	10	0.8	0.09	negative
<i>Staphylococcus albus</i>	0.007	0.1	0.001	positive
<i>Staphylococcus aureus</i>	0.03	0.03	0.001	positive
<i>Streptococcus fecalis</i>	1	1	0.1	positive
<i>Streptococcus hemolyticus</i>	0.001	14	10	positive
<i>Streptococcus viridans</i>	0.005	10	40	positive

Visualization

Bacteria	Antibiotic				Gram Staining
	Penicillin	Streptomycin	Neomycin		
<i>Aerobacter aerogenes</i>	870	1	1.6		negative
<i>Brucella abortus</i>	1	2	0.02		negative
<i>Brucella anthracis</i>	0.001	0.01	0.007		positive
<i>Diplococcus pneumoniae</i>	0.005	11	10		positive
<i>Escherichia coli</i>	100	0.4	0.1		negative
<i>Klebsiella pneumoniae</i>	850	1.2	1		negative
<i>Mycobacterium tuberculosis</i>	800	5	2		negative
<i>Proteus vulgaris</i>	3	0.1	0.1		negative
<i>Pseudomonas aeruginosa</i>	850	2	0.4		negative
<i>Salmonella (Eberthella) typhosa</i>	1	0.4	0.008		negative
<i>Salmonella schottmuelleri</i>	10	0.8	0.09		negative
<i>Staphylococcus albus</i>	0.007	0.1	0.001		positive
<i>Staphylococcus aureus</i>	0.03	0.03	0.001		positive
<i>Streptococcus fecalis</i>	1	1	0.1		positive
<i>Streptococcus hemolyticus</i>	0.001	14	10		positive
<i>Streptococcus viridans</i>	0.005	10	40		positive

Visualization

Bacteria	Antibiotic				Gram Staining
	Penicillin	Streptomycin	Neomycin		
<i>Aerobacter aerogenes</i>	870	1	1.6		negative
<i>Brucella abortus</i>	1	2	0.02		negative
<i>Brucella anthracis</i>	0.001	0.01	0.007		positive
<i>Diplococcus pneumoniae</i>	0.005	11	10		positive
<i>Escherichia coli</i>	100	0.4	0.1		negative
<i>Klebsiella pneumoniae</i>	850	1.2	1		negative
<i>Mycobacterium tuberculosis</i>	800	5	2		negative
<i>Proteus vulgaris</i>	3	0.1	0.1		negative
<i>Pseudomonas aeruginosa</i>	850	2	0.4		negative
<i>Salmonella (Eberthella) typhosa</i>	1	0.4	0.008		negative
<i>Salmonella schottmuelleri</i>	10	0.8	0.09		negative
<i>Staphylococcus albus</i>	0.007	0.1	0.001		positive
<i>Staphylococcus aureus</i>	0.02	0.02	0.001		positive

What are some questions we could ask?



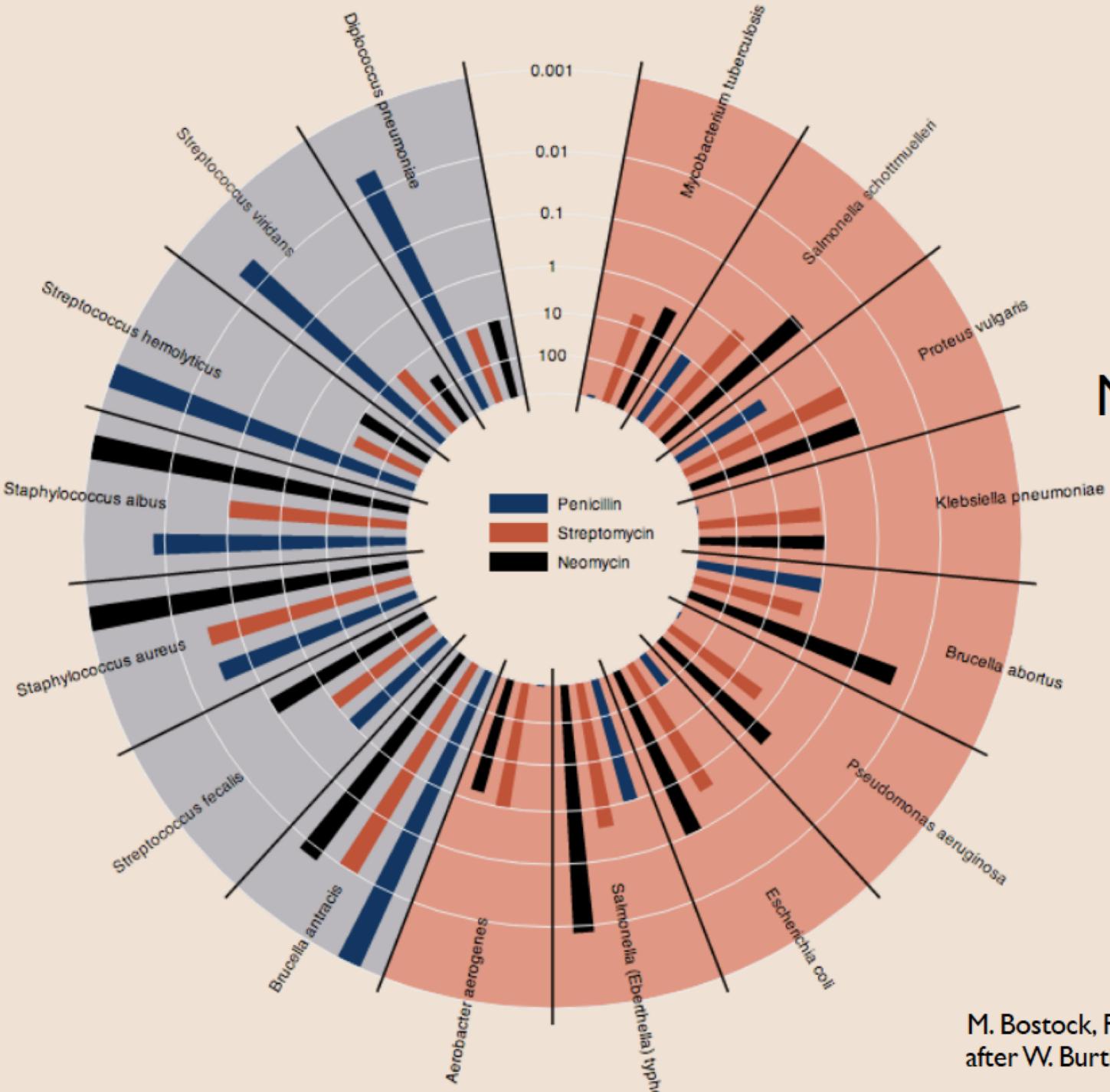
Visualization

Bacteria	Antibiotic				Gram Staining
	Penicillin	Streptomycin	Neomycin		
<i>Aerobacter aerogenes</i>	870	1	1.6		negative
<i>Brucella abortus</i>	1	2	0.02		negative
<i>Brucella anthracis</i>	0.001	0.01	0.007		positive
<i>Diplococcus pneumoniae</i>	0.005	11	10		positive
<i>Escherichia coli</i>	100	0.4	0.1		negative
<i>Klebsiella pneumoniae</i>	850	1.2	1		negative
<i>Mycobacterium tuberculosis</i>	800	5	2		negative
<i>Proteus vulgaris</i>	3	0.1	0.1		negative
<i>Pseudomonas aeruginosa</i>	850	2	0.4		negative
<i>Salmonella (Eberthella) typhosa</i>	1	0.4	0.008		negative
<i>Salmonella schottmuelleri</i>	10	0.8	0.09		negative
<i>Staphylococcus albus</i>	0.007	0.1	0.001		positive
<i>Staphylococcus aureus</i>	0.02	0.02	0.001		positive

Q: How effective are the antibiotics?



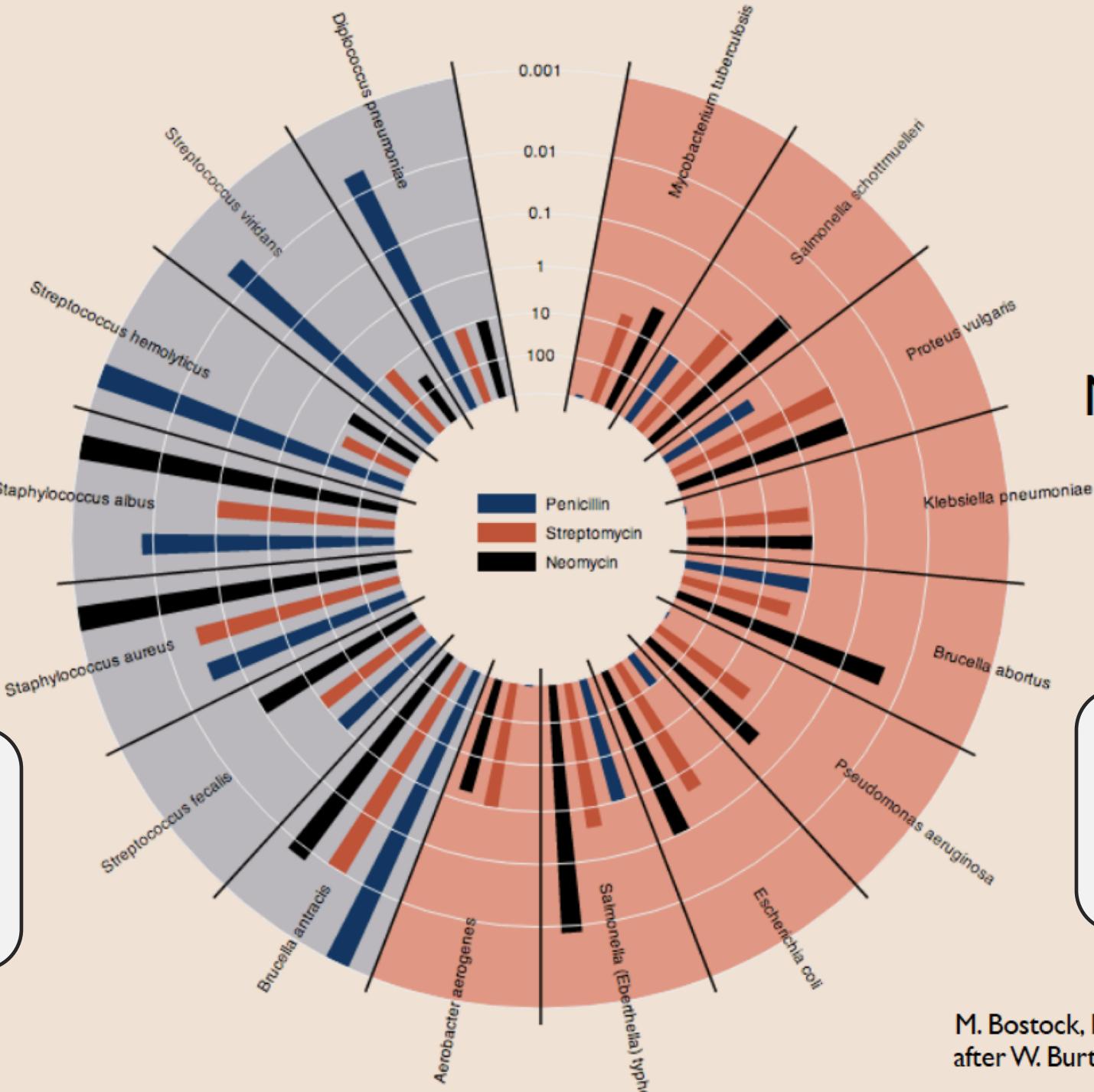
Gram Positive



Gram Negative

Gram Positive

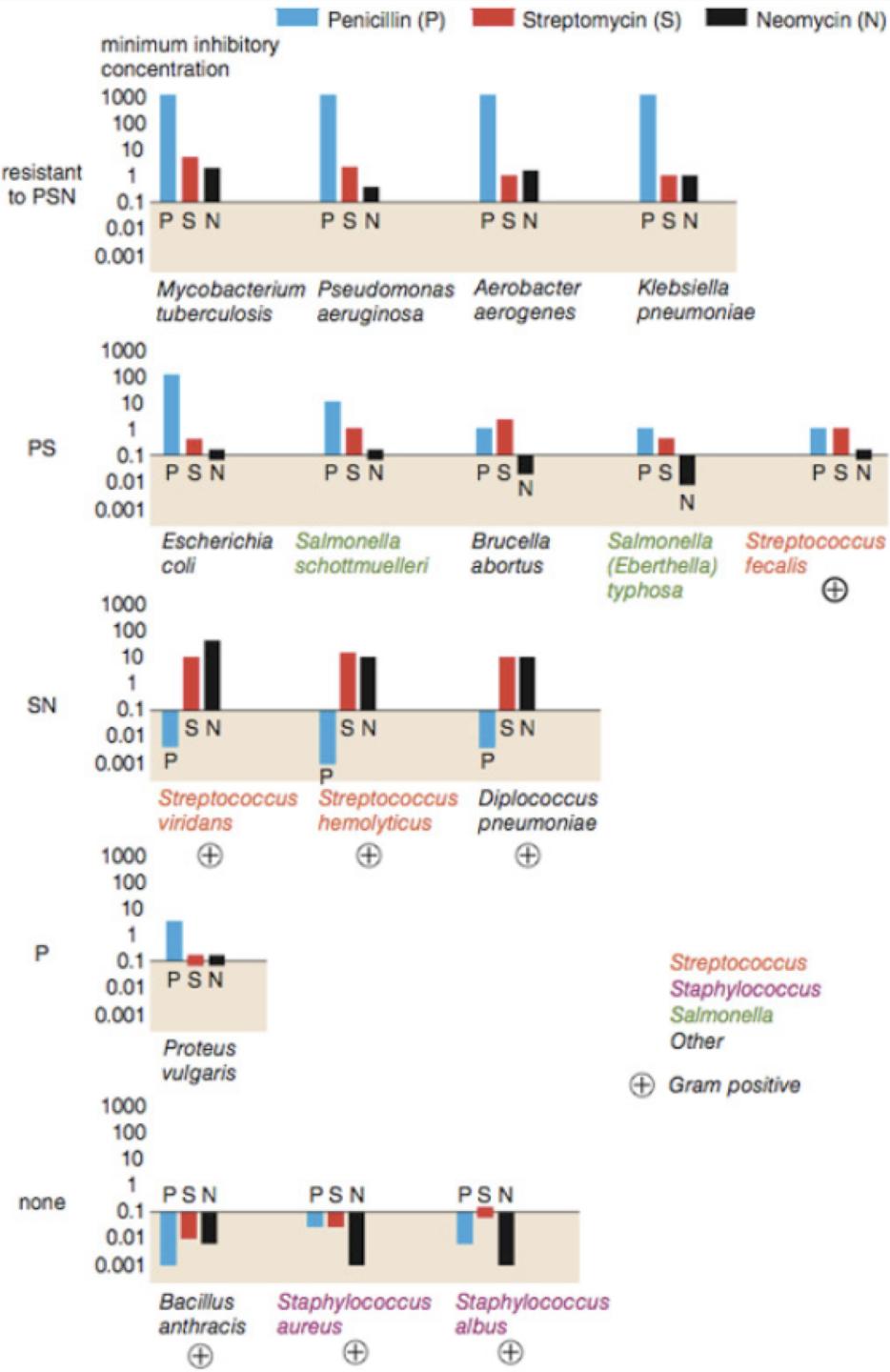
If bacteria is gram positive, Penicillin & Neomycin are most effective



Gram Negative

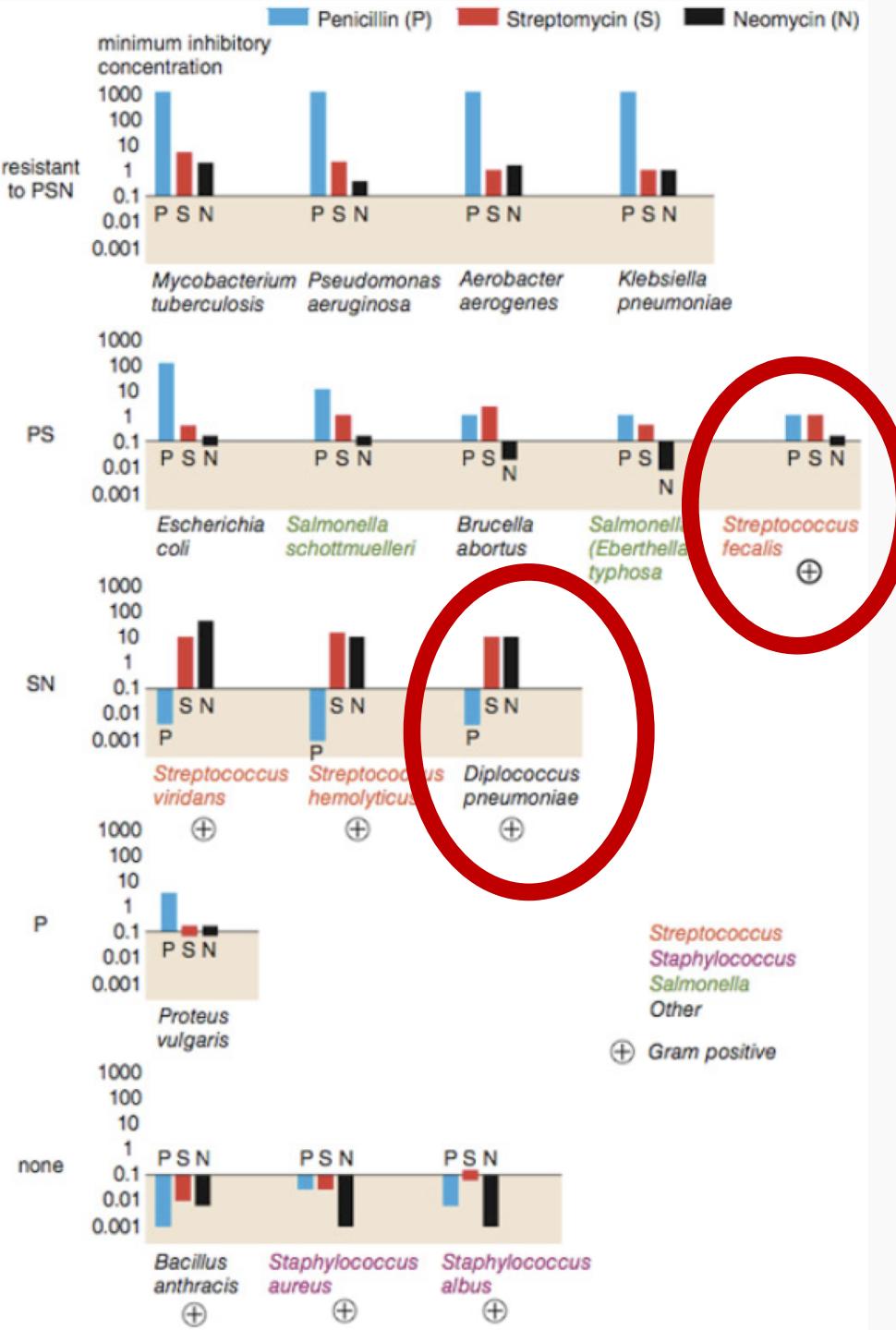
If bacteria is gram negative, Neomycin is most effective

How do the bacteria compare?



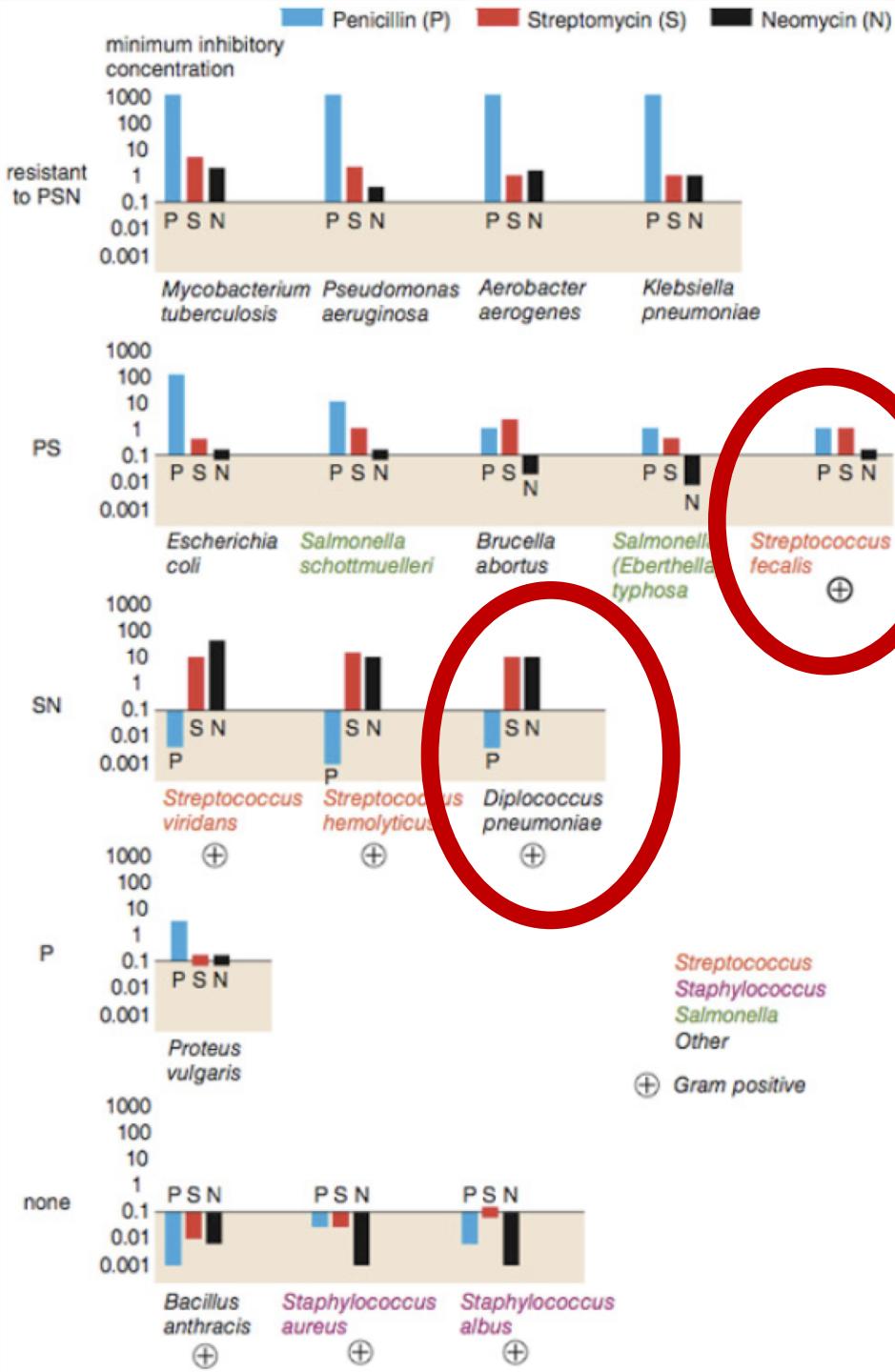
Wainer & Lysen, "That's funny..."
American Scientist, 2009
Adapted from Brian Schmotzer

How do the bacteria compare?



Wainer & Lysen, "That's funny..."
American Scientist, 2009
Adapted from Brian Schmotzer

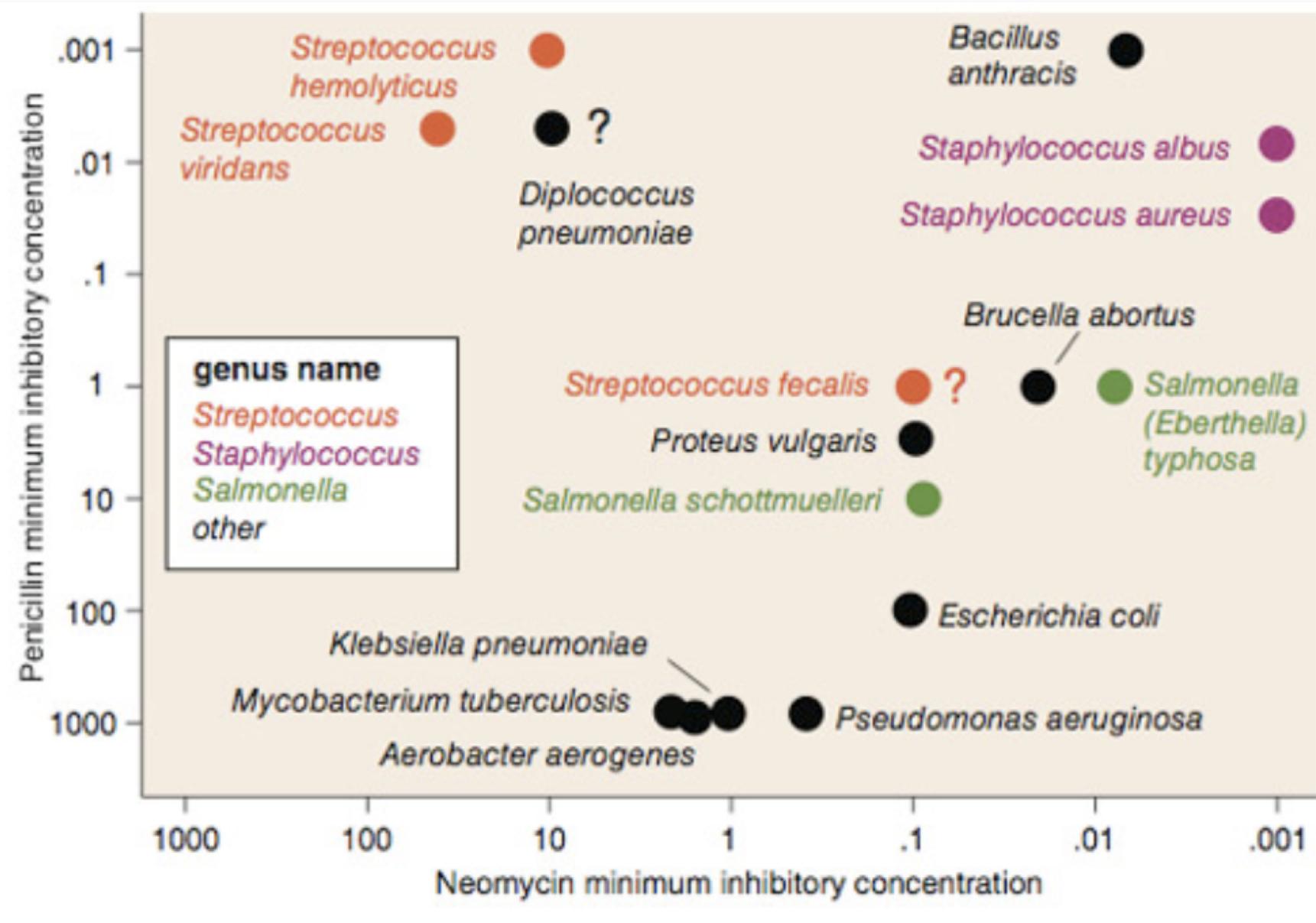
How do the bacteria compare?



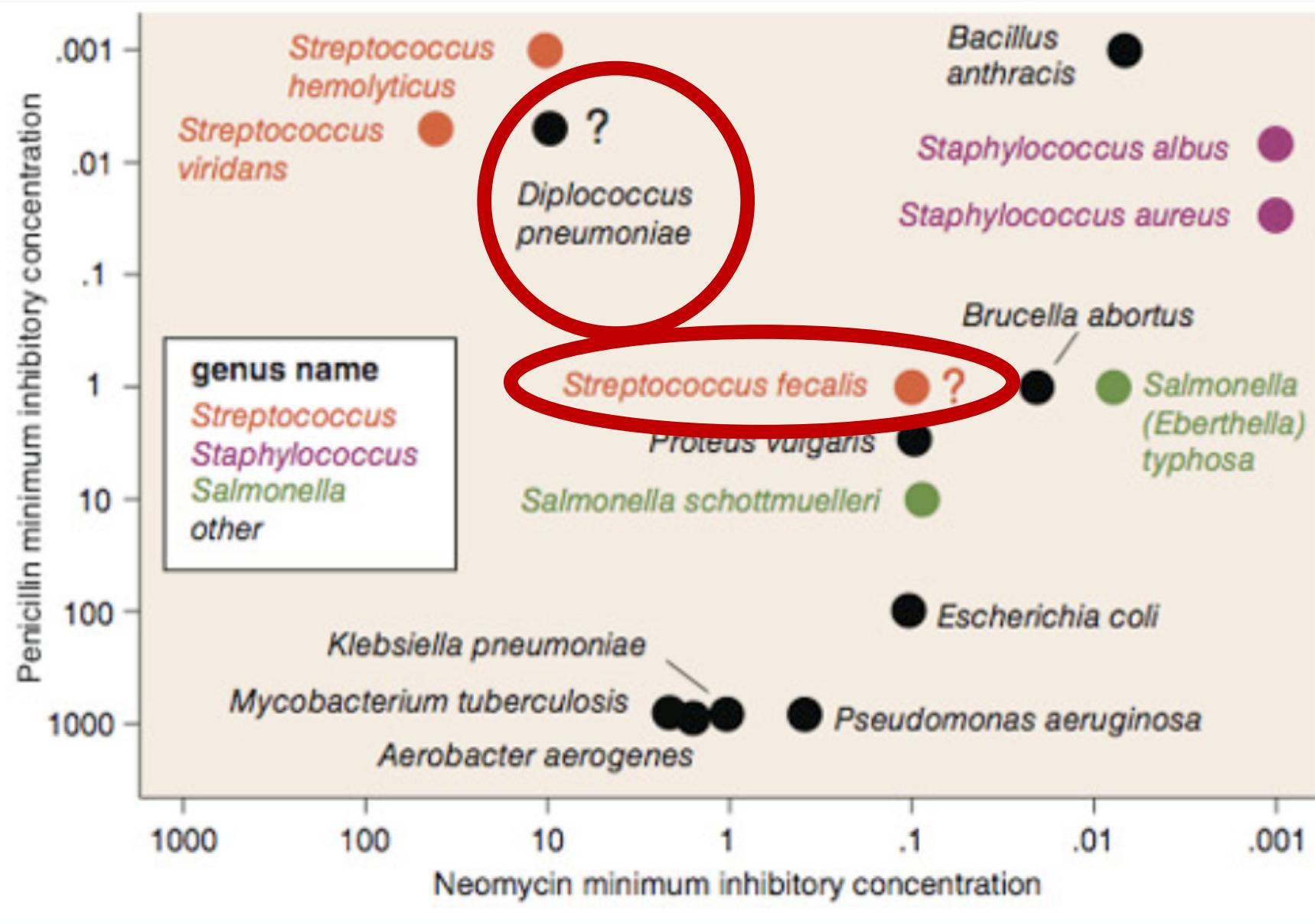
Not a streptococcus!
(realized ~30 years later)

Actually a streptococcus!
(realized ~20 years later)

Wainer & Lysen, "That's funny..."
American Scientist, 2009
Adapted from Brian Schmotzer



Wainer & Lysen, "That's funny..."
American Scientist, 2009



Wainer & Lysen, "That's funny..."
American Scientist, 2009

Visualization

"The greatest value of a picture is when it forces us to notice what we never expected to see."



John Tukey

Visualization Goals

Communicate (**explanatory**)

- Present data and ideas
- Explain and inform
- Provide evidence and support
- Influence and persuade

Analyze (**exploratory**)

- Explore the data
- Assess a situation
- Determine how to proceed
- Decide what to do



Visualization Goals

Communicate (**explanatory**)

- Present data and ideas
- Explain and inform
- Provide evidence and support
- Influence and persuade

Analyze (**exploratory**)

- Explore the data
- Assess a situation
- Determine how to proceed
- Decide what to do



**You're essentially
communicating drafts to yourself**

Communicate

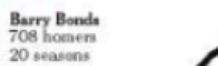
755



Steroids or Not, the Pursuit Is On

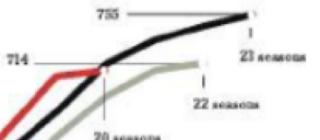
Baury Bonds is taking aim at the career home run record. He needs only six more to tie Babe Ruth and 47 to equal Hank Aaron.

Lines are cumulative home runs.



Bonds takes lead
Home runs after 16 seasons
Bonds 567
Aaron 554
Ruth 516

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.



Bonds was injured last season. He played 14 games and hit 5 homers

Homer Pace After Age 34

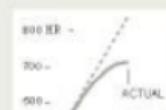
If the accusations are correct, Bonds was 34 in his first season on steroids. Here are projected home run paces for each player after age 34.

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.

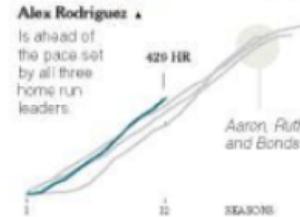
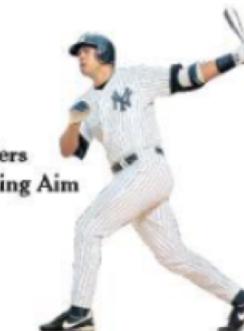


Bonds
From age 35 to 39, he averaged 14 more homers a season than projected.



Note: Ages as of July 1 of each season.

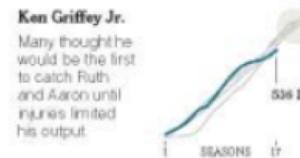
Others Taking Aim



429 HR
Aaron, Ruth and Bonds



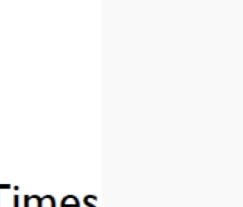
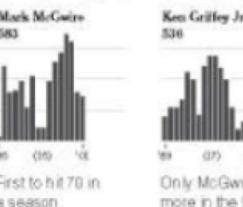
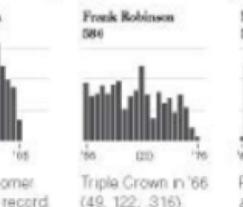
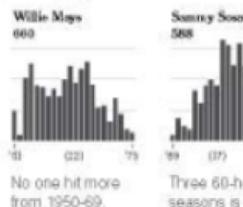
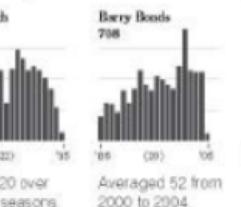
201 HR
SEASONS



536 HR
SEASONS

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 (tied 257th)

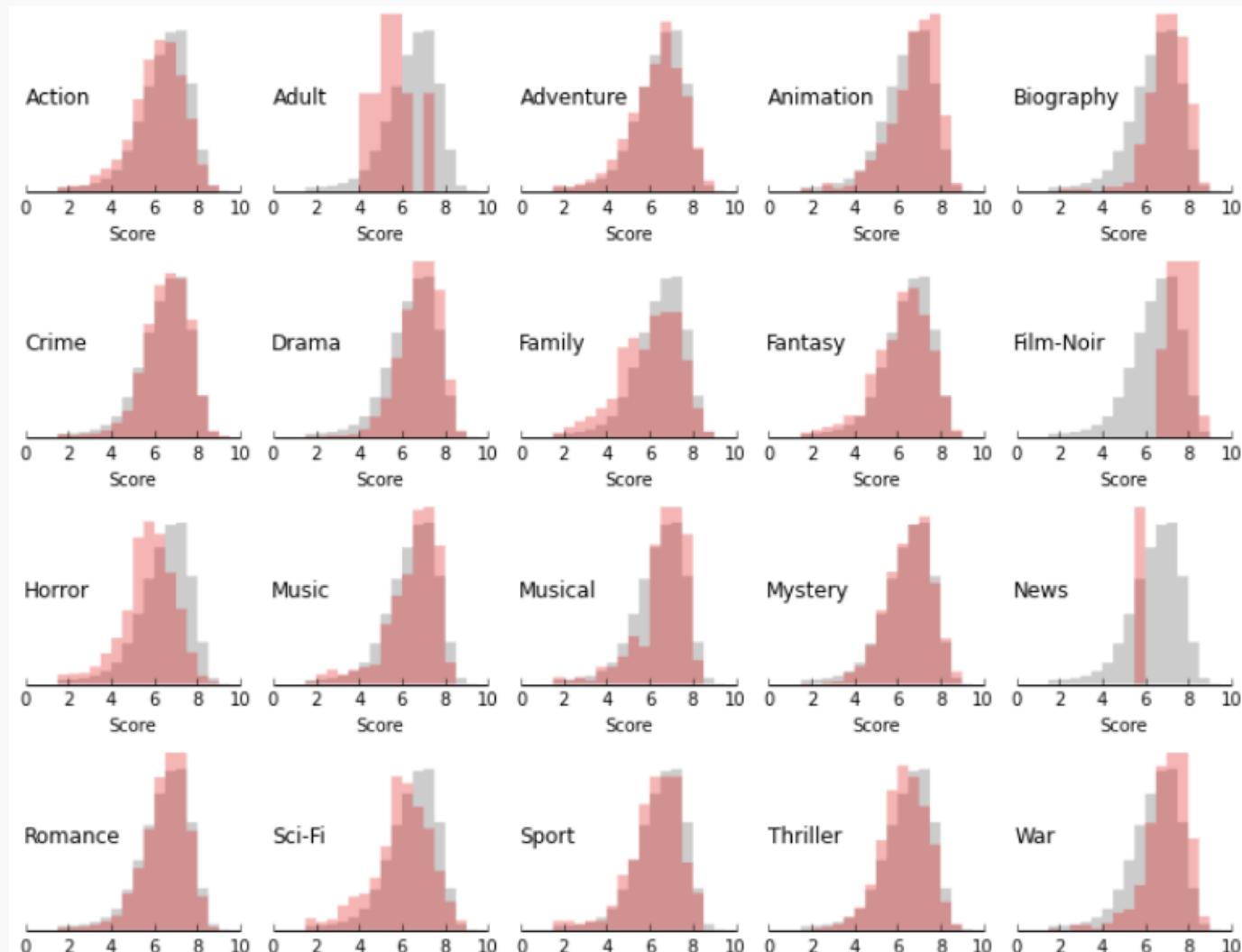


Youngest to reach 400 homers.

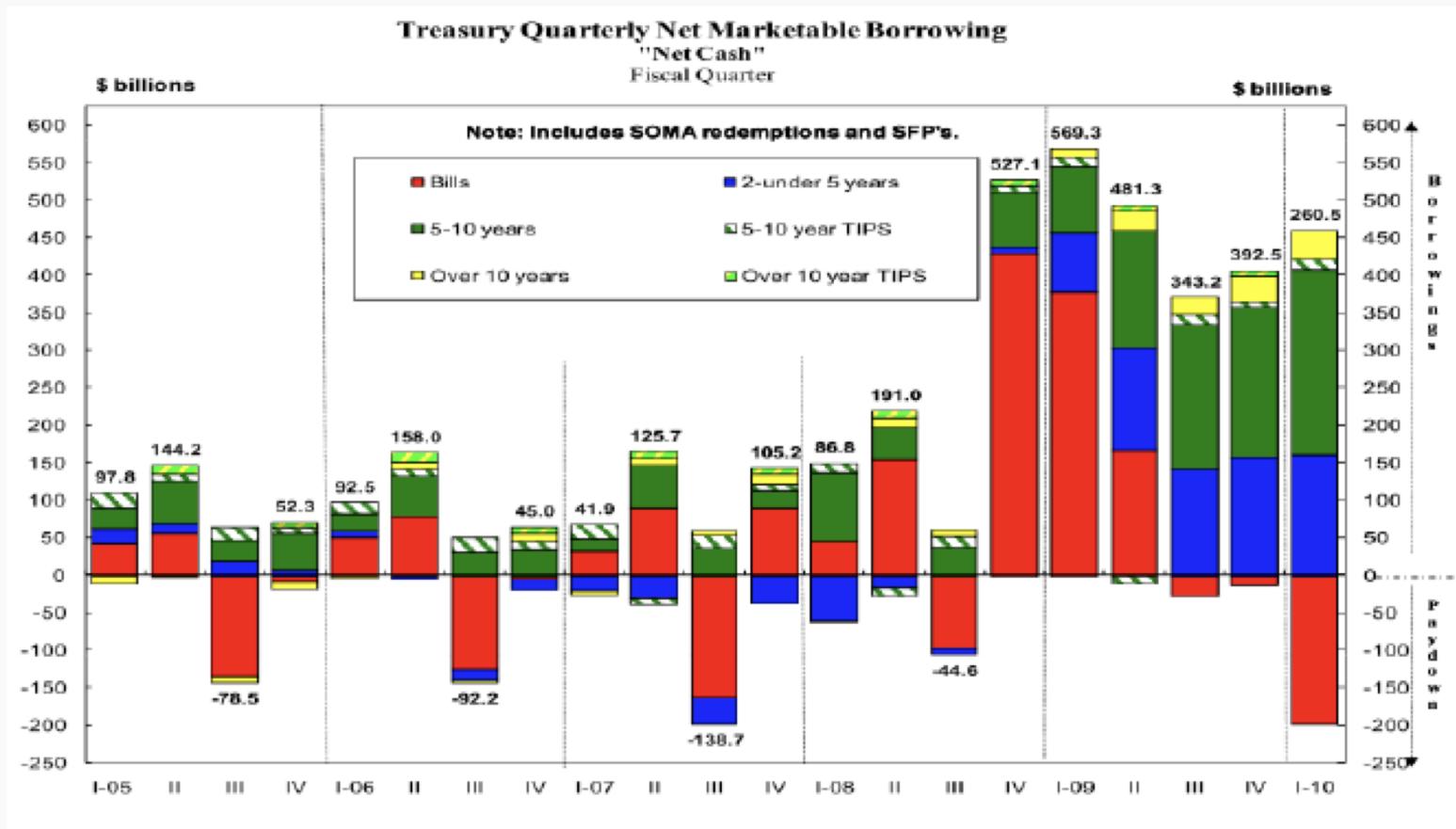
Second most ever in first 10 years.



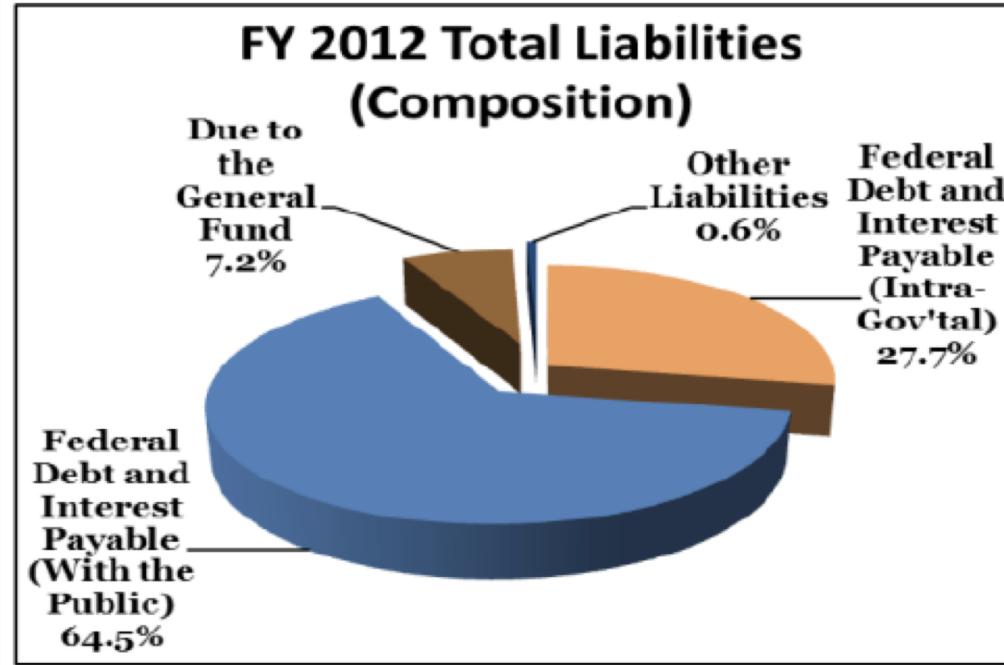
Explore



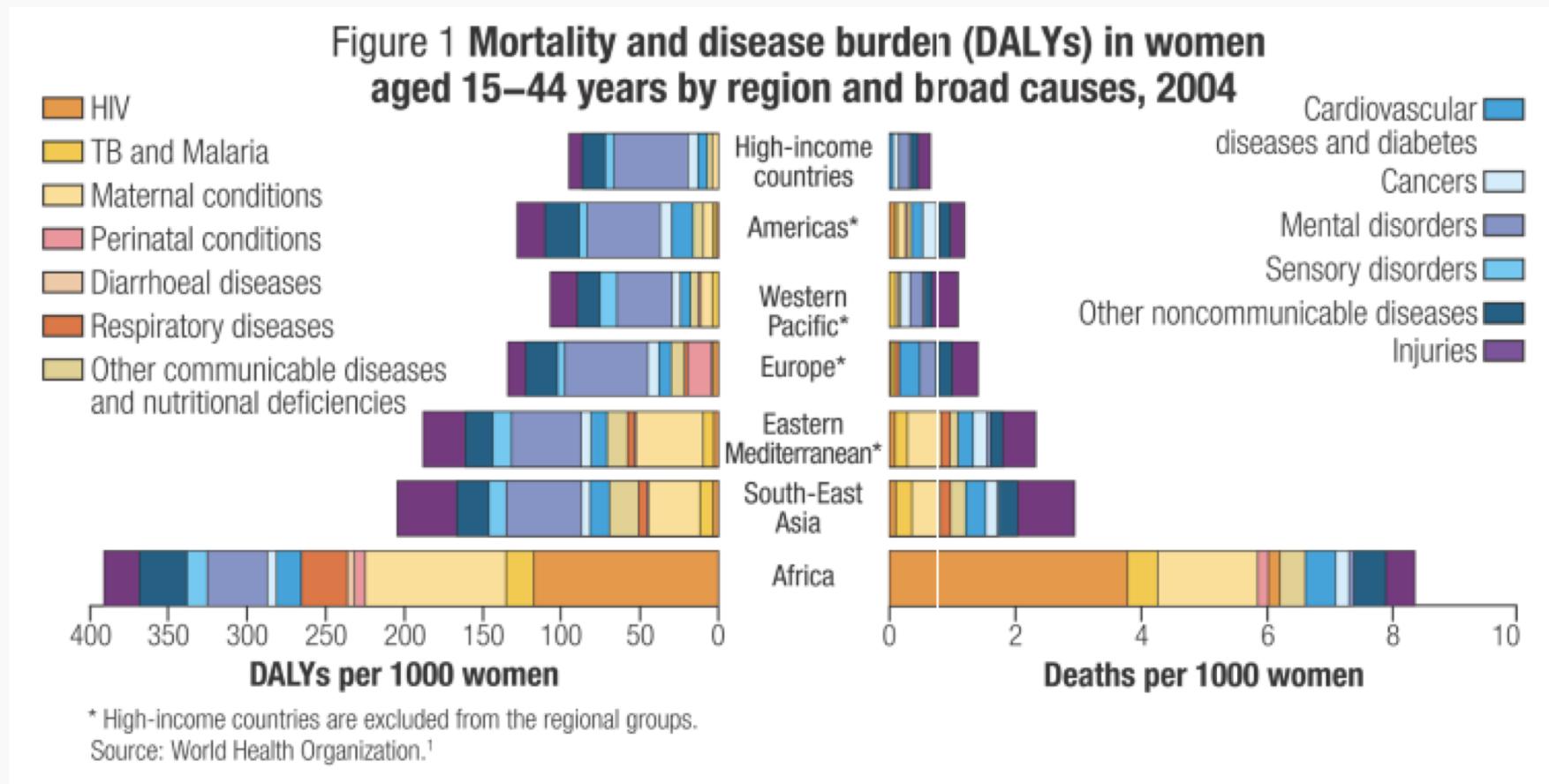
Not Effective



Not Effective



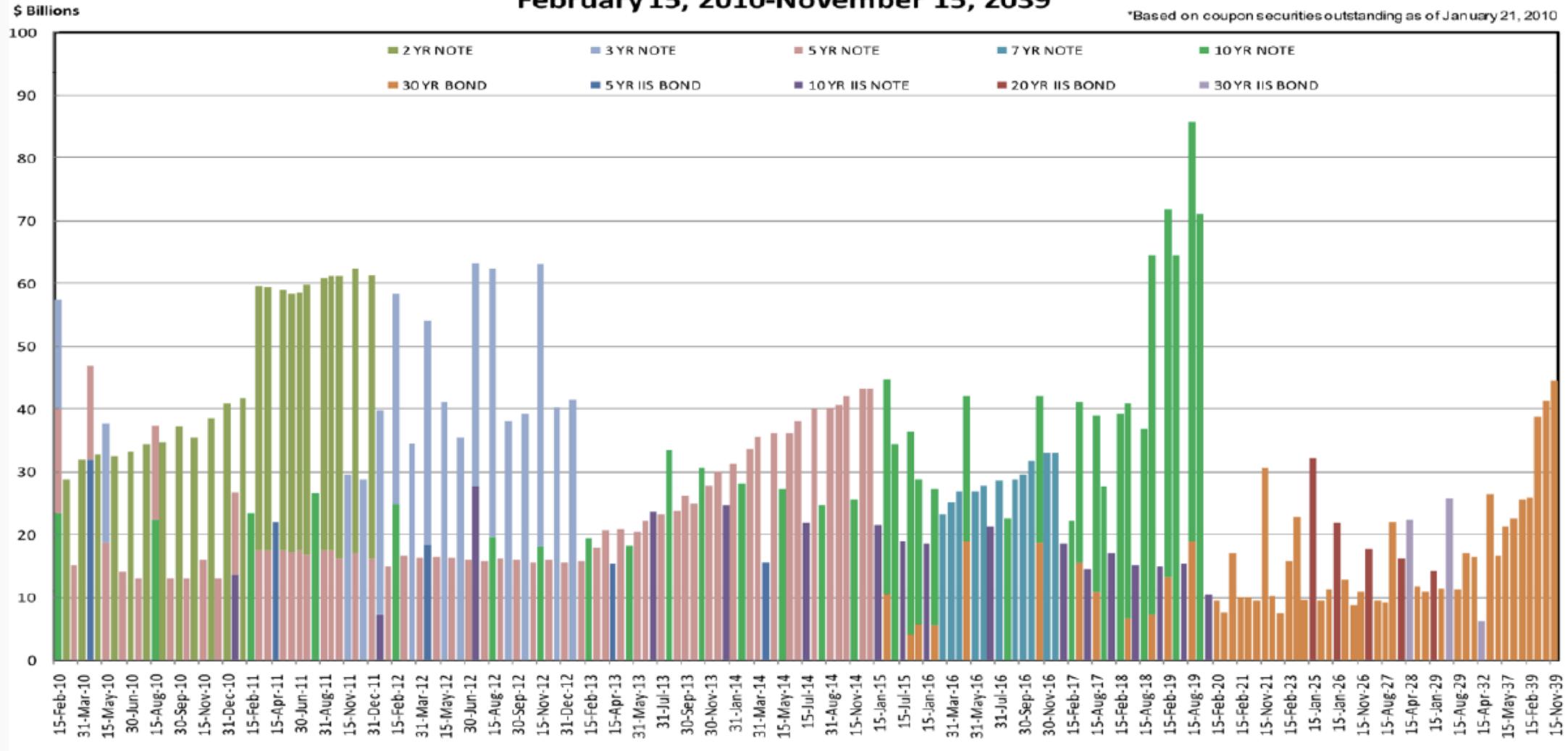
Not Effective



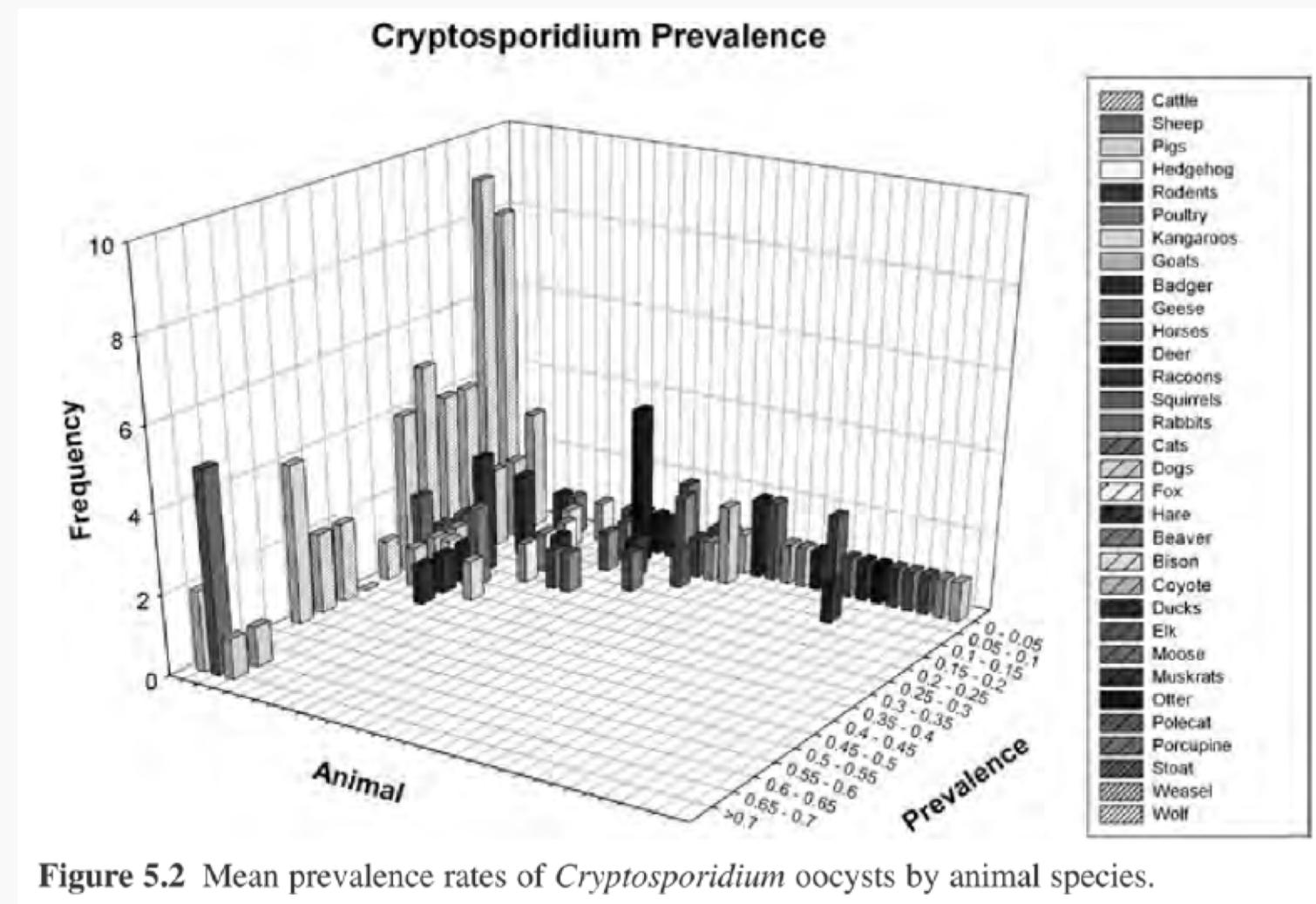
Not Effective

Coupons Maturing*
February 15, 2010-November 15, 2039

*Based on coupon securities outstanding as of January 21, 2010



Not Effective



Visualization

Let's say that we are interested in the English Premier League (football/soccer) and want to build a model to predict a player's market value.

Question

Does age affect one's market value?

What type of visualization would help us explore this question?

