STA305/1004

Sept. 5, 2019

INTRODUCTION

- Course syllabus https://scidesign.github.io/syllabus.html
- Course schedule https://scidesign.github.io/schedule_fall2019.html
- Pre-requisite: STA302
- Statistical computing: R (https://utoronto.syzygy.ca) or RStudio Cloud (https://rstudio.cloud)

COURSE WEBSITES

- Course website: https://scidesign.github.io/index.html
- Piazza discussion forum: https://piazza.com/utoronto.ca/fall2019/sta305h1004/home
- Class notes: https://scidesign.github.io/designbook/

WHY DESIGN?

Why should scientific studies be designed?

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- Avoid bias
- Variance reduction
- System optimization

ABRAHAM WALD AND THE MISSING BULLET HOLES

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- Abraham Wald born in 1902 in Austria.
- Emigrated to the U.S. and eventually became a professor at Columbia.

ABRAHAM WALD AND THE MISSING BULLET HOLES

- During World War II he spent much of his time in the Statistical Research Group (SRG). A classified program that assembled the best American statisticians to the war effort.
- The SRG was in an apartment building in NYC a few blocks from Columbia U.

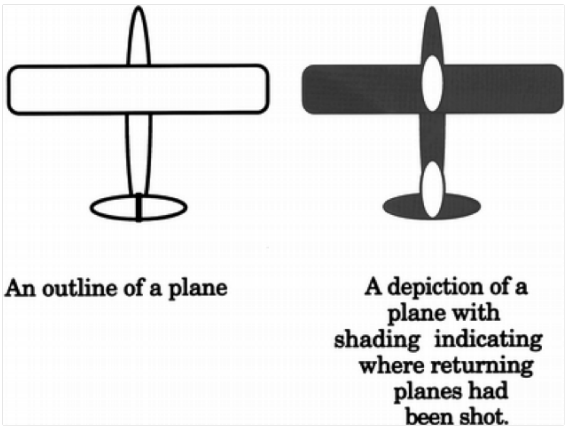
ABRAHAM WALD AND THE MISSING BULLET HOLES

- The SRG was a very influential group and the military frequently listened to their advice.
- Wald at the time was still an "enemy alien", he was not technically allowed to see the reports he was producing.

ABRAHAM WALD AND THE MISSING BULLET HOLES

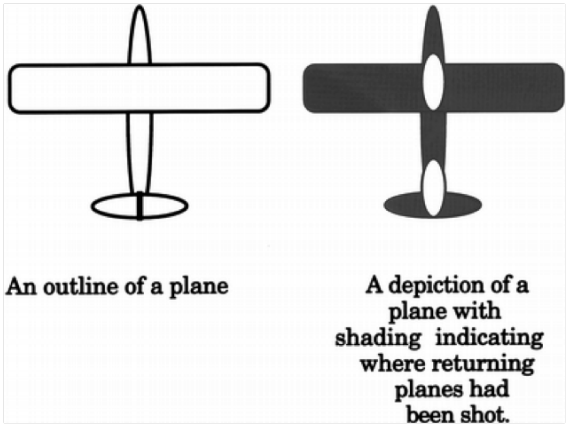
Question: You don't want planes to get shot down by enemy fighters, so you armour them. But armour makes planes heavier, and are less maneuverable and use more fuel. Armouring planes too much is a problem; armouring the planes too little is a problem.

Somewhere in between there's an optimum.



ABRAHAM WALD AND THE MISSING BULLET HOLES

The military supplied the SRG with some data



ABRAHAM WALD AND THE MISSING BULLET HOLES

Planes were covered in bullet holes, but the holes weren't uniformly distributed across the aircraft.

ABRAHAM WALD AND THE MISSING BULLET HOLES

Data from American planes that came back from engagements over Europe.

What parts of the plane has the greatest need for armour?

Section of plane	Bullet holes per square foot
Engine	1.11
Fuselage	1.73
Fuel system	1.55
Rest of the plane	1.8

ABRAHAM WALD AND THE MISSING BULLET HOLES

The officers saw an opportunity for efficiency.

Get the same protection with less armour if you concentrate on places with the greatest need.

They asked Wald how much more armour belonged on those parts of the plane.

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ABRAHAM WALD AND THE MISSING BULLET HOLES

Based on the data where should the military add extra armour?

Respond at **PollEv.com/nathantaback**
Text **NATHANTABACK** to **37607** once to join, then **A, B, C, or D**

Engine	**A**
Fuselage	**B**
Fuel system	**C**
Rest of the plane	**D**

Total Results: 0

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ABRAHAM WALD AND THE MISSING BULLET HOLES

Wald said that the armour doesn't go where the bullet holes are. It goes where the bullet holes aren't: on the engines.

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ABRAHAM WALD AND THE MISSING BULLET HOLES

Wald's insight was to ask: where are the missing holes?

The missing bullet holes were on the missing planes.

The reason planes were coming back with fewer hits to the engine is that planes that got hit in the engine weren't coming back.

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In statistical lingo, the rate of survival and location of bullet holes are correlated.

BIG DATA

"… big data may be as important to business - and society - as the Internet has become. Why? More data lead to more accurate analyses."

(SAS, http://www.sas.com/en_id/insights/big-data/what-is-big-data.html)

BIG DATA

In 2015 the population of Canada is 35.8 Million people.

To estimate the mean number of hours spent on the Internet is it better to:

(a) take a simple random sample of 100 people (and ask about hours spent on internet) and estimate the mean number of hours spent on the Internet; or

(b) use a large database (e.g., millions of people) that contain hours spent on the Internet for each person?

BIG DATA

- An equivalent precision of a random sample of 100 people a database would have to contain over 96% of the population 34.3 Million people.

- This illustrates the power of random sampling and the danger of putting faith in "Big Data" simply because it's big.

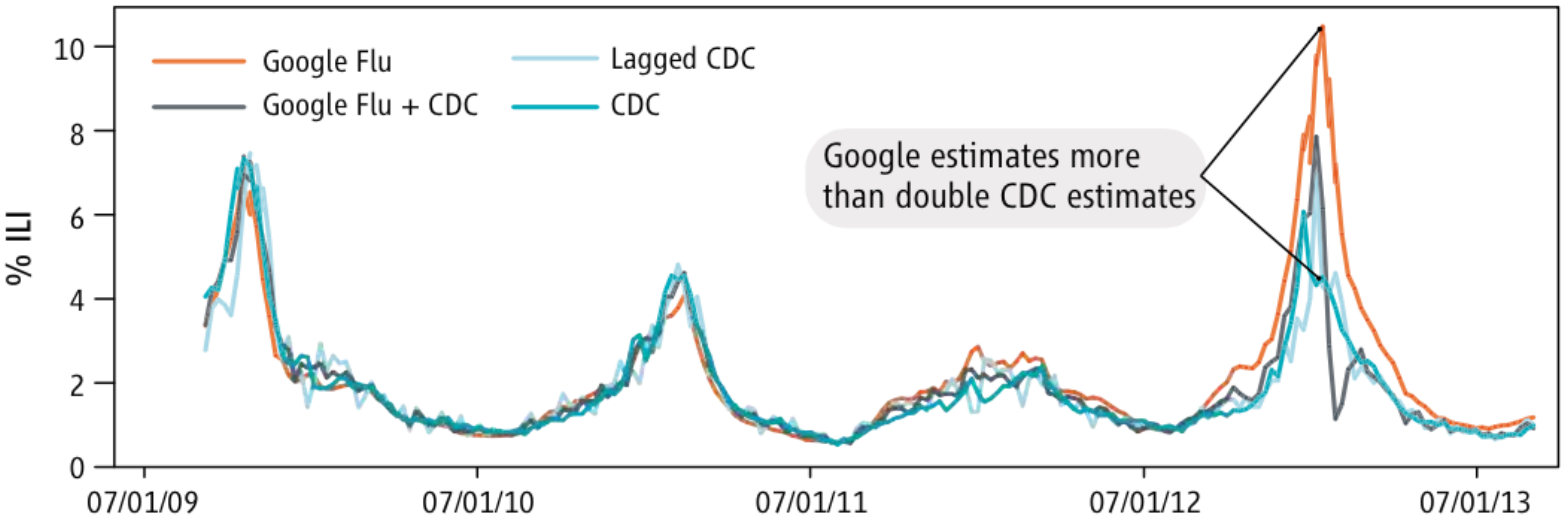
INTRODUCTION

- Data is usually very expensive.
- In a clinical trial the average per patient cost is between $5500-$7600.
- Statistics can help unfold what's going on in the lab or production facility.

INTRODUCTION

Most "big data" is not obtained from instruments designed to produce valid and reliable data amenable for scientific analysis.

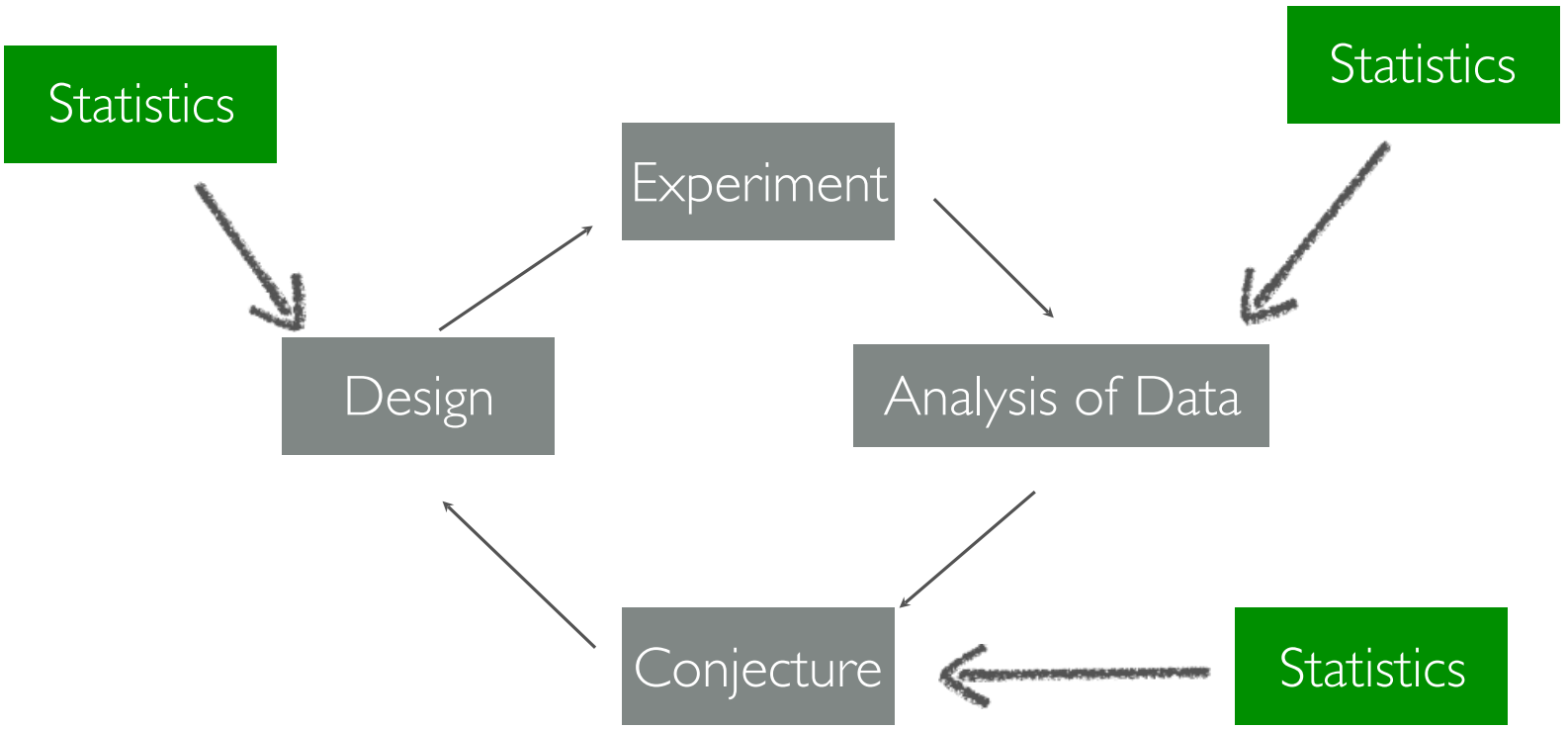
Google Flu (Lazer et al., Science 14 March 2014)



The data collection method has an impact on the quality of conclusions drawn from the data.

INTRODUCTION

Connected to Scientific Method



INTRODUCTION

- When you repeat an experiment you won't get the same response on two different occasions.
- Observation = true response + error
- The observations we get by repeating an experiment differ.

INTRODUCTION

- Good experimental design helps protect real effects from being obscured by experimental error.
- Designed experiments can increase signal-to-noise ratio.
- Statistical analysis provides measures of precision of estimated quantities under study.