

Statistical Literacy

Chapter 1

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*Statistical Literacy:
Critical Thinking about Everyday Statistics
Kendall-Hunt 2023*

*[www.StatLit.org/pdf/
2023-Schild-StatLit-Ch1-Slides.pdf](http://www.StatLit.org/pdf/2023-Schild-StatLit-Ch1-Slides.pdf)*

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Learning Outcomes:

Chapter 1

Critical thinking outcomes:

- Distinguish association from causation using an ABC classification.

Statistical literacy outcomes:

- Learn that statistics are numbers in context: they can be influenced.
- Learn that statistics are socially constructed by people with motives and values.
- Learn that "take care" is the best advice when dealing with statistics.
- Learn how all influences on statistics can be grouped into four categories.
- Learn CARE categories: Confounding, Assembly, Randomness, and Error.
- See how each influence can change the size and direction of an association.
- Use "Take CARE" to analyze statistics in the everyday media..

What are Statistics?

Everyday statistics are different:

“Lies, damned lies and statistics” – not ‘numbers’

1. Statistics are **numbers in context** – context matters!
2. Statistics can be influenced – influenced by context!
3. Statistics are socially constructed – like words!
4. Statistical advice: *Take care!*

Statistics: *Not data summaries (math)*

Statistics: *Not sample summaries (math-stat)*

Critical Thinking: Numbers as Evidence

Fruits, Veggies Cut Breast Cancer Risk
Four or more daily servings reduces chances of disease by half



The point of the argument

The more disputable the point,
the stronger the evidence must be

Statistics as Evidence

“All Statistics are Socially Constructed”

So, “Take CARE”!!

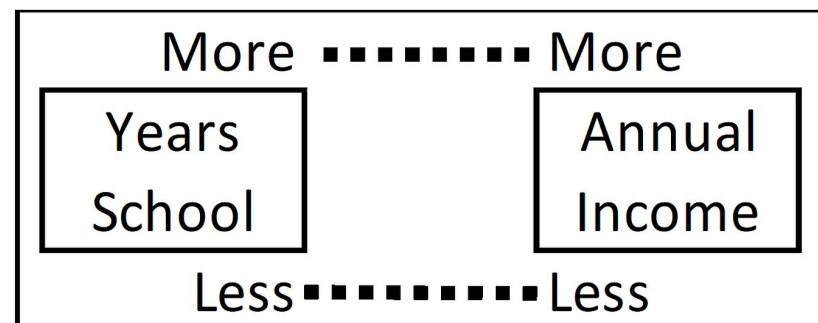
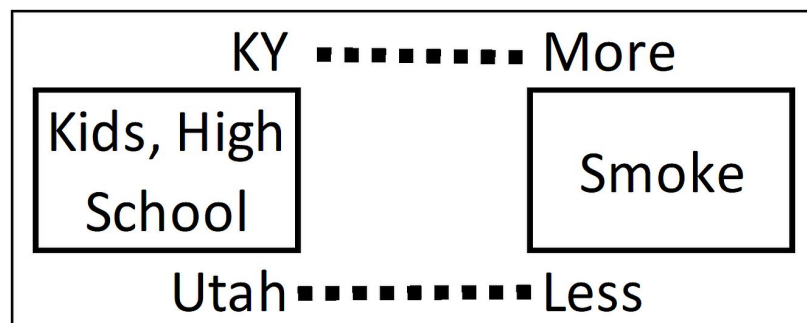
Statistics may be influenced

Association is [often] Evidence of Causation

Association (statistical): an observable quantitative connection between groups or characteristics.

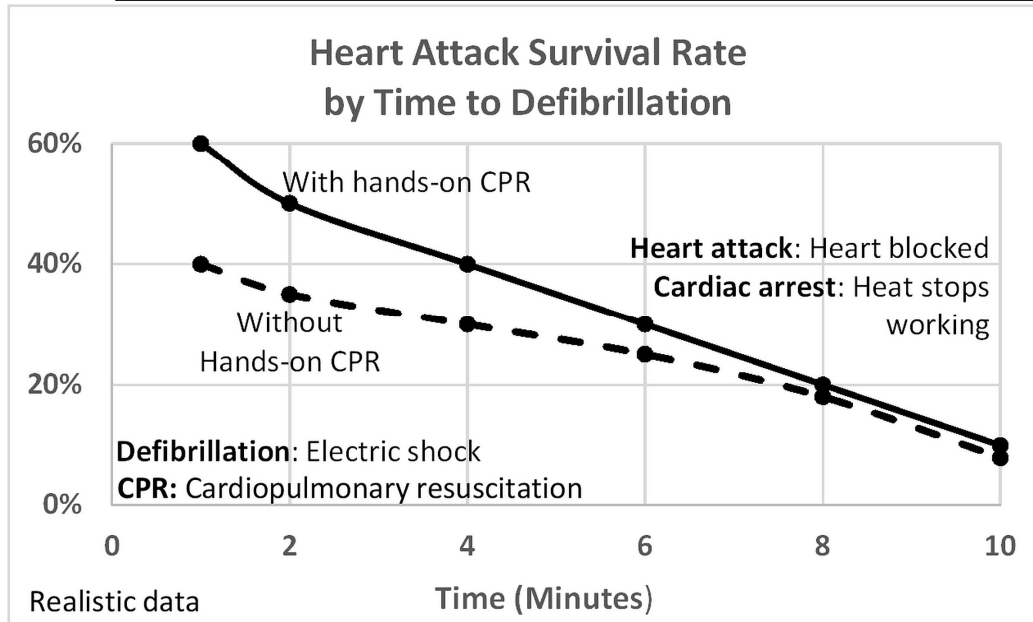
ASSOCIATION (statistical)

Comparison (Two-groups)	Type	Co-Variation (Two factors)
Women live longer than men	Ordered	As height increases, weight increases
US women live five years (6.6%) longer than men.	Arithmetic	For each additional inch in height, weight increases by five pounds



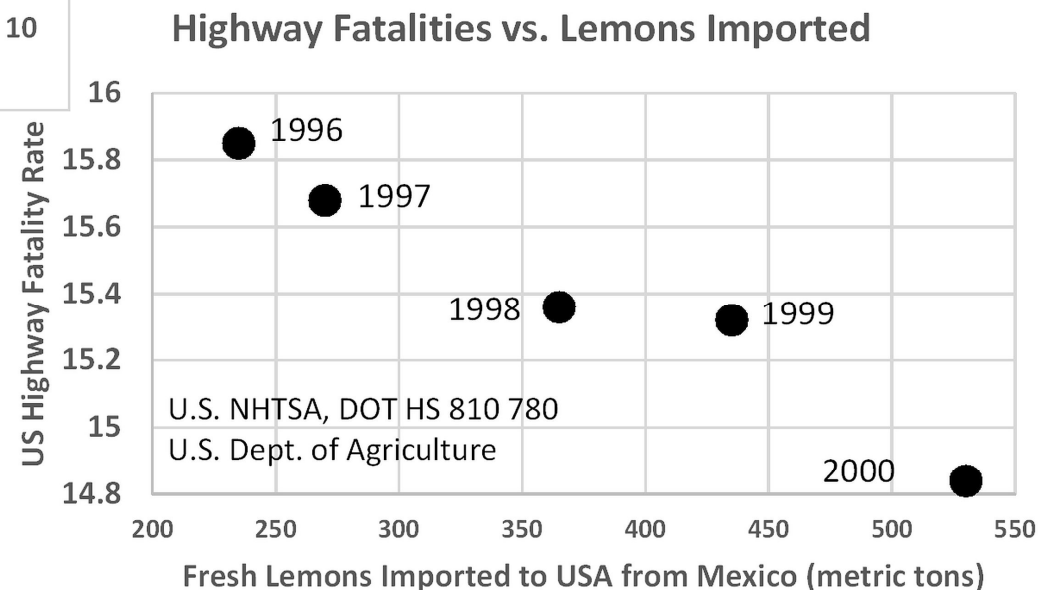
Association: Evidence of Cause

Association: observable



Describe association:
As X increases,
Y increases/decreases

Describe the association:
The more X, the more/less Y



Causation and Experiments: Ideal Experiments

Cause: an event or condition whose level or presence makes (or can make) a difference in something else.

Causation is most clearly identified in experiments.

Experiment: A study involving a doing: subjects are given or assigned to a treatment by someone or by nature.

Doing: where someone (or nature) manipulates the subject or something related to the subject.

Ideal experiment: Experiment that can be replicated on the same subject (or identical subjects) in same condition.

Association-Between-Causation Grammar

A-B-C GRAMMAR

Between: ???

Association: See

Causation: Do

Semantics: Association is not [necessarily] Causation

A: Association

Asserts an association;

Says "what"

associated/association

correlation

Two-group comparisons:

"Women live longer than men"

"Men more likely to drink beer"

B: Between

Asserts an association

but suggest causation

increases, raises, ups; cut

"As $x \uparrow$, $y \downarrow$ "; "more x, less y"

before/after; linked, factor

leads to; causal factor

due to, because of

C: Causation

Asserts causation;

Asserts "how" *

cause, create, produce

effect, result, consequence

Sufficient: prevent, stop

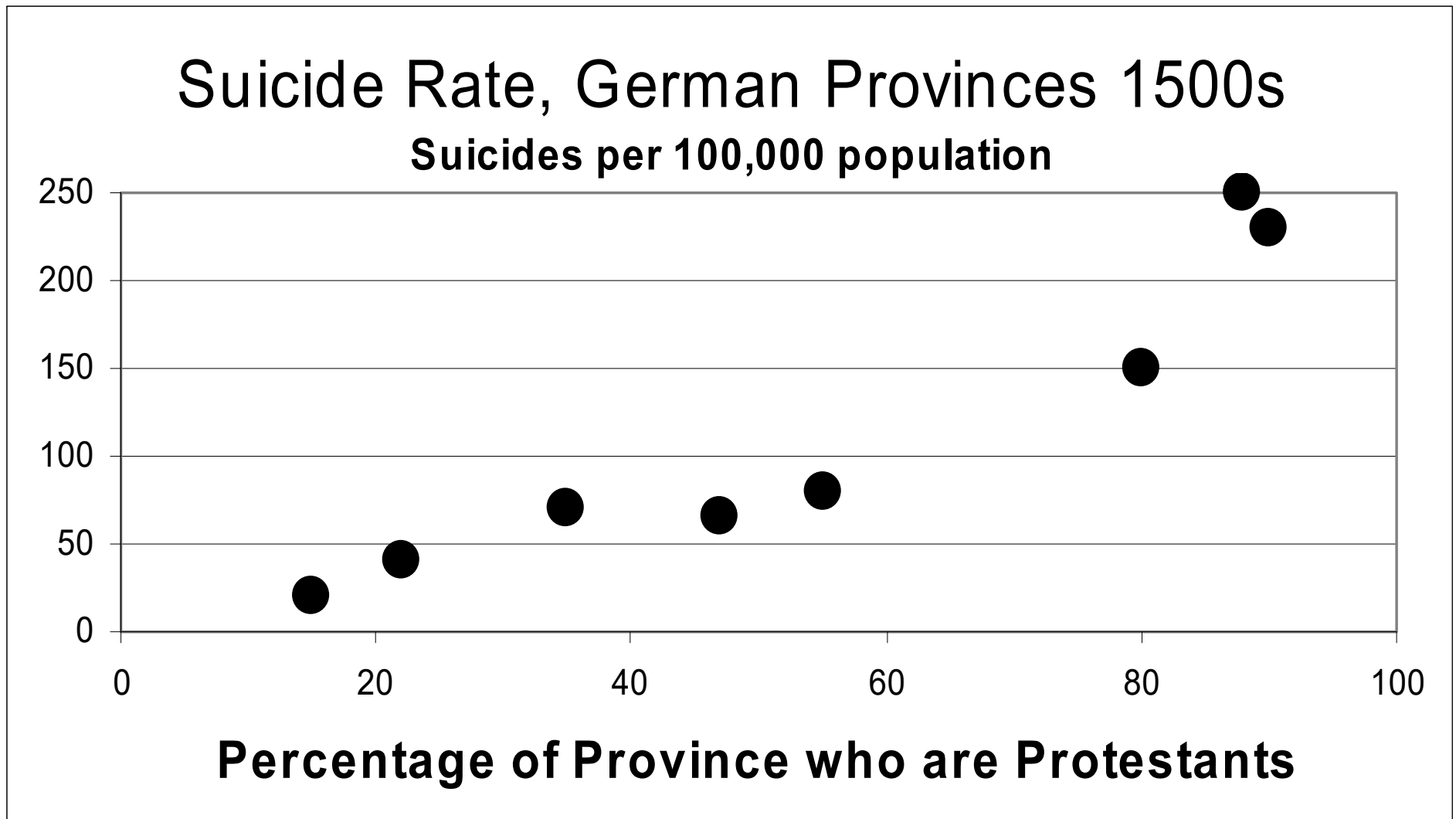
"If X, then Y will happen"

Contra-factual

Based on common usage by many today, but not "etched in stone" for all.

* Other words OK in context. Schield VOK

Association may be Causation



What is the Point? Evidence?

Does Evidence have a Statistic?

Two hunters are being chased by an angry bear. The first yells to the second, "It's hopeless. This bear can run faster than we can."



The second yells back: "No, it's not hopeless! I don't have to outrun the bear. I just have to outrun you."

Review: Statistics are Different!!!

Statistics are different from numbers! 1 is a number.

- Numbers lack units, or the units don't matter.

1 apple plus 1 orange = how many fruit?

- Statistics have units – where the units matter.

'1 malnourished white worker' is a statistic.

Numbers: 1 plus 1 is always 2!

Stats: 1 bunny and 1 bunny? More than 2 bunnies?

Stats: 1 ice cube and 1 ice cube? Less than 2 ice cubes?

Review: Statistics are different from numbers.

Statistics are numbers in context!

Statistics are socially constructed – by people.

Statistics can be influenced or manipulated

When dealing with statistics:
"TAKE CARE!"

Statistics can be influenced: So, “take CARE!”

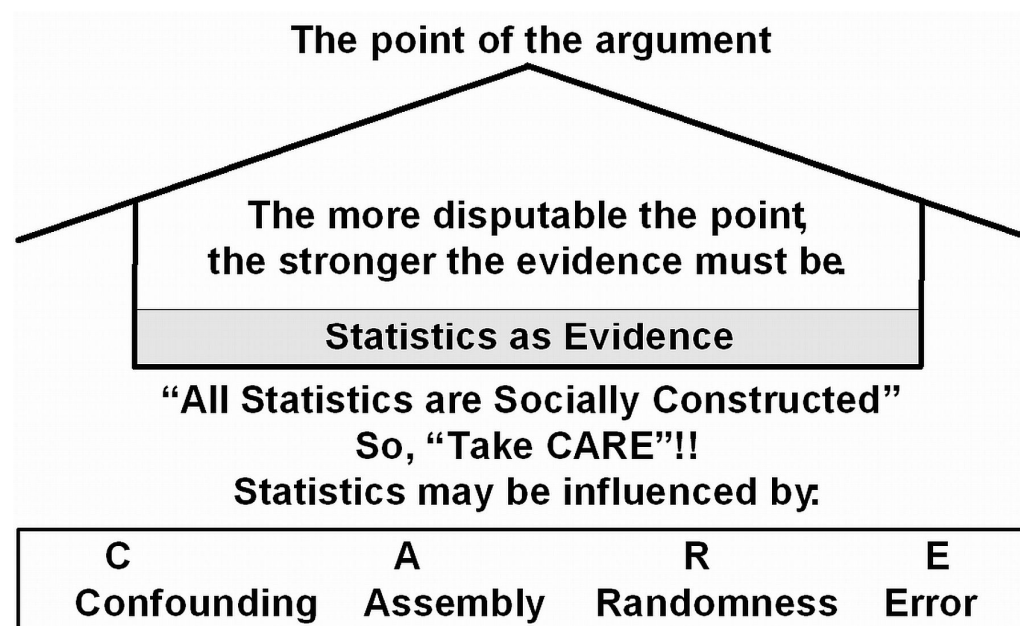
CARE: Four kinds of influence on a statistic

C Confounding: Influenced by related factors

A Assembly: Influenced by other choices

R Randomness: Influenced randomly by chance

E Error: Influenced systematically (e.g, bias)



CARE: C=Confounding.

‘Take into account’ the context!

A father and his children were on a New York subway. The kids were out of control. Their dad did nothing. The dad slumped forward looking at the floor. Finally, an unhappy onlooker said to him, “Control your kids”!

The father looked up sadly and said they had just left the hospital where his wife, the kid's mother, *had just died*. Immediately their negative judgments were transformed into pity for the father and his children.

Onlookers confused! Did not know kids’ mom had died.

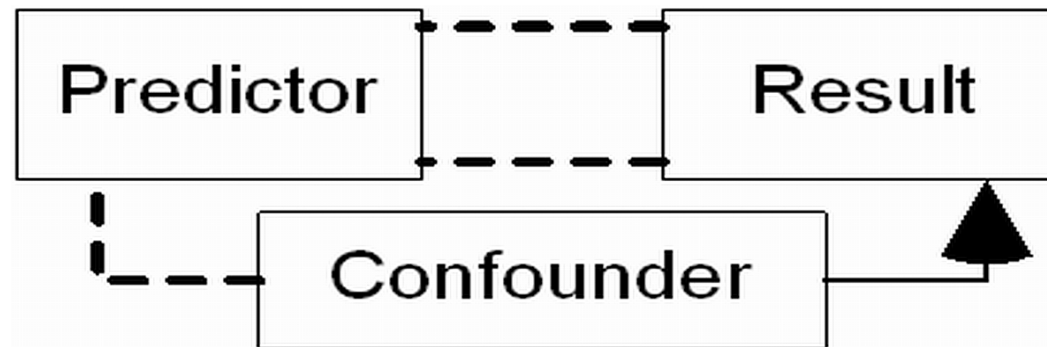
CARE: C=Confounding Confounder

Confounded or *confounding* means confused or confusing. Confound == “found with”.

A **confounder** is *anything* that provides an alternate explanation for an association.

Technically a confounder is a *third factor* that causes the result in an association, and is related to—but not caused by—the predictor.

CARE: C=Confounding Confounder



CARE: CONFOUNDER

Third factor: Alternate explanation for association	
Causes outcome. Not caused by predictor	
Common Cause	"Confounder"
Causes predictor	Doesn't cause the predictor

CARE: C=Confounding Confounder

Confounder (two kinds): common cause & single cause.

- **Common cause:** causes both predictor and outcome.
- **Single cause:** causes just outcome (not predictor).

Crude comparison: mixed fruit or apples & oranges.

A two-group compare: big difference in the groups.

Take into account or control for (quantitatively):

Adjust comparison for differences (changes) in groups

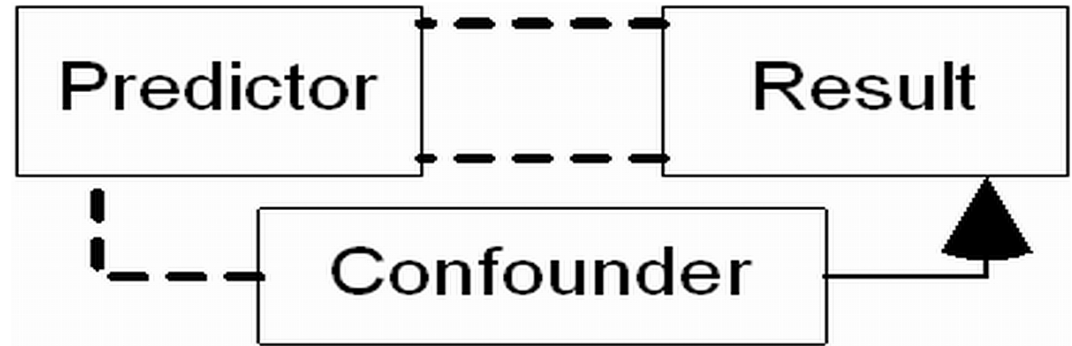
CARE: C=Confounding

Single Cause

Arrow: Causation

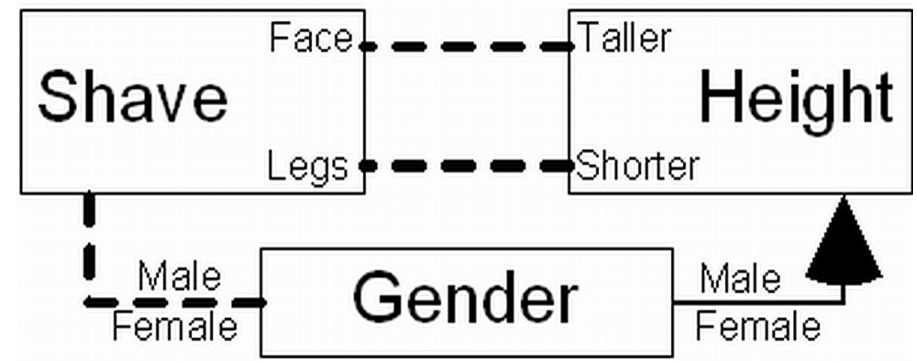
Dashes: Association

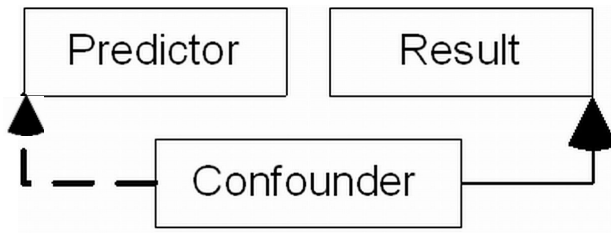
One arrow: single cause



#1: People who shave their face are (tend to be) taller than those who shave their legs. *True? Result?*

#2: If you shave your legs and want to get taller, shave your face.
Confounding? Confounder?



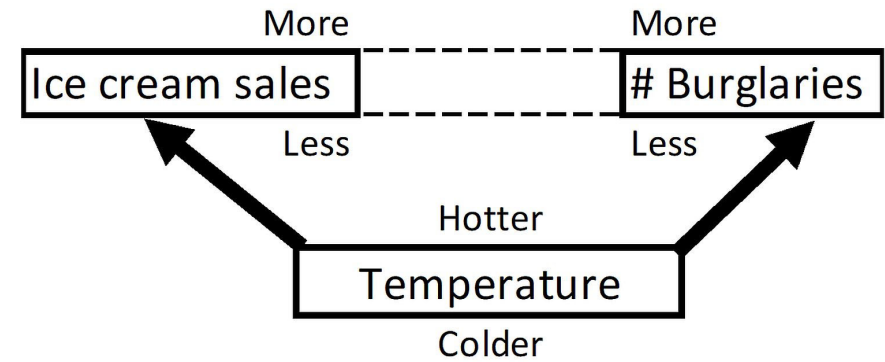


C=Confounding Common Cause

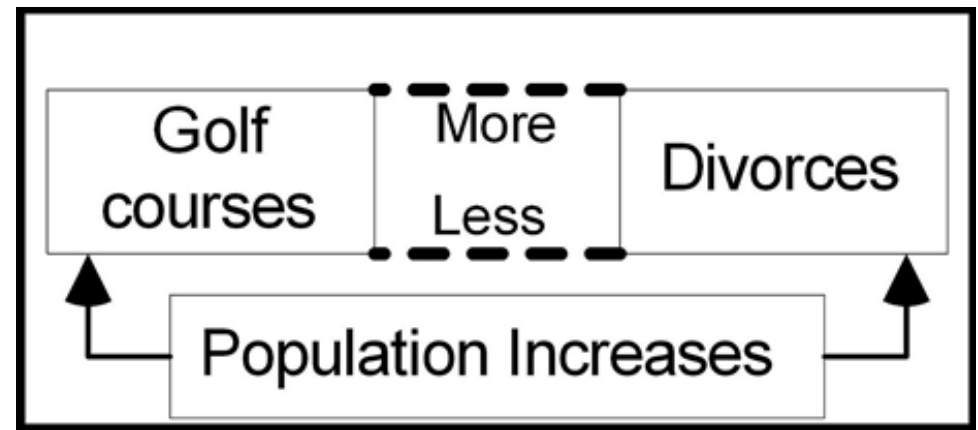
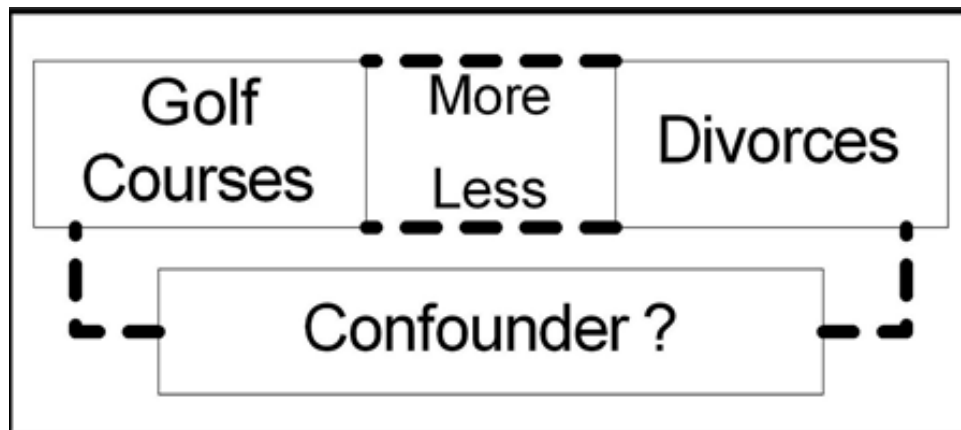
What is the association?

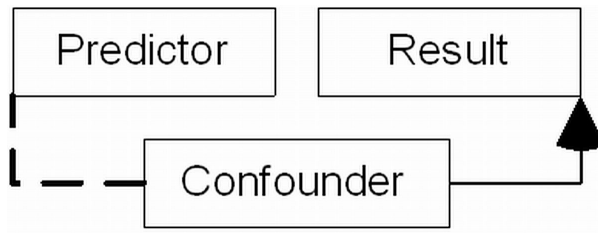
What is a causal claim?

What is the confounder?

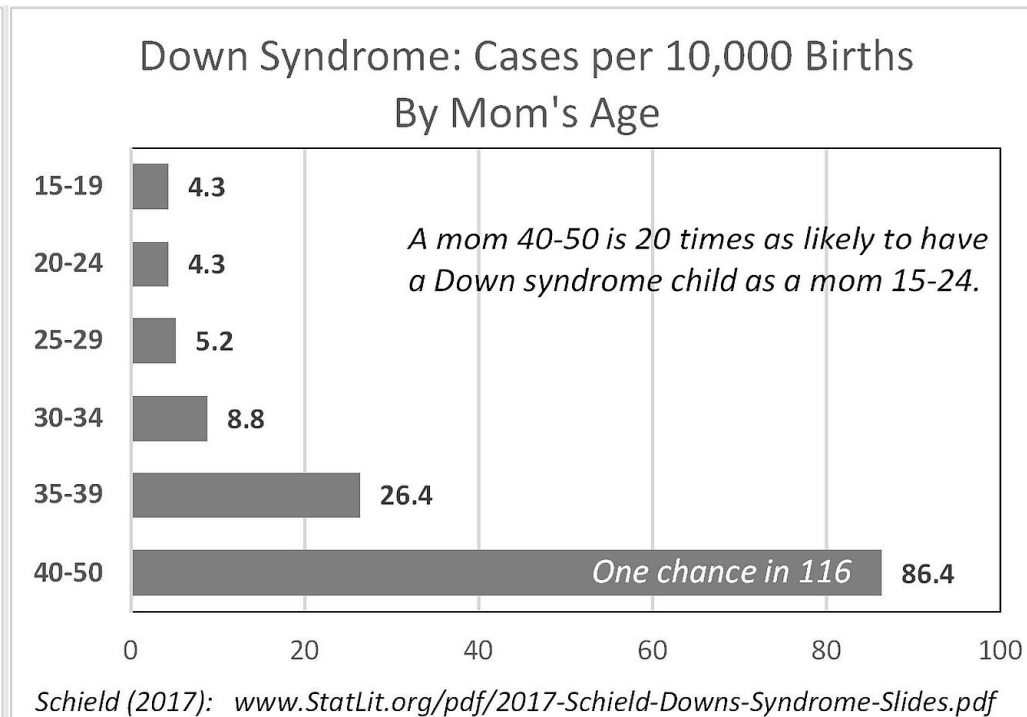
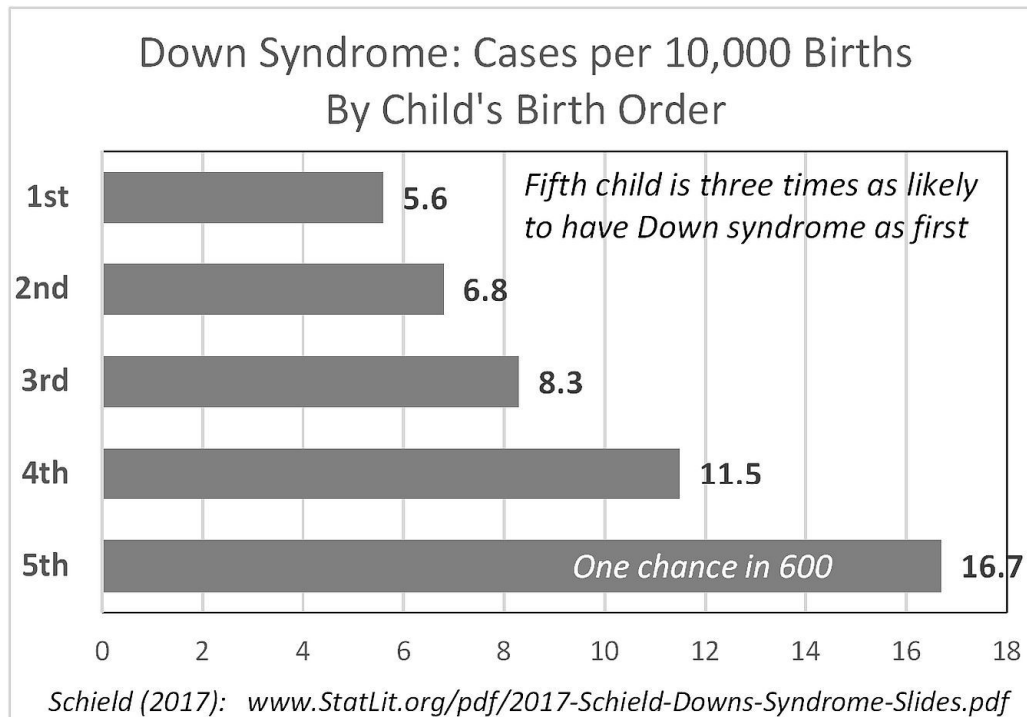


Describe the direct association (left to right). Make a causal claim.
Describe the *reverse association* (right to left). Make a causal claim





C=Confounding Examples



Crude comparison: a comparison that conflates (fails to take into account) important related factors. It is also known as a mixed-fruit comparison or an apples and oranges comparison. P. 25

Apples and oranges comparison (a mixed-fruit comparison): a metaphor for any comparison of things that have a major difference.

A=Assembly: Data Definition

Assembly (assumptions) involves all the choices that influence a statistic and are not covered elsewhere under CARE.

Assembling statistics is like ‘wordsmithing’ or ‘lawyering.’

Assembly can be done carefully (to highlight relevant differences); opportunistically (to create false impressions); or ambiguously (to tell a half-truth).

Assembly is arguably the easiest way to twist the facts.

New College is the #1 honors college in Sarasota.

New College is a top 10 US public liberal-arts college.

A=Assembly: Definition and Summarization

Assembly is arguably the easiest way to twist the facts.

And: The more required (adjectives), the smaller the count.

Or: The more options available, the larger the count.

=====

Students are surveyed on their happiness at college.

Administration: 80% are satisfied

Student newspaper: 70% are not satisfied.

Data: Very happy 30%. OK 50%. Unhappy 20%.

CARE: A=Assembly Manipulation/Summarization

CARE: ASSEMBLY

BEFORE/DURING SELECTION IN THE DATA		AFTER SELECTION ON THE DATA
Plan/Define	Select/Aquire	Manipulation*

* Includes presentation

Q. Which group had more people living with AIDS?
Blacks if by race and ethnicity (Hispanic are separate).
Whites if just by race and 70K of Hispanics are white.

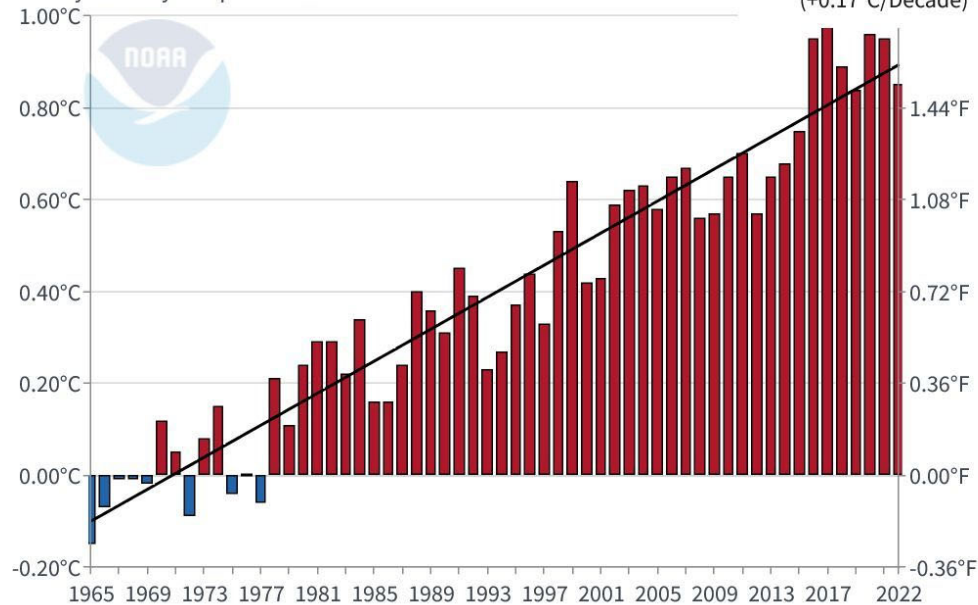
All (1,000) ³⁰	White (non-Hispanic)	Black (non-Hispanic)	Hispanic
434	150	186	78



A=Assembly Presentation

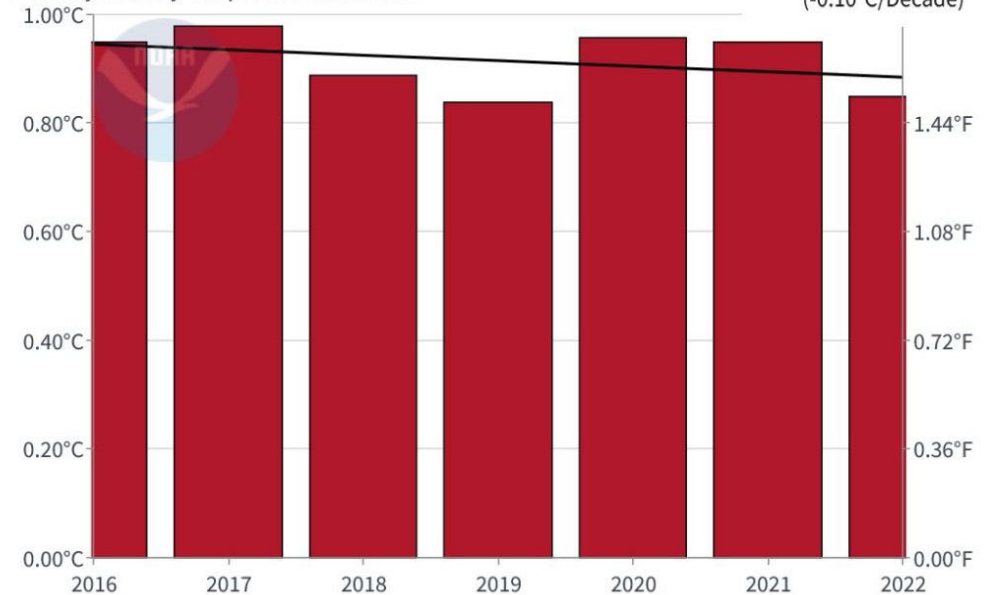
Global Land and Ocean

February-January Temperature Anomalies



Global Land and Ocean

February-January Temperature Anomalies



CARE: R=Randomness: Extremes

Chance is a possibility of something happening.
Coincidence is a noteworthy connection between unlikely events with no obvious connection.

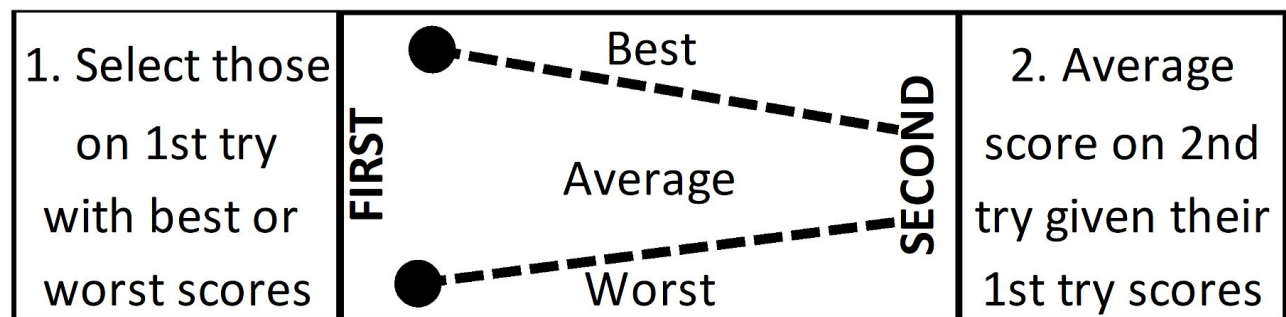
Randomness—pure chance—is the absence of any pattern that will help in predicting the next outcome. Randomness is hard to see (a negative).
Synonyms for possibility: chance, risk, likely, luck, accident, probability, uncertainty and coincidence. Modals: can/could, may/might.

CARE: R=Randomness: Classify and Extremes

CARE: RANDOM

Extremes	Big Data	Small Samples
Sports Illustrated	Lottery, Words	Galton board
Pilot performance	Runs, Patterns	Sample size
Pre-vs-post	Birthday match	Small classes

Extremes:



Dot indicates an extreme score. Some correlation

R=Randomness

Big Data: Patterns

Cancer clusters. On bonfire night in 2003, someone tore down the cell-phone tower in Wishaw: a small village in England. No one confessed; no one was ever charged.

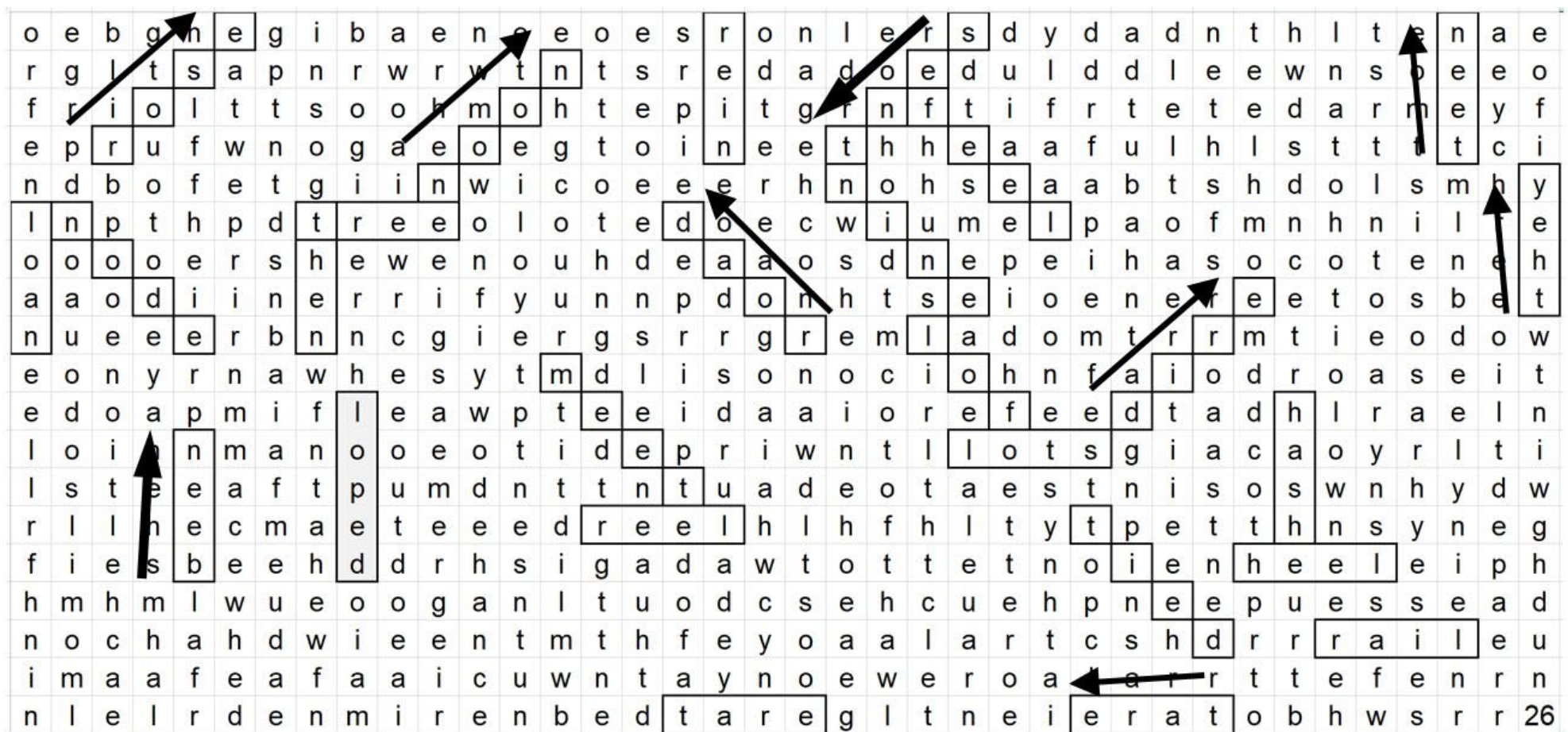
It may have been related to the fact that “among the 20 households within 500 yards of the tower, there had been nine cases of cancer.” The chance of nine cancers among those in 20 adjacent houses is extremely small.

Big data: But the chance of finding nine cancers in 20 houses near a cellphone tower *somewhere in England sometime* is much larger.

R=Randomness

Big Data: Patterns

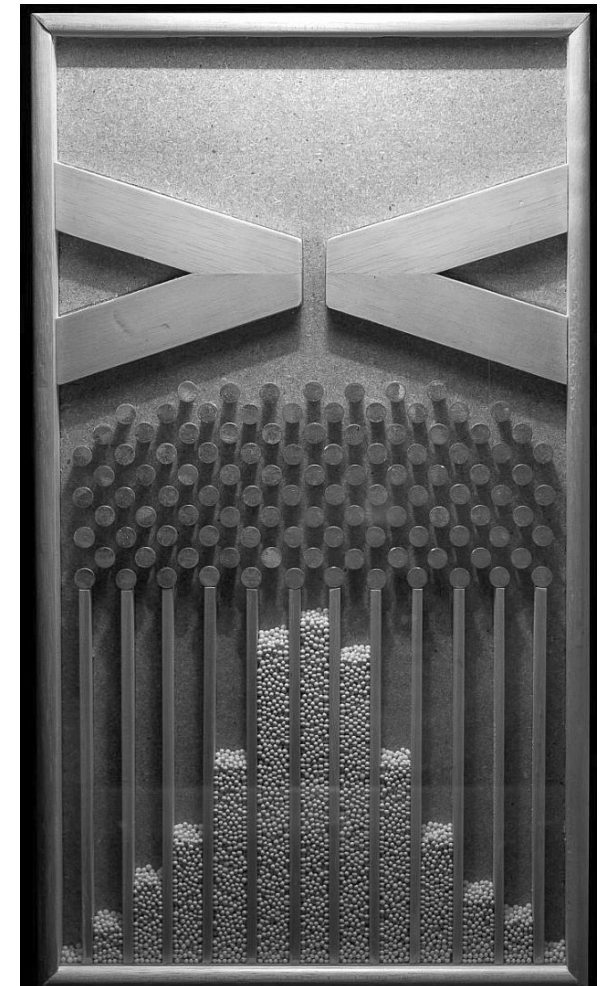
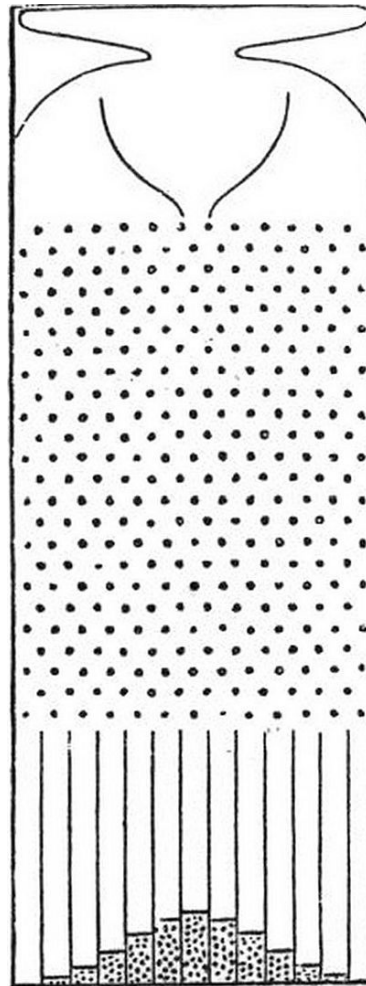
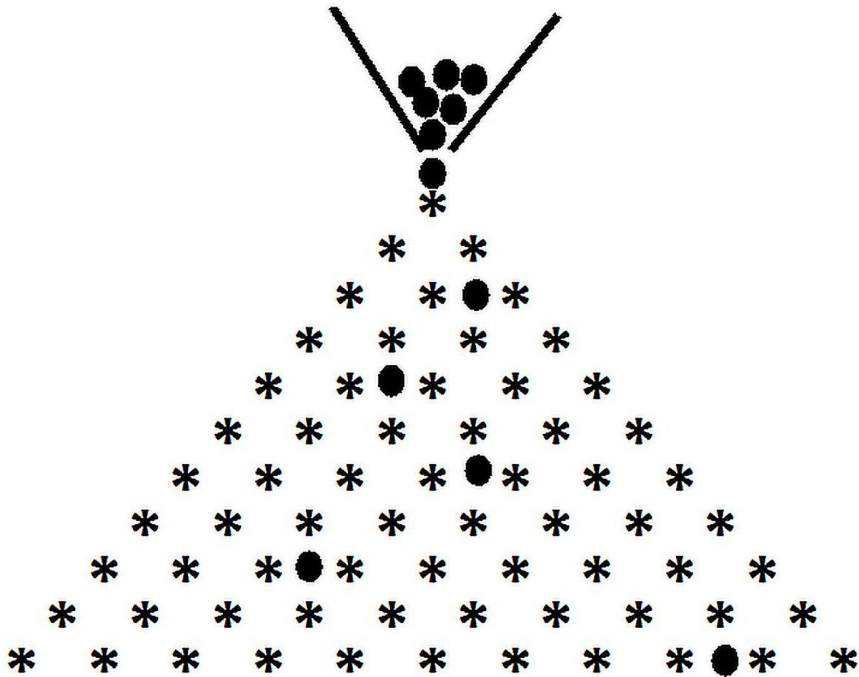
Random letters generate meaningful words.



R=Randomness

Small Samples: Variability

Randomness generates predictable patterns.

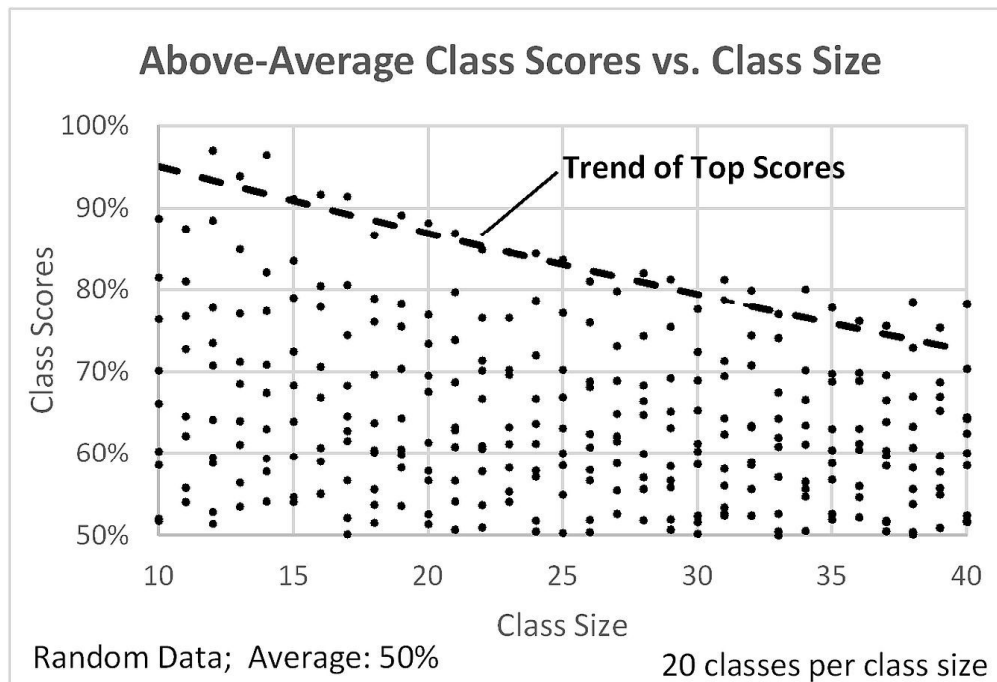


R=Randomness

Small Samples: Variability

Randomness generates predictable patterns.

As class size decreases, top scores increase.



CARE: E=Error

Classification and Bias

CARE: ERROR

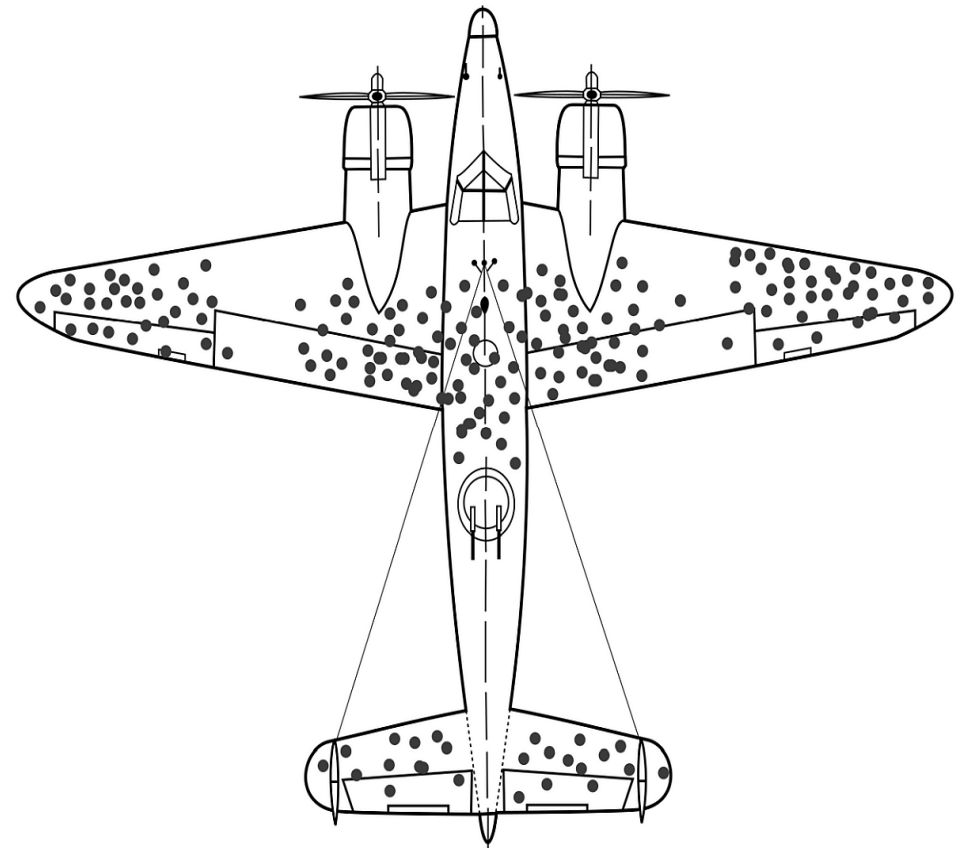
Wrong Order	Bias	Lies
Subtract, Divide	Subject	Mistakes
Comparisons	Measurement	Prevarication
Ratios	Sampling	Weasel words

Subject (respondent) bias is when people lie/misremember in a systematic way.

Measurement (researcher) bias is systematic error in measurements.

Selection (sampling) bias is systematic error in the outcome due to a non-representative selection from a population

Sampling bias



Take CARE !!!

CARE: CONFOUNDER*

Causes outcome. Not caused by predictor	
Common Cause	Single-Cause Confounder
Causes predictor	Doesn't cause predictor

*An alternate explanation for an association

CARE: ASSEMBLY

DATA COLLECT/SUMMARIZE		MODELLING
In the data	Done to data	Assumptions
Plan/Define	Minipulate	Select model
Select/Aquire	Present	Select input

CARE: RANDOM

Extremes	Big Data	Small Samples
Sports Illustrated	Lottery, Words	Galton board
Pilot performance	Runs, Patterns	Sample size
Pre-vs-post	Birthday match	Small classes

CARE: ERROR

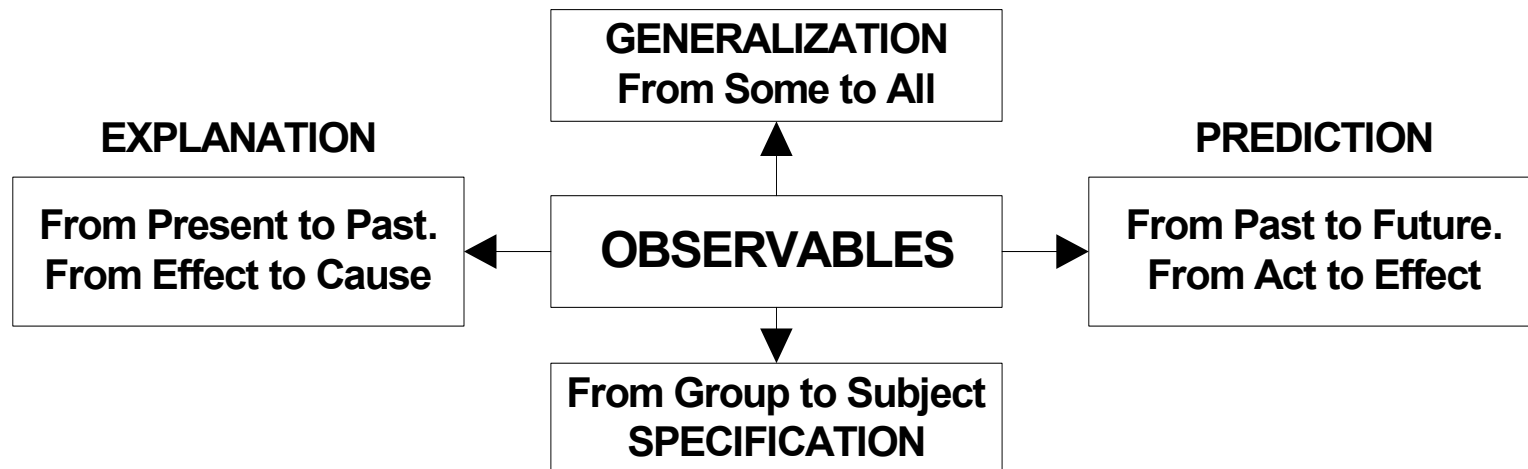
Wrong Order	Bias	Lies
Subtract, Divide	Subject	Mistakes
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Critical Thinking

Argument (inference): a peaceful way to persuade.

- Point: a more disputable claim (usually unobservable)
- Evidence: less disputable claim supporting the point

Inference: deductive or inductive



Critical Thinking versus Statistical Literacy

Point of the argument

Critical Thinking

A more disputable point
needs stronger evidence

Statistics as evidence

Strength and Relevance of the Statistic(s)

Statistics as the point

Statistical Literacy

A stronger statistic is
more resistant to influence

Statistics are numbers in context
Statistics can be influenced

Confounding Assembly Randomness Error

Association- Moral Causation Disparity vs Discrimination

A-B-C GRAMMAR

Between: ???

Association: See

Causation: Do

Semantics: Differences or Disparities are not [necessarily] Discrimination

A: Association	B: Between (moral)	C: Causation (moral)
Math Differences:	Descriptive Differences	Immoral Differences:
Count/Rate/Amount	with a Moral Connotation	Evaluative or Judgemental
different, unequal	unequal/inequality	inequity/inequitable
Rank: first, second, last	disproportionate	unfair/unjust/undeserved
Superlatives: highest/lowest	discriminate: discern difference	discriminate: with prejudice
Comparatives: more, higher,	disparity / disparate impact	discrimination*
times as much, percent more	over/under represented	racism/sexism

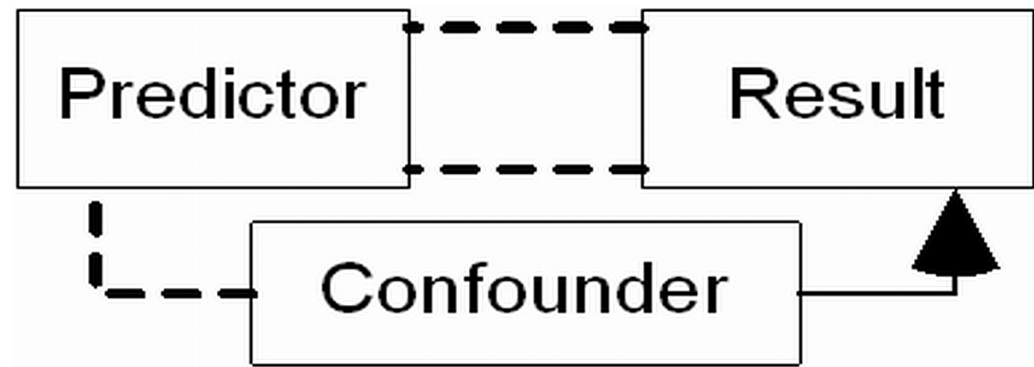
* Discrimination: direct/intended (racist/sexist) vs indirect/unintended; individual vs social (systemic or structural)

Based on common usage by many today, but not "etched in stone" for all.

CARE: C=Confounding Triangle Diagrams

Arrow: Causation

Dashes: Association



ASSOCIATION: THIRD FACTORS

Third factor: causes outcome, associated with predictor

CONFOUNDER*		Mechanism**
Not caused by the predictor		Caused by predictor
Common Cause	Alternate Confounder	** The way the predictor causes the outcome. A detailed explanation of an association.
Causes predictor	Doesn't cause predictor	

*An alternate explanation for an association

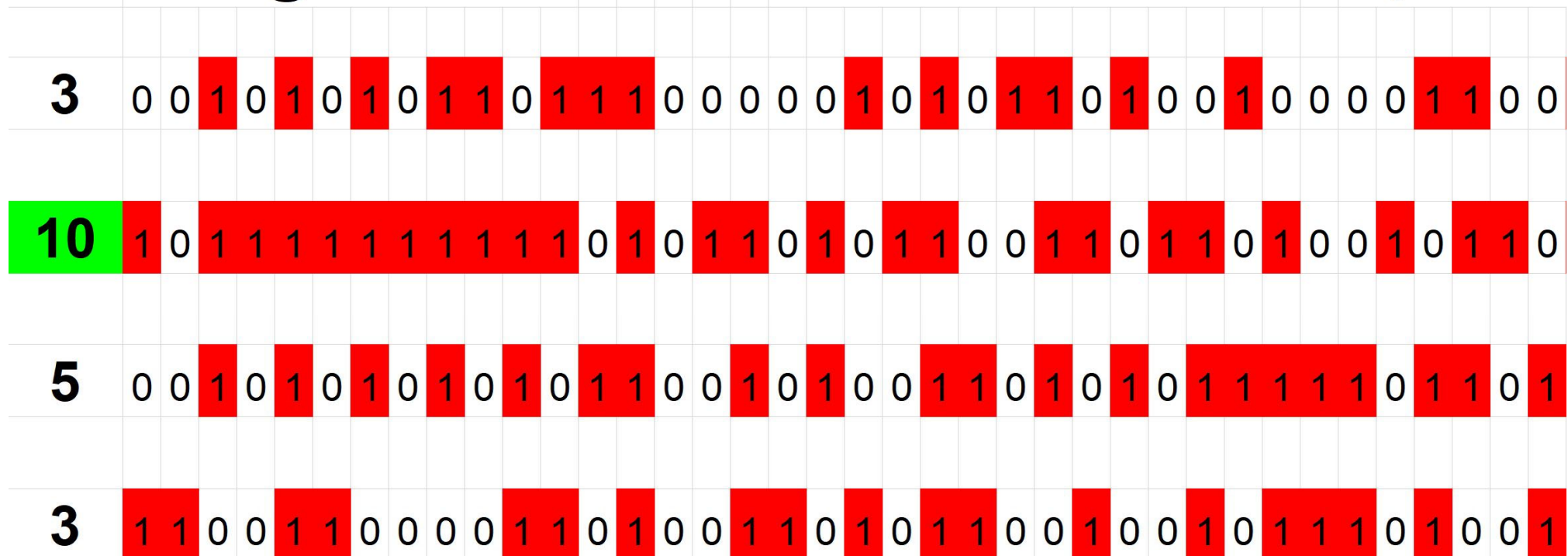
CARE: R=Random

Big Data: Longest Run

Fair coin: find longest run of heads in a row

10 Longest run!

One chance in 1,024



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Learning Outcomes: Chapter 1

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Statistical literacy outcomes:

- Learn that statistics are numbers in context: they can be influenced.
- Learn that statistics are socially constructed by people with motives and values.
- Learn that "take care" is the best advice when dealing with statistics.
- Learn how all influences on statistics can be grouped into four categories.
- Learn CARE categories: Confounding, Assembly, Randomness, and Error.
- See how each influence can change the size and direction of an association.
- Use "Take CARE" to analyze statistics in the everyday media..

3

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- Statistics are socially constructed – like words!
- Statistical advice: *Take care!*

Statistics: *Not data summaries (math)*
Statistics: *Not sample summaries (math-stat)*

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Critical Thinking: Numbers as Evidence

Fruits, Veggies Cut Breast Cancer Risk
Four or more daily servings reduces chances of disease by half



The point of the argument

The more disputable the point
the stronger the evidence must be

Statistics as Evidence

"All Statistics are Socially Constructed"
So, "Take CARE"!!
Statistics may be influenced

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Association is [often] Evidence of Causation

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Women live longer than men	Ordered	As height increases, weight increases
US women live five years (6.6%) longer than men.	Arithmetic	For each additional inch in height, weight increases by five pounds

KY More

Kids, High School Utah Less

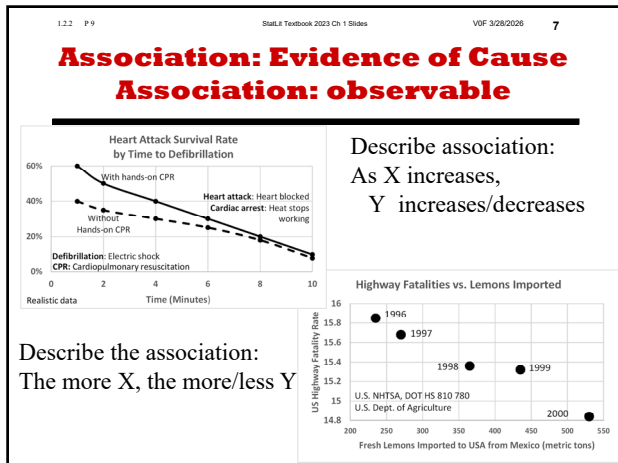
Smoke

More More

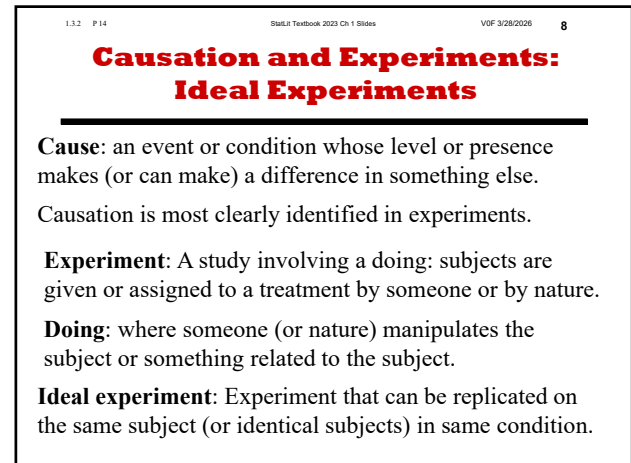
Years School Annual Income

Less Less

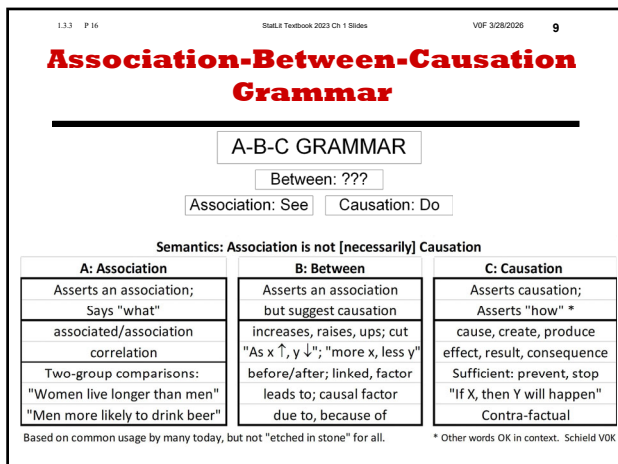
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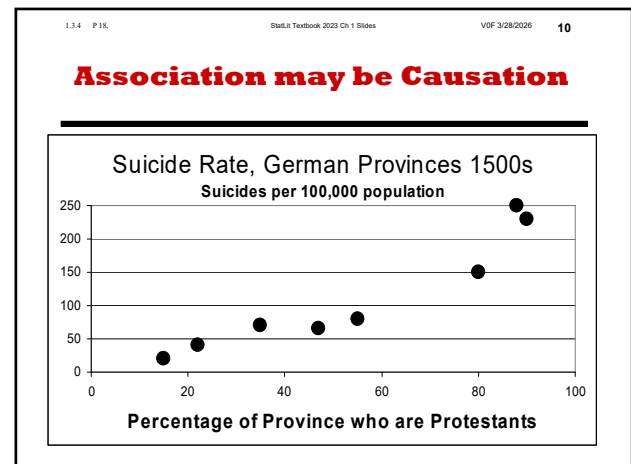
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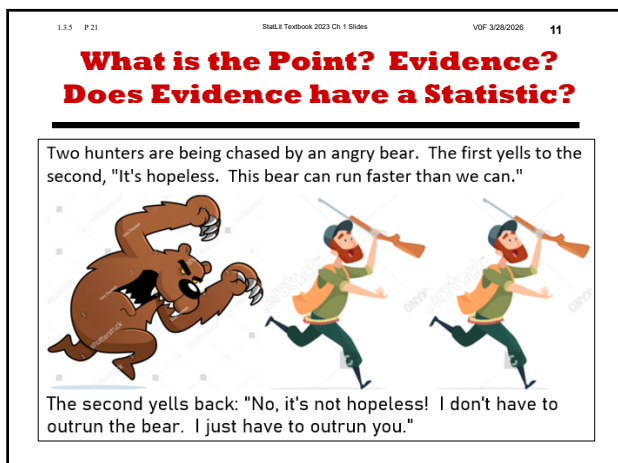
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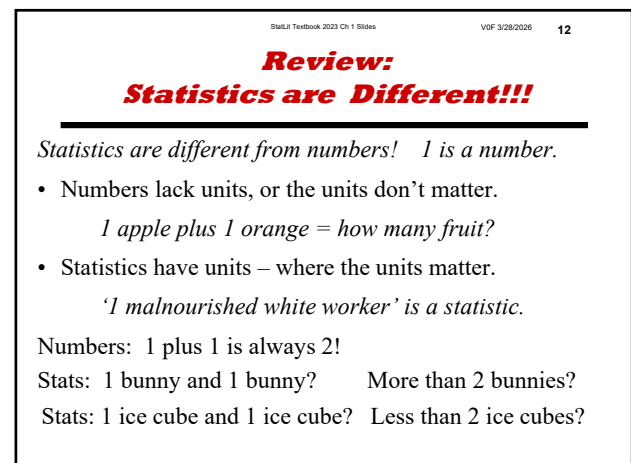
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Review: Statistics are different from numbers.

Statistics are numbers in context!

Statistics are socially constructed – by people.
Statistics can be influenced or manipulated

When dealing with statistics:
"TAKE CARE!"

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Statistics can be influenced: So, "take CARE!"

CARE: Four kinds of influence on a statistic
C Confounding: Influenced by related factors
A Assembly: Influenced by other choices
R Randomness: Influenced randomly by chance
E Error: Influenced systematically (e.g. bias)

The point of the argument

The more disputable the point the stronger the evidence must be

Statistics as Evidence

"All Statistics are Socially Constructed"
So, "Take CARE!!"

Statistics may be influenced by:

C	A	R	E
Confounding	Assembly	Randomness	Error

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CARE: C=Confounding. 'Take into account' the context!

A father and his children were on a New York subway.
The kids were out of control. Their dad did nothing.
The dad slumped forward looking at the floor. Finally, an unhappy onlooker said to him, "Control your kids!"

The father looked up sadly and said they had just left the hospital where his wife, the kid's mother, *had just died*.
Immediately their negative judgments were transformed into pity for the father and his children.

Onlookers confused! Did not know kids' mom had died.

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CARE: C=Confounding Confounder

Confounded or confounding means confused or confusing. Confound == "found with".

A **confounder** is *anything* that provides an alternate explanation for an association.
Technically a confounder is a *third factor* that causes the result in an association, and is related to—but not caused by—the predictor.

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CARE: C=Confounding Confounder

CARE: CONFOUNDER

Third factor: Alternate explanation for association	
Causes outcome. Not caused by predictor	
Common Cause	"Confounder"
Causes predictor	Doesn't cause the predictor

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CARE: C=Confounding Confounder

Confounder (two kinds): common cause & single cause.

- **Common cause:** causes both predictor and outcome.
- **Single cause:** causes just outcome (not predictor).

Crude comparison: mixed fruit or apples & oranges.
A two-group compare: big difference in the groups.
Take into account or control for (quantitatively):
Adjust comparison for differences (changes) in groups

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CARE: C=Confounding Single Cause

Arrow: Causation
Dashes: Association
One arrow: single cause

#1: People who shave their face are (tend to be) taller than those who shave their legs. *True? Result?*

#2: If you shave your legs and want to get taller, shave your face.

Confounding? Confounder?

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C=Confounding Common Cause

What is the association?
What is a causal claim?
What is the confounder?

Describe the direct association (left to right). Make a causal claim.
Describe the *reverse association* (right to left). Make a causal claim

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C=Confounding Examples

Crude comparison: a comparison that conflates (fails to take into account) important related factors. It is also known as a mixed-fruit comparison or an apples and oranges comparison. P. 25

Apples and oranges comparison (a mixed-fruit comparison): a metaphor for any comparison of things that have a major difference.

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A=Assembly: Data Definition

Assembly (assumptions) involves all the choices that influence a statistic and are not covered elsewhere under CARE.

Assembling statistics is like ‘wordsmithing’ or ‘lawyering.’

Assembly can be done carefully (to highlight relevant differences); opportunistically (to create false impressions); or ambiguously (to tell a half-truth).

Assembly is arguably the easiest way to twist the facts.

New College is the #1 honors college in Sarasota.
New College is a top 10 US public liberal-arts college.

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A=Assembly: Definition and Summarization

Assembly is arguably the easiest way to twist the facts.

And: The more required (adjectives), the smaller the count.
Or: The more options available, the larger the count.

Students are surveyed on their happiness at college.
Administration: 80% are satisfied
Student newspaper: 70% are not satisfied.

Data: Very happy 30%. OK 50%. Unhappy 20%.

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CARE: A=Assembly Manipulation/Summarization

CARE: ASSEMBLY

BEFORE/DURING SELECTION IN THE DATA		AFTER SELECTION ON THE DATA
Plan/Define	Select/Aquire	Manipulation*

* Includes presentation

Q. Which group had more people living with AIDS? Blacks if by race and ethnicity (Hispanic are separate). Whites if just by race and 70K of Hispanics are white.

All (1,000) ³⁰	White (non-Hispanic)	Black (non-Hispanic)	Hispanic
434	150	186	78

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R=Randomness Small Samples: Variability

Randomness generates predictable patterns.

As class size decreases, top scores increase.

Above-Average Class Scores vs. Class Size

Random Data. Average: 50%
20 classes per class size

All Class Scores vs. Class Size

Random Data. Average: 50%
20 classes per class size

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CARE: E=Error Classification and Bias

CARE: ERROR

Wrong Order	Bias	Lies
Subtract, Divide	Subject	Mistakes
Comparisons	Measurement	Prevarication
Ratios	Sampling	Weasel words

Subject (respondent) bias is when people lie/misremember in a systematic way.

Measurement (researcher) bias is systematic error in measurements.

Selection (sampling) bias is systematic error in the outcome due to a non-representative selection from a population

Sampling bias

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Take CARE !!!

CARE: CONFOUNDER*

Causes outcome. Not caused by predictor	
Common Cause	Single-Cause Confounder
Causes predictor	Doesn't cause predictor

*An alternate explanation for an association

CARE: ASSEMBLY

DATA COLLECT/SUMMARIZE	MODELLING
In the data	Done to data
Plan/Define	Manipulate
Select/Acquire	Select model
	Select input

CARE: RANDOM

Extremes	Big Data	Small Samples
Sports Illustrated	Lottery, Words	Galton board
Pilot performance	Runs, Patterns	Sample size
Pre-vs-post	Birthday match	Small classes

CARE: ERROR

Wrong Order	Bias	Lies
Subtract, Divide	Subject	Mistakes
Comparisons	Measurement	Prevarication
Ratios	Sampling	Weasel words

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Critical Thinking

Argument (inference): a peaceful way to persuade.

- Point: a more disputable claim (usually unobservable)
- Evidence: less disputable claim supporting the point

Inference: deductive or inductive

```

graph LR
    EX[EXPLANATION  
From Present to Past.  
From Effect to Cause] --> OBS[OBSERVABLES]
    OBS --> PRED[PREDICTION  
From Past to Future.  
From Act to Effect]
    OBS --> GEN[GENERALIZATION  
From Some to All]
    OBS --> SPEC[From Group to Subject  
SPECIFICATION]
  
```

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Critical Thinking versus Statistical Literacy

Point of the argument

Critical Thinking

**A more disputable point
needs stronger evidence**

Statistics as evidence

Strength and Relevance of the Statistic(s)

Statistics as the point

Statistical Literacy

**A stronger statistic is
more resistant to influence**

Statistics are numbers in context
Statistics can be influenced

Confounding Assembly Randomness Error

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Association- Moral Causation Disparity vs Discrimination

A-B-C GRAMMAR

Between: ???

Association: See Causation: Do

Semantics: Differences or Disparities are not [necessarily] Discrimination

A: Association	B: Between (moral)	C: Causation (moral)
Math Differences:	Descriptive Differences	Immoral Differences:
Count/Rate/Amount	with a Moral Connotation	Evaluative or Judgemental
different, unequal	unequal/inequality	inequity/inequitable
Rank: first, second, last	disproportionate	unfair/unjust/undeserved
Superlatives: highest/lowest	discriminate: discern difference	discriminate: with prejudice
Comparatives: more, higher, times as much, percent more	disparity / disparate impact	discrimination*
	over/under represented	racism/sexism

* Discrimination: direct/intended (racist/sexist) vs indirect/unintended; individual vs social (systemic or structural)
Based on common usage by many today, but not "etched in stone" for all.

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CARE: C=Confounding
Triangle Diagrams

Arrow: Causation
Dashes: Association

PredictorResult

Confounder

ASSOCIATION: THIRD FACTORS

Third factor: causes outcome, associated with predictor

CONFOUNDER*		Mechanism**
Not caused by the predictor		Caused by predictor
Common Cause	Alternate Confounder	
Causes predictor	Doesn't cause predictor	

*An alternate explanation for an association

** The way the predictor causes the outcome. A detailed explanation of an association.

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CARE: R=Random
Big Data: Longest Run

Fair coin: find longest run of heads in a row

10 Longest run! One chance in 1,024

300101010110111000001010110100100001100

1010111111111101011010110011011010010110

500101010101011001010011010101111101101

311001100001101001101011000101011101001

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