

VIC 2022 Schield CCT2 1

## Statistical Literacy: Critical Thinking about Statistics

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**Milo Schield**  
**University of New Mexico**  
 Statistical Literacy Coordinator  
 Fellow, American Statistical Association

**July 25, 2022**  
**2022 Conference on Critical Thinking**  
[www.StatLit.org/pdf/2022-Schild-CCT2-Slides.pdf](http://www.StatLit.org/pdf/2022-Schild-CCT2-Slides.pdf)  
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Induction 2022 Schield CCT2 2

## Critical Thinking: Headwinds

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Critical thinking faces two major problems:

- Philosophy shuns critical thinking
- The social sciences shun critical thinking.

Q. Why is this?  
 A. The failure to resolve the problem of induction.

In critical thinking,

- induction is not about motors or inducing labor at birth.
- Induction is essential for reasoning from evidence.

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## Induction: Reasoning from observed to unobserved

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**EXPLANATION**

From Present to Past.  
From Effect to Cause

**GENERALIZATION**  
From Some to All

↑

**OBSERVABLES**

↓

From Group to Subject  
SPECIFICATION

**PREDICTION**

From Past to Future.  
From Act to Effect

Associations are observable.  
 The objects of induction (generalizations, predictions, specifications and causes) are not usually observable.

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## Example of Induction

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Inferring what is unseen from what is seen.

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## The Fall in Philosophy No Certainty

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1748 Hume: *Human Understanding*:  
**The problem of causation;**  
**The problem of induction**

Cannot generalize with certainty

"induction is the glory of science and the scandal of philosophy"  
 C. F. Broad, Philosopher

Hume has posed "a most fundamental challenge to all human knowledge claims."  
 Emanuel Kant, Philosopher

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### **Critical Thinking: Problems Teaching**

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What is called critical thinking ... tends to be

- **reductionist** (explaining complex phenomena in terms of more elemental events),
- **positivistic** (limiting the “real” to what is physically observable or which can be proved),
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### **Rise of Psychology and the Social Sciences**

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The hard sciences avoided induction (generalizing) by performing repeatable experiments.

To be like the hard sciences, psychology and sociology focused on experiments or studies.

But with human subjects, they could not conduct scientific experiments: they could not repeat with the same subjects *in the same condition*.

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### **Statistics Ignores Critical Thinking**

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So they turned to statistics: one-try experiments. But, traditional statistics shuns critical thinking

- by using a *fixed-level* for statistical significance for all conjectures.
- by ignoring *confounding in observational studies*. By ignoring how controlling for a measured confounder can change statistical significance into insignificance.

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### **Confounding is the elephant in observational statistics**


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We know it.

We don't teach it.

We should teach it.

But there isn't time in traditional statistics.



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### **Today's Students are Interested in Arguments.**

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Many stories in the everyday media involve *controversial claims*.

Most give reasons – they involve *arguments*.

Many of these arguments involve **statistics**.

Most of these statistics are **Social statistics**: statistics about people.

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### **Today's student need to study Statistics**

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**Disparities in**

- Education, suspensions and graduation
- Policing, crime, sentencing and prison
- Wages, income, assets, loans and wealth
- Health, health care, homicides and deaths

**Disparities by**  
gender, race, ethnicity, religion, politics, age, etc.

**All of these rely on statistics: social statistics.**

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## University of New Mexico is offering a new course!

Taught 7 sections in 2021-22



**Statistical Literacy** 


**MATH 1300 (3)**  
Participants will study the social statistics encountered by consumers. Investigate the story behind the statistics. Study the influences on social statistics. Study the techniques used to control these influences. Strong focus on confounding.

Meets New Mexico General Education Curriculum Area 2: Mathematics and Statistics.

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## Math 1300: Statistical Literacy

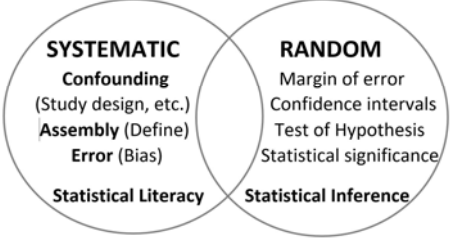
Less than 30% overlap with traditional statistics



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## Statistics as a Discipline

**STATISTICS STUDIES VARIATION**  
Two kinds of variation



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## Math 1300: Confounder-Based Statistical Literacy


Traditional statistics is designed for the producers of statistics: students in STEM majors

Statistical literacy is designed for the *consumers of statistics*: students in non-quantitative majors like journalism and political science.

*Q. Who or what determines the content?*  
A. The statistics in the everyday media

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## “Statistics are Socially Constructed”



Joel Best, author of “*Lies, Damned Lies and Statistics*” identified this fact as *the most important, the most fundamental*, aspect of all reality-based statistics.


Statistics, just like words, are created by people: people with motives, values and goals.

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## Statistical Literacy: Social Statistics vs. Numbers


Statistics are numbers in context (in reality)  
Statistics can be influenced by reality:

- In arithmetic, 1 plus 1 is always 2.



$1 + 1 \leq 2$


Bunny math:  $1 + 1 \geq 2$



Ice cube math

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## Statistics can Be Influenced



Q. Best advice when dealing with statistics?  
 A. "Take CARE". Statistics can be influenced.

All influences are grouped into four categories:

- C: Confounding:** Confused by related factors
- A: Assembly:** how things are defined, counted, etc.
- R: Randomness**
- E: Error** (including bias)

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## Statistics in Arguments: "Take CARE"

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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## Admonition: "Take CARE"



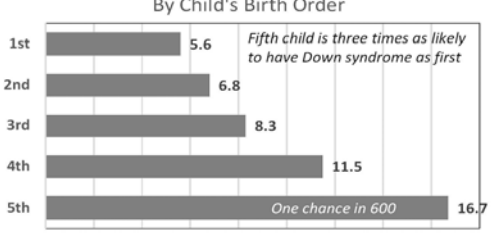
Students like "CARE". It gives them a structure.

When asked to rank what idea they considered the most valuable, students chose "Take CARE".

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## Statistics can be Confounded: Down Syndrome

Down Syndrome: Cases per 10,000 Births By Child's Birth Order



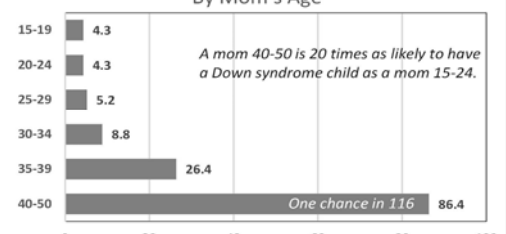
Birth Order	Cases per 10,000 Births
1st	5.6
2nd	6.8
3rd	8.3
4th	11.5
5th	16.7

Schield (2017): [www.StatLit.org/pdf/2017-Schield-Downs-Syndrome-Slides.pdf](http://www.StatLit.org/pdf/2017-Schield-Downs-Syndrome-Slides.pdf)

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## Statistics can be Confounded: Down Syndrome

Down Syndrome: Cases per 10,000 Births By Mom's Age



Mom's Age	Cases per 10,000 Births
15-19	4.3
20-24	4.3
25-29	5.2
30-34	8.8
35-39	26.4
40-50	86.4

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## Assembly

Bullying at school: using physical force to get what you want from others.

Re-define "bullying":

- To increase the count
- To decrease the count



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### Hypothetical Thinking

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Confounding:  
 Would having the first child at age 40 be more risky than having 5 kids before turning 30?

Assembly:  
 How could a statistic have been defined when the definition isn't given?

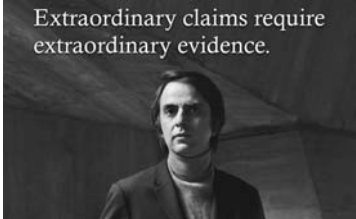
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### Randomness: Statistical Significance

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Using a fixed rule (one chance in 20) violates the Sagan rule:

Extraordinary claims require extraordinary evidence.



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### Use Ordinary English

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Association is not ... causation.

- *People who shave their face are taller than those who shave their legs.*



Disparity is not ... discrimination.

- *Tall people are 10 times as likely to be in prison as short people.*



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### New Course; New Textbook

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Field tested:

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## Statistical Literacy

*Seeing the story behind the statistics*

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### Students Find Statistical Literacy Valuable

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*How valuable is this course in helping you read and interpret everyday statistics?*

Negative (1%), Neutral (4%), Some value (12%), Fair value (38%), Highly valuable (45%).

*How helpful was this course in developing your critical thinking skills?*

Not helpful (0), Neutral (5%), Somewhat (21%), Very (42%), Extremely (32%)


76 students, Fall 2021 UNM Math 1300

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### Conclusion

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Students need to be able to read and interpret social statistics in order to evaluate today's arguments.



Faculty in the humanities need to persuade their math-stat colleagues to offer a statistical literacy course.

# **Statistical Literacy: Critical Thinking about Statistics**

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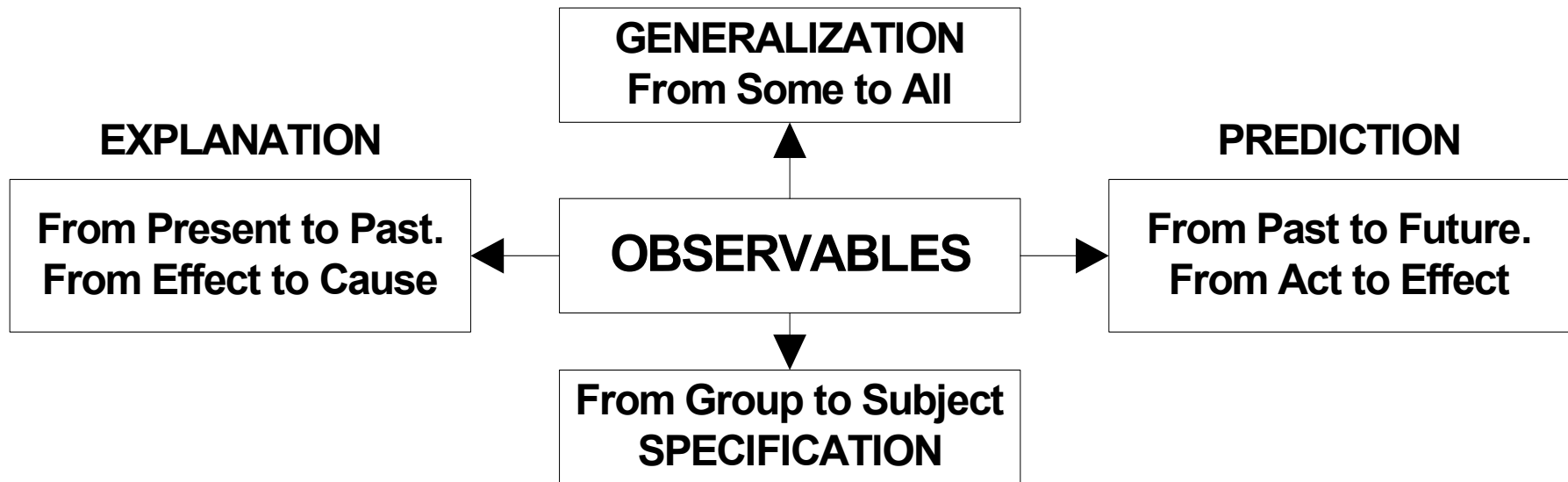
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## Reasoning from observed to unobserved

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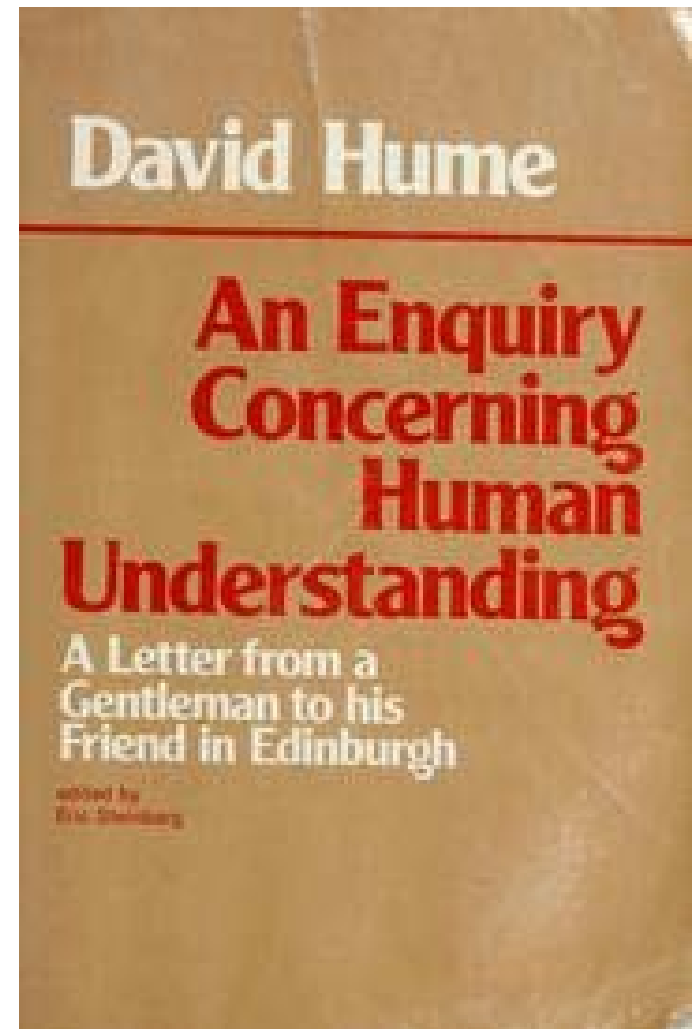
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# DAVID HUME

IF IT'S  
NOT *EMPIRRICAL*,  
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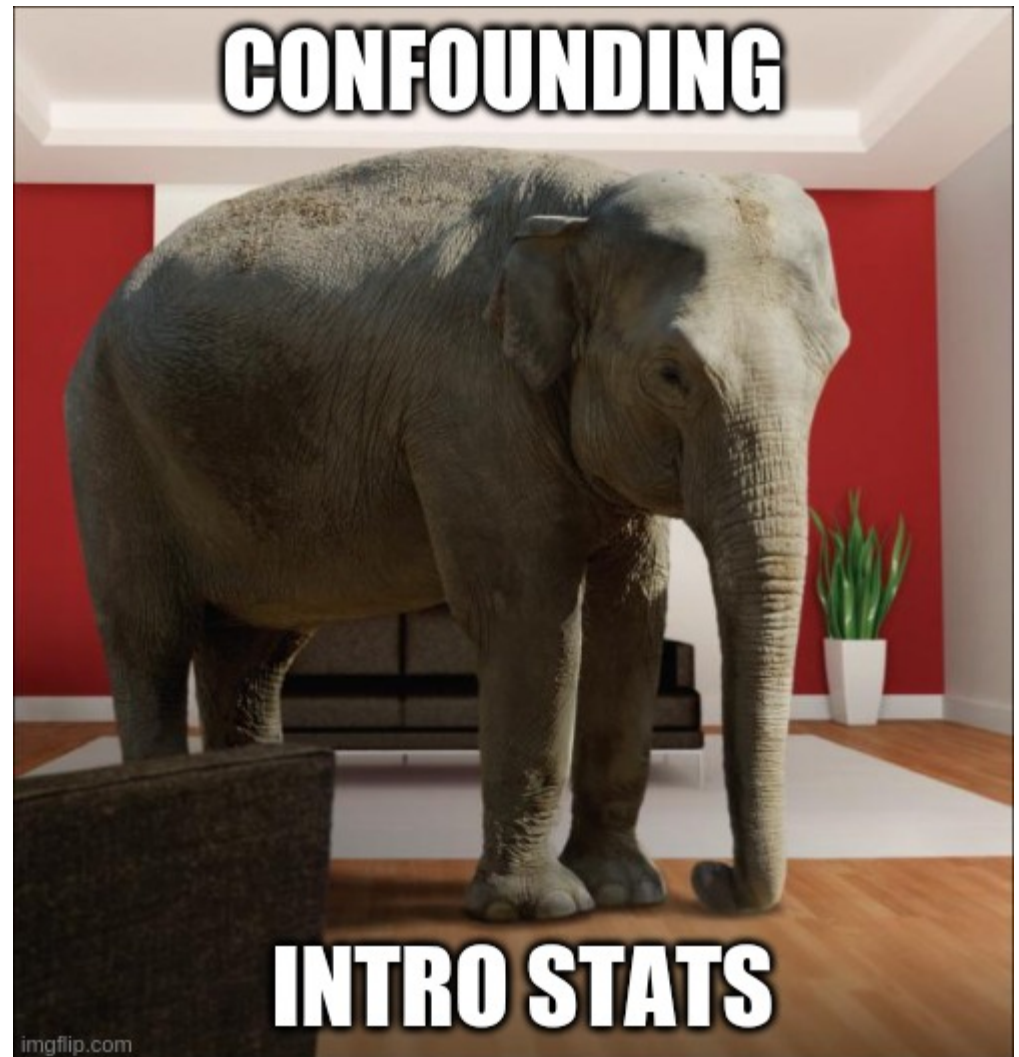
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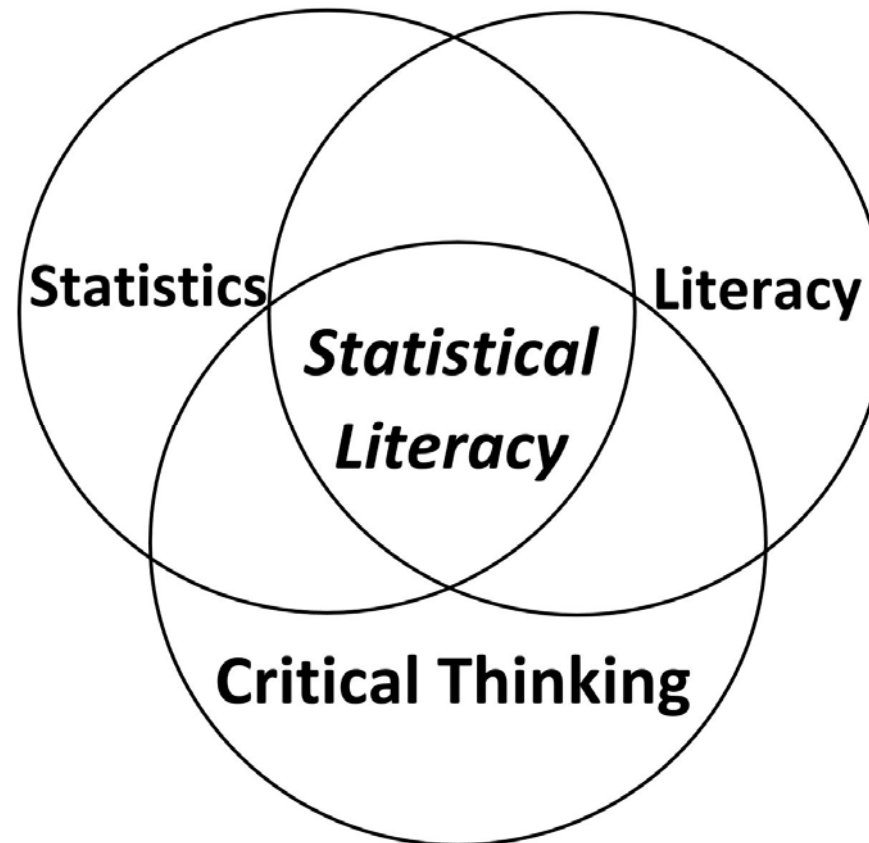
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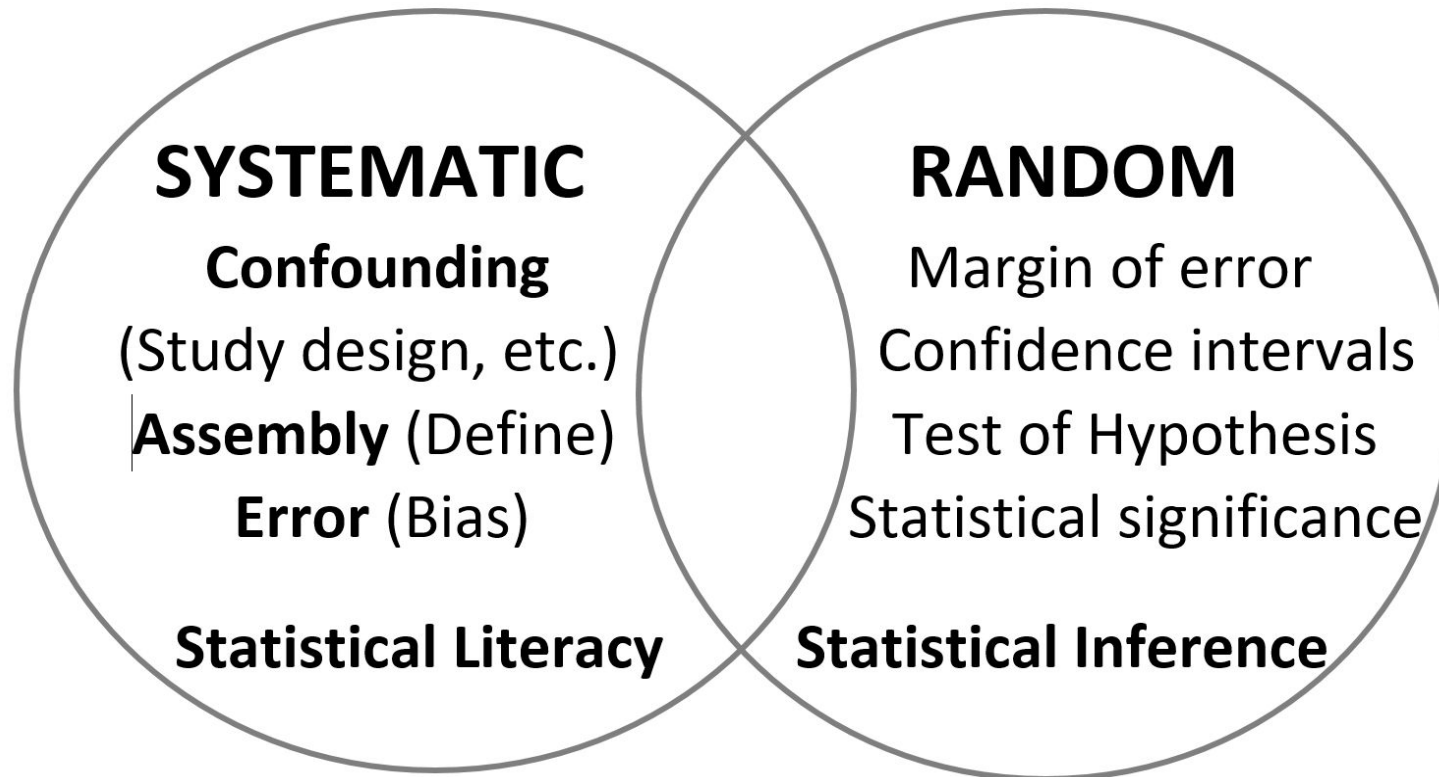


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# **Admonition: “Take CARE”**

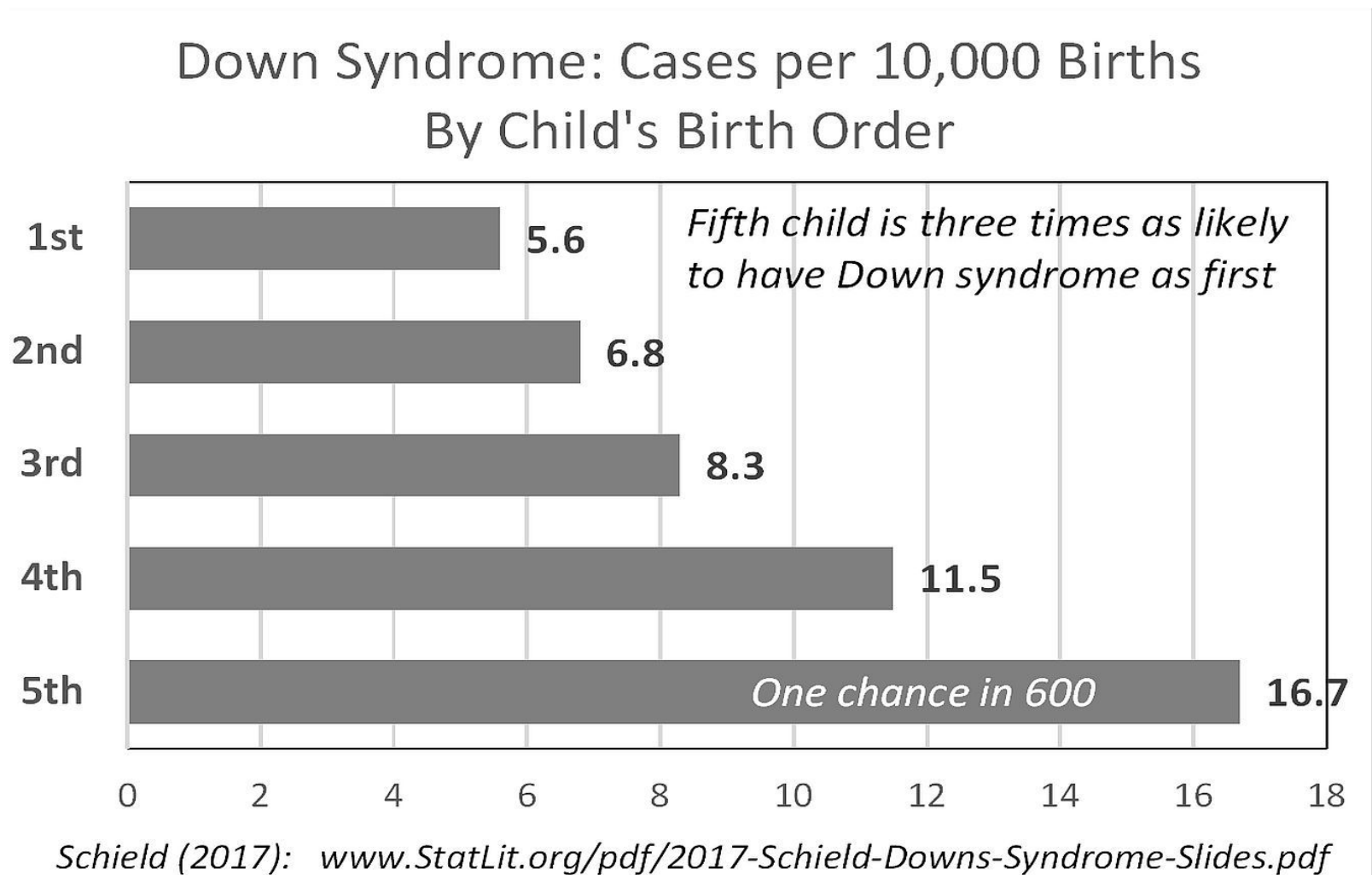
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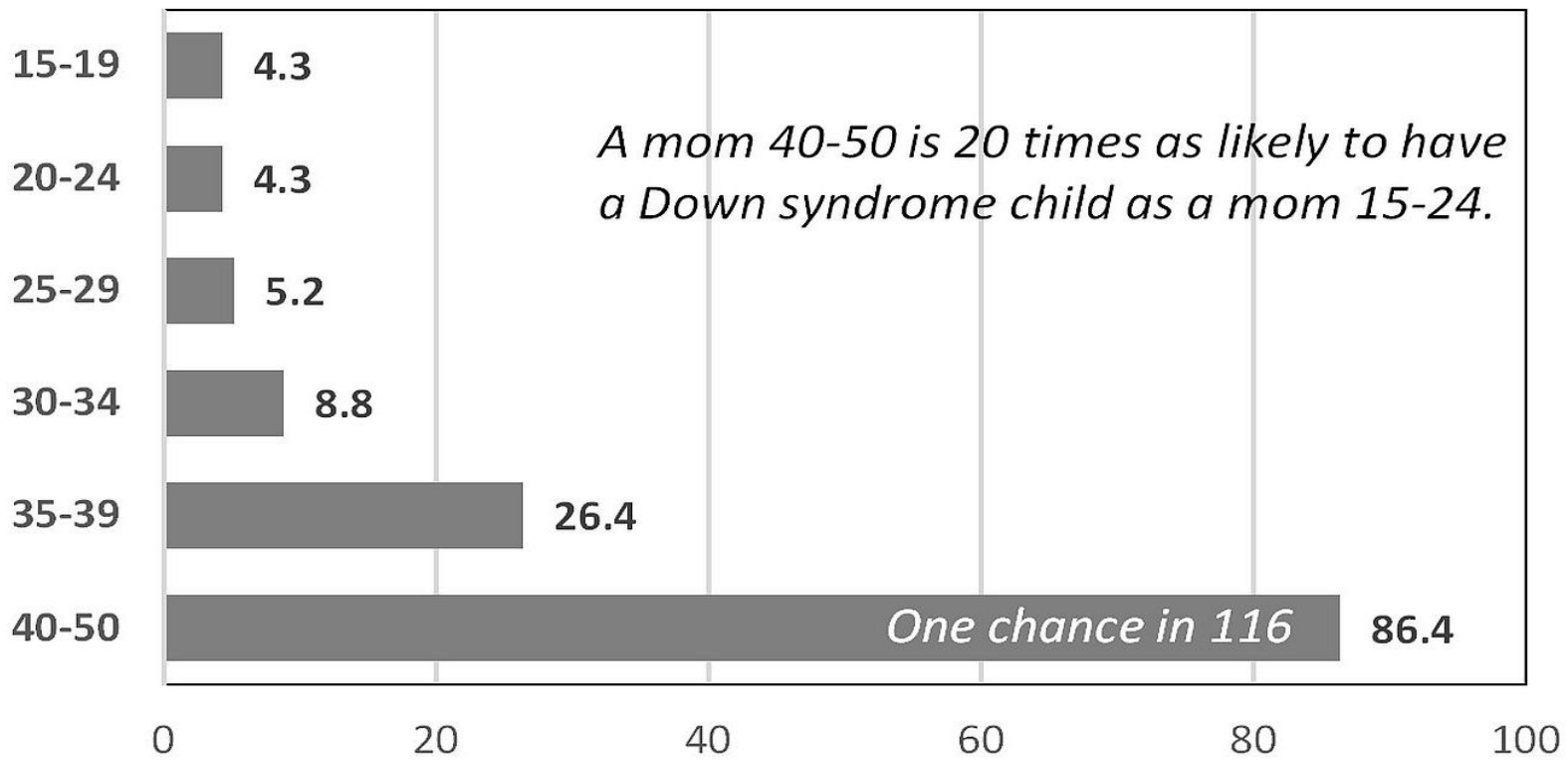
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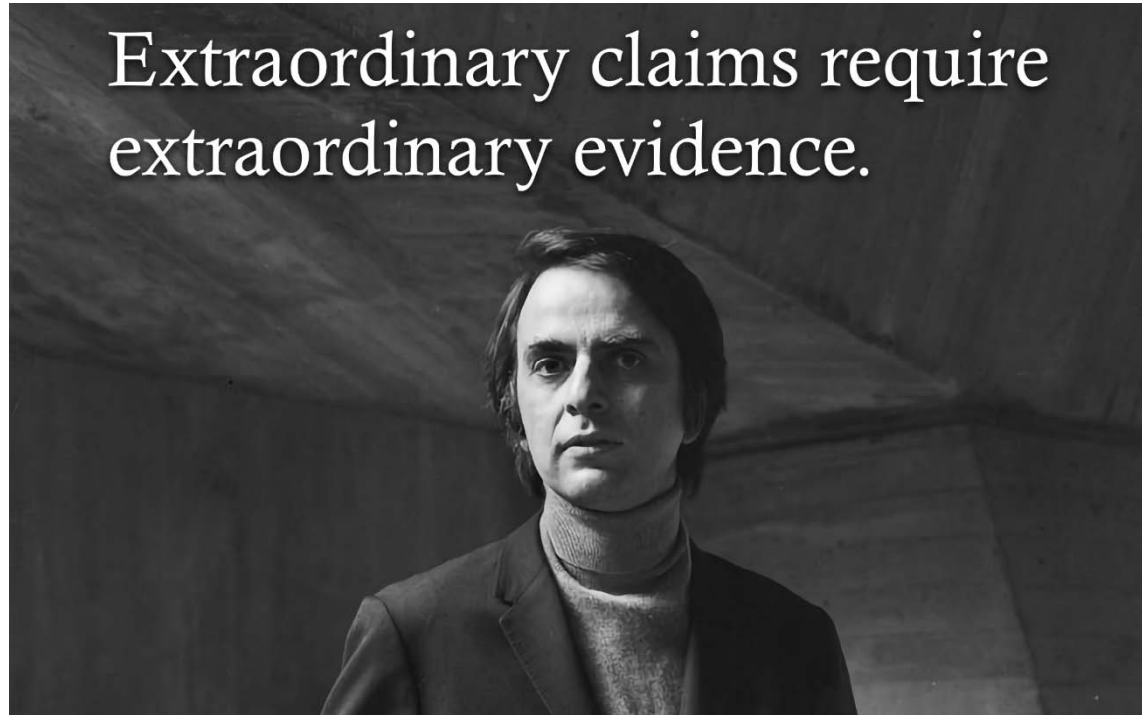
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