

Statistical Literacy for All

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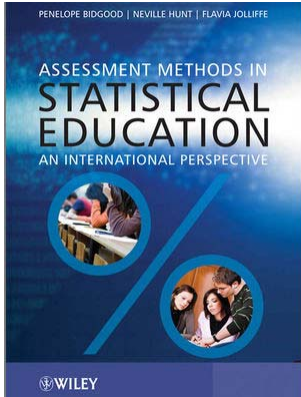
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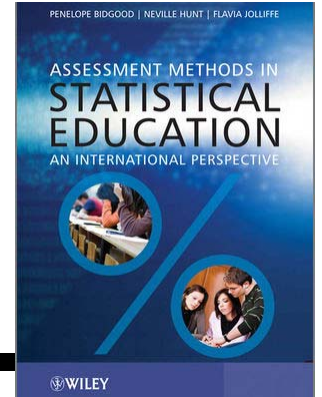
February 24, 2012

Slides at www.StatLit.org/pdf/2012Schield-Lehman6up.pdf

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Statistical Literacy



Statistical literacy is the ability to **read and interpret** summary statistics in the everyday media: in graphs, tables, statements and essays.

Statistical literacy is needed by ‘data consumers.’

About 40% of all US college students graduating in 2003 had non-quantitative majors.

Schild (2010) in *Assessment Methods in Statistical Education*

Wired Magazine: Oct 2010

COURSE LISTINGS

1. STATISTICAL LITERACY

Making sense of today's data-driven world.

FALL SEMESTER 2011

WIRED

UNIVERSITY!

Statistical Literacy: Take CARE

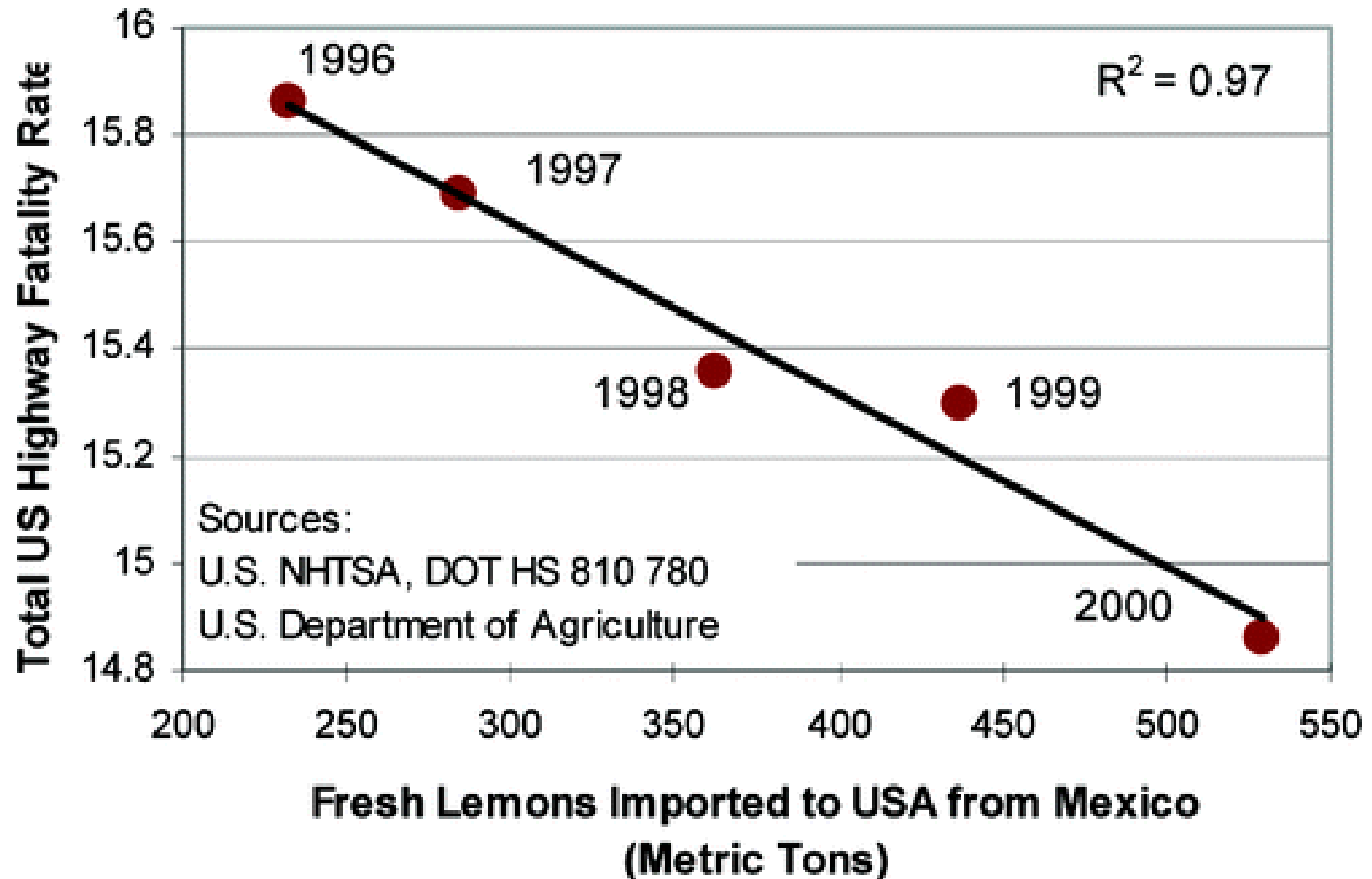
Associations may be useful in

- identifying causation
- making a prediction, a generalization or a specification.

Statistical associations may be influenced by:

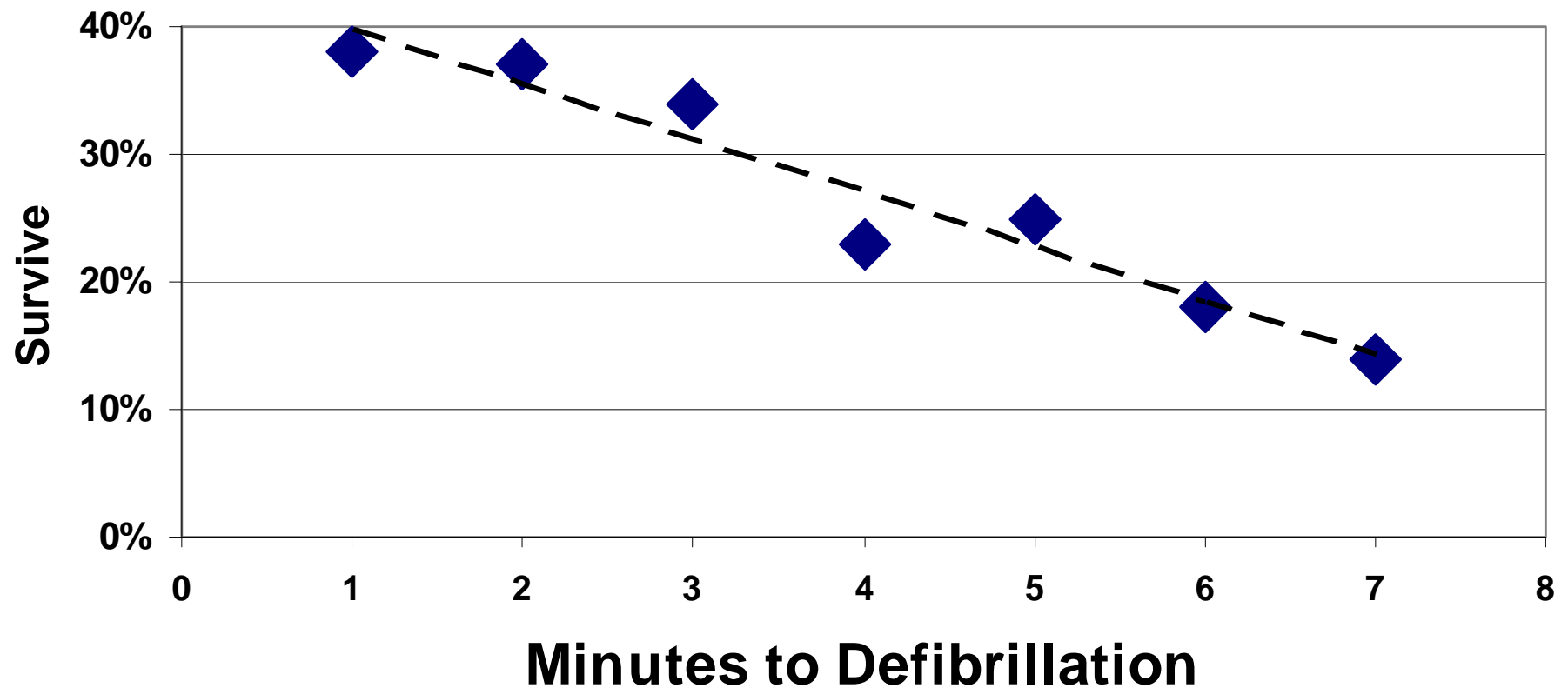
- Context: what is (and is not) taken into account
- Assembly: how things are defined or measured
- Randomness: coincidence or margin of error
- Error/bias: Subject, research or sampling bias

1a. Association is probably not Causation

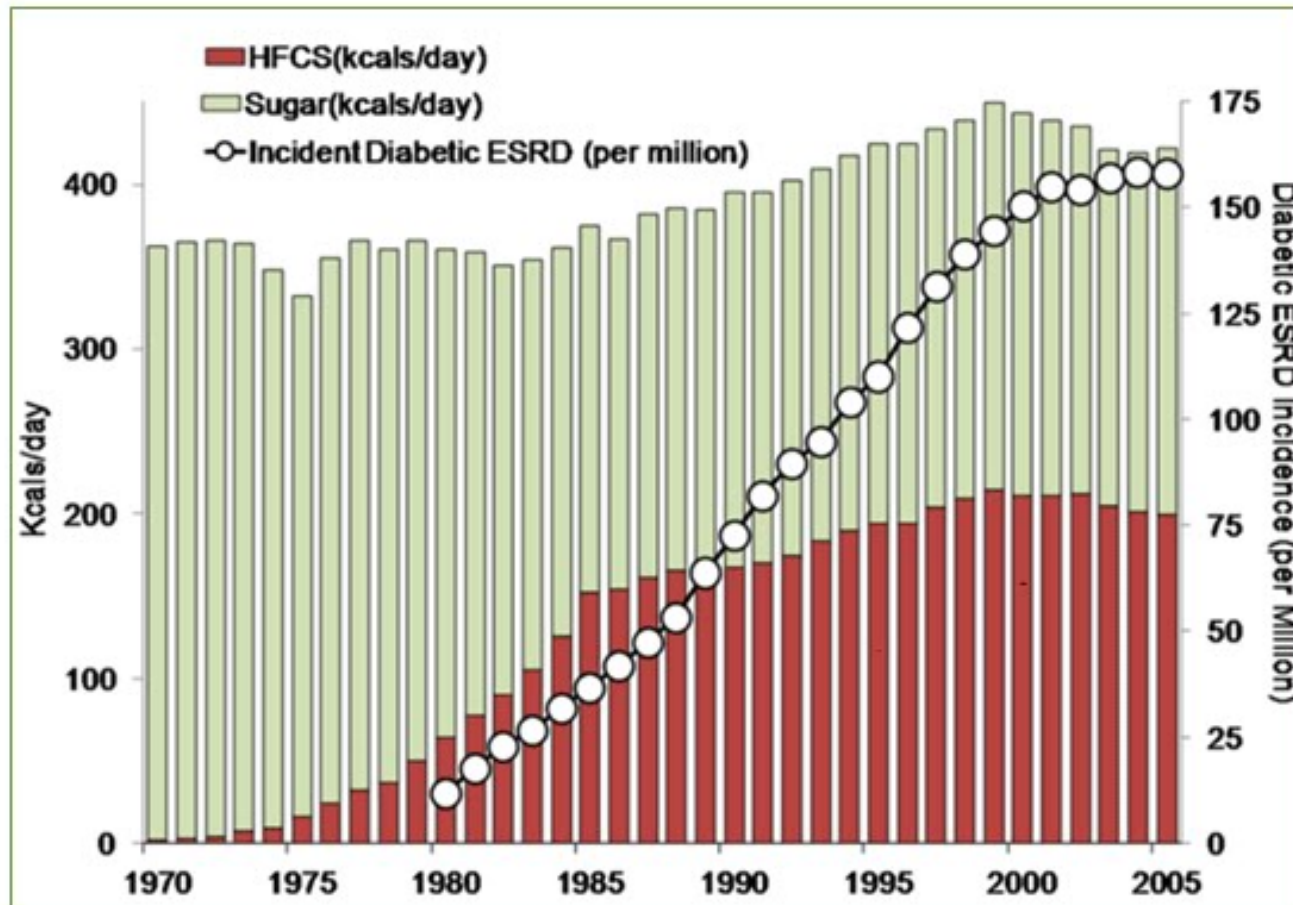


1b. Association is Probably Causation

Heart-Attack Survival Rate

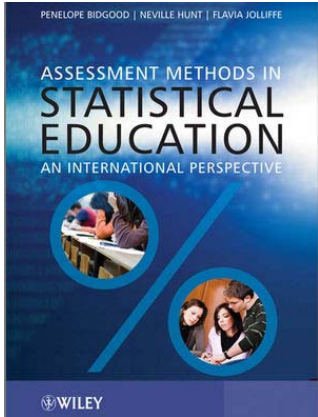


1c. Association is possibly a sign of Causation



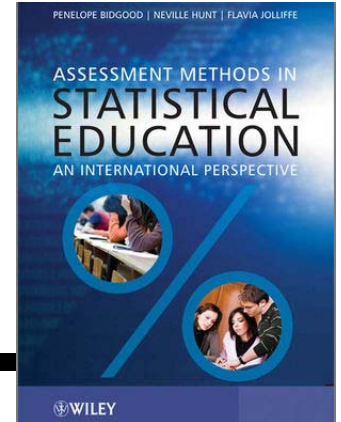
U.S. Trends in Total Sugar and High Fructose Corn Syrup (HFCS) availability, and Incident Diabetic End-Stage Renal Disease (ESRD)

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Statistical Literacy

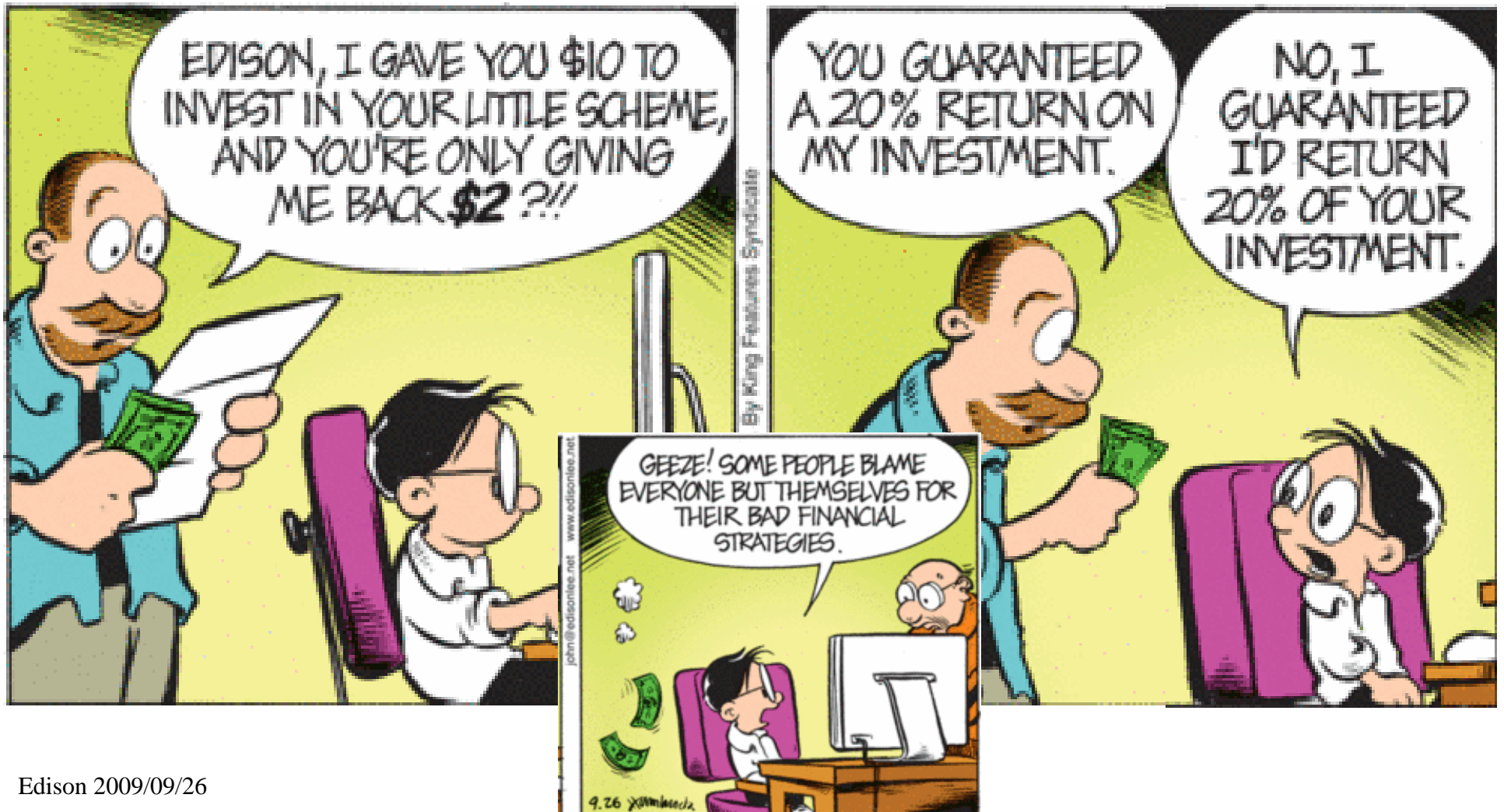
Describing & Comparing



“Literacy” is a big idea in statistical literacy
Must be able to describe and compare percentages
and rates presented in tables and graphs.

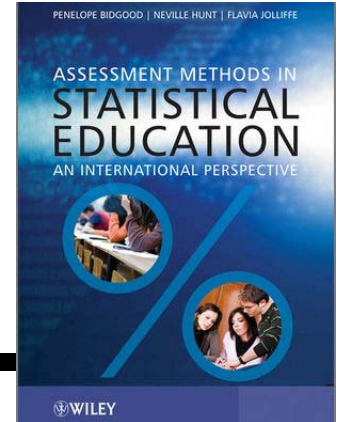
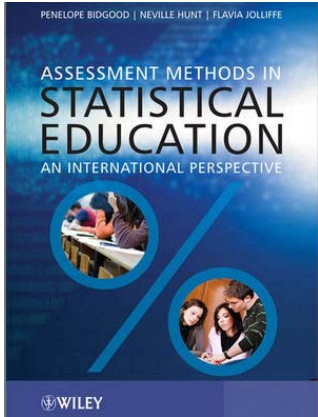
Is “*the percentage of men who smoke*” the same as
“*the percentage of men among smokers*”? No
If “*Smoking is more likely among women than
men*” does this mean that “*Smokers are more
likely to be women than men*”? No

Small Change in Syntax; Big Change in Semantics



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Statistical Literacy #1: Context & Confounding



“Confounding” is a big idea in Statistical Literacy.

Controlling for a confounder can influence:

- the size of rates, percentages and relative risks
- the percentage or # of cases attributed to X
- whether a difference is statistically Significant

Statistically-significant differences can become *statistically insignificant* (and vice versa).

Intro statistics textbooks do NOT mention this!

Size of a statistic depends on what is “taken into account”

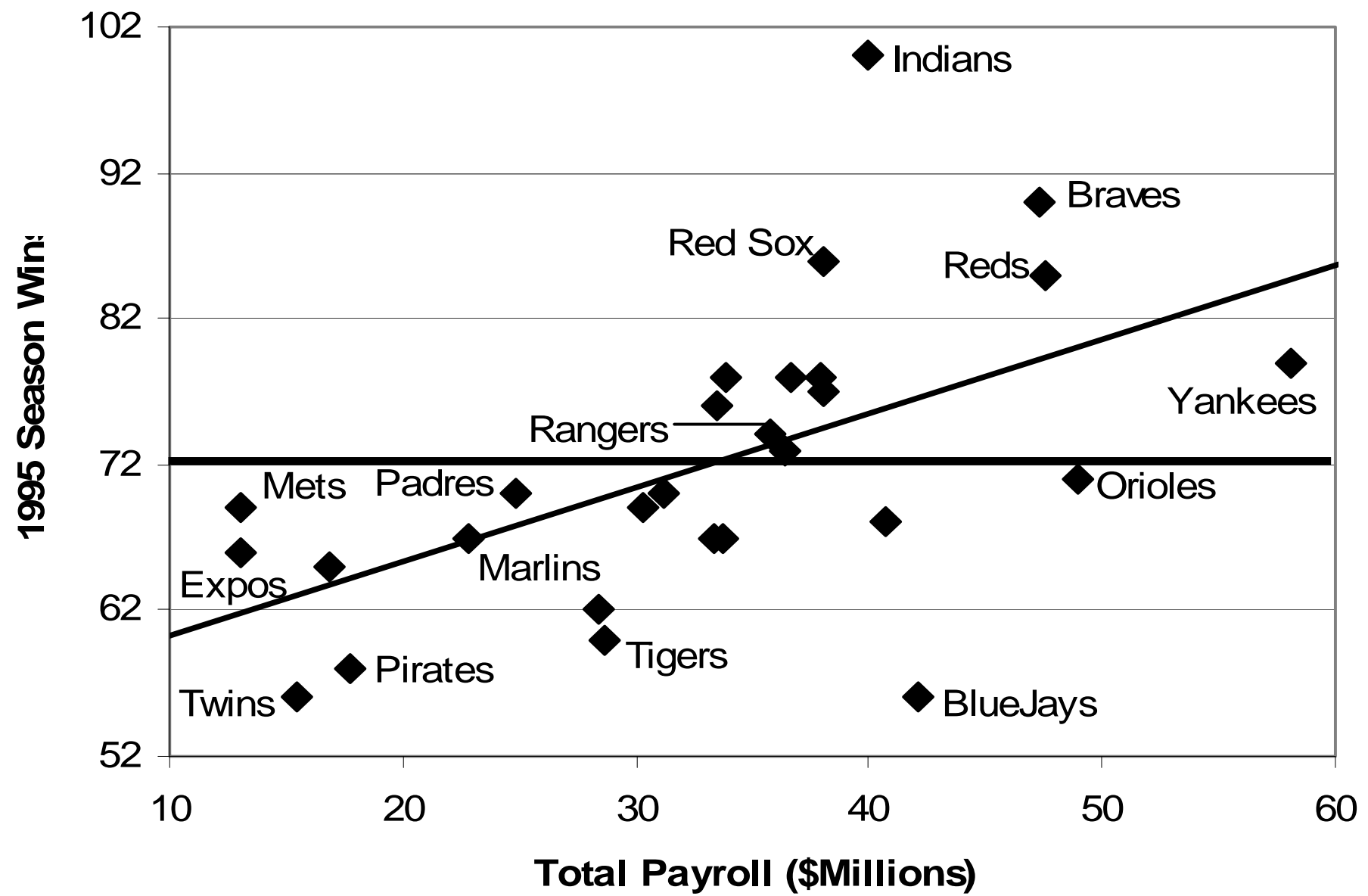
State Prison Expense (1996)

| State | Total | Compare | Inmates | Per Inmate | Compare |
|-------|--------|----------|---------|------------|----------|
| MN | \$184M | 27% more | 4,865 | \$37,825 | 56% more |
| IA | \$144M | 12% less | 5,929 | \$24,286 | 36% less |

| State | Total | Compare | Inmates | per Inmate | Compare |
|-------|--------|----------|---------|------------|----------|
| CA | \$2.9B | 50% more | 136K | \$21,385 | 25% less |
| NY | \$1.9B | 34% less | 69K | \$28,426 | 33% more |

SEASON WINS vs. TOTAL PAYROLL

US Major League Baseball



US SAT-VERBAL SCORES

| Average SAT-V | 1981 | 2002 | Change | 1981 | 2002 |
|-----------------|------|------|--------|------|------|
| All Test-Takers | 504 | 504 | 0 | 100% | 100% |
| White | 519 | 527 | 8 | 85% | 65% |
| Black | 412 | 431 | 19 | 9% | 11% |
| Asian | 474 | 501 | 27 | 3% | 10% |
| Mexican | 438 | 446 | 8 | 2% | 4% |
| Puerto Rican | 437 | 455 | 18 | 1% | 3% |
| American Indian | 471 | 479 | 8 | 0% | 1% |

Patient Death Rates

City hospital has a higher death rate than Rural.

| DEATH RATE | | Patient Condition | |
|------------|------|-------------------|-------|
| Hospital | Good | Poor | TOTAL |
| City | 1.0% | 6.0% | 5.5% |
| Rural | 2.0% | 7.0% | 3.5% |
| TOTAL | 1.9% | 6.3% | 4.5% |

After controlling for patient condition
(compare within a given column),
City hospital has a lower death rate than Rural.

Death Rates per 10,000 Auto Accidents

People in auto accidents are less likely to die if their car has an air bag.

| | Seatbelt | | |
|--------|----------|-----|-------|
| Airbag | No | Yes | Total |
| Yes | 122 | 18 | 34 |
| No | 105 | 25 | 58 |
| Total | 111 | 21 | 45 |

After controlling for the use of a seat belt (compare in a column), airbags make almost no difference in survival compared to seat belts (compare in a row)

Assembly: Making small things big

7 nanograms per gram = 7 parts in a billion

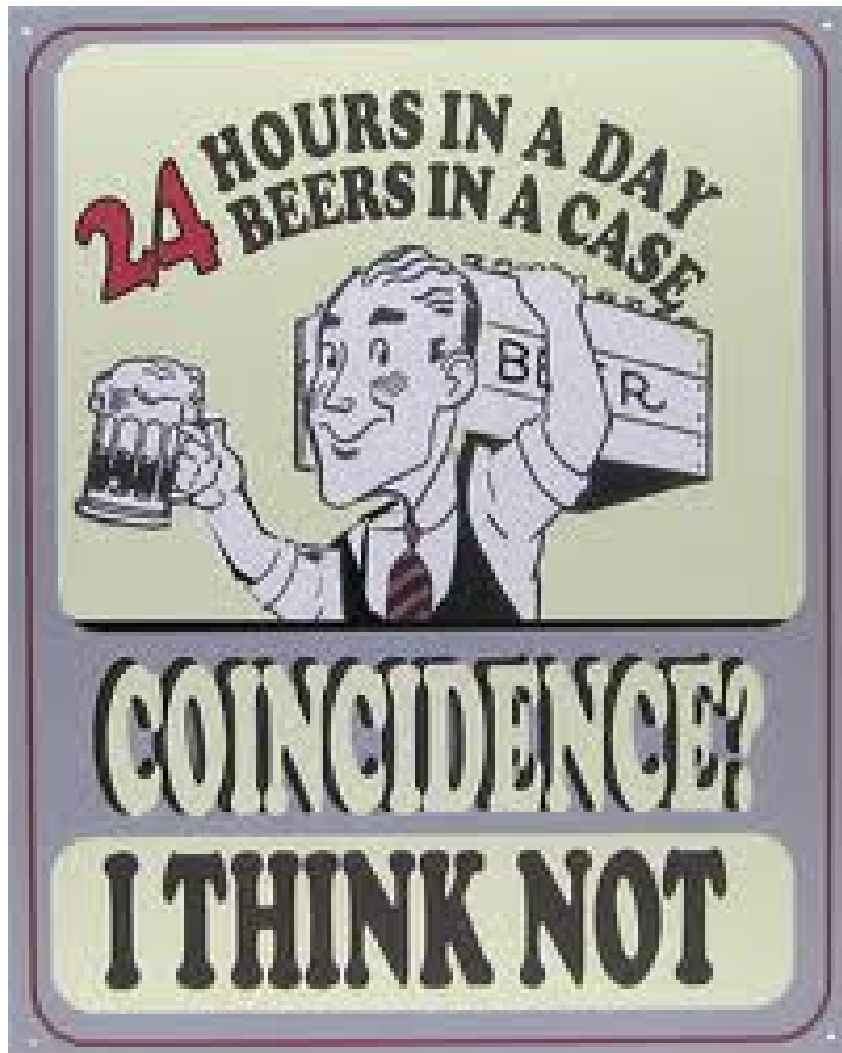


Hyatt: Close to the US Capital

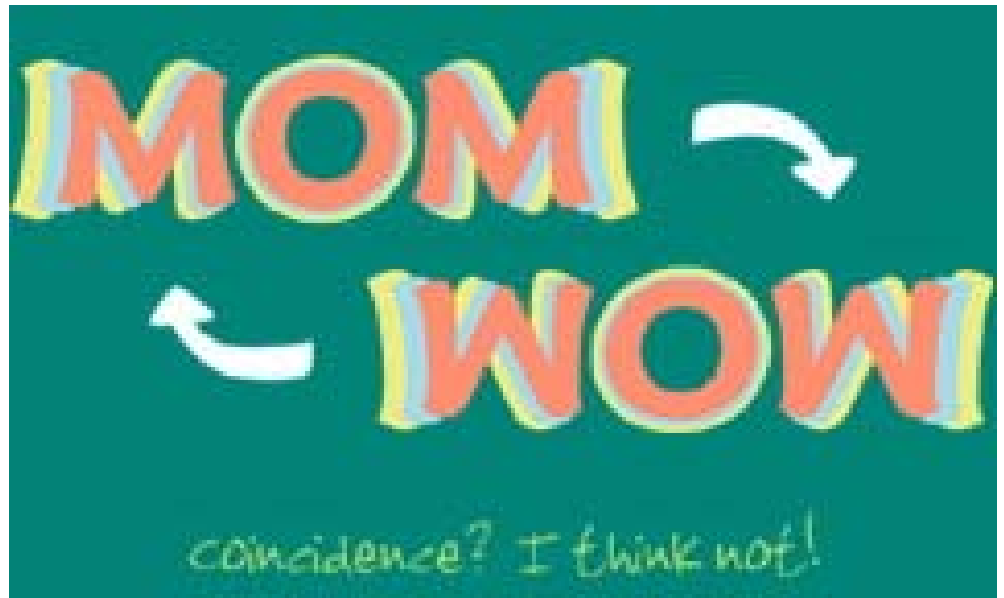
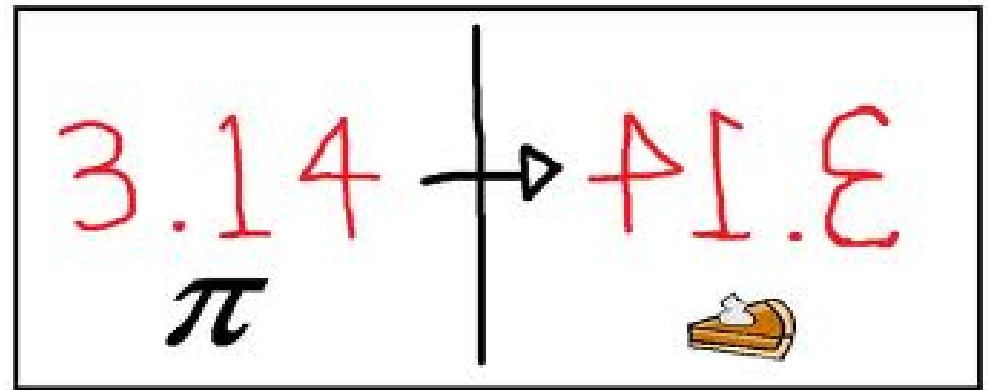


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Randomness: Coincidence



Randomness: Coincidence?



Seeing Coincidence

| A3 | | fx =RANDBETWEEN(0,9) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----|---------------|----------------------|---|---|---|--------|---|---|---|---|--------------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|-----------------------------------------------|---|----|----|----|----|----|----|----|----|----|--|--|--|--|
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | AA | AB | AC | AD | AE | AF | AG | AH | AI | | | | |
| 1 | Rice-10 sheet | | | | | | | | | | Find the largest group of high cells (red fill) that are touching each other. | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | 0 Low | | | | | 9 High | | | | | a. touching on sides in a row | | | | | | | | | | | | | | b. touching on sides (but not just on points) | | | | | | | | | | | | | | |
| 3 | 1 | 1 | 4 | 1 | 0 | 1 | 4 | 9 | 8 | 0 | 2 | 3 | 9 | 2 | 9 | 2 | 1 | 9 | 8 | 2 | 7 | 6 | 7 | 8 | 7 | 4 | 6 | 4 | 6 | 5 | 0 | 0 | 9 | 6 | 0 | | | | |
| 4 | 7 | 9 | 8 | 8 | 8 | 2 | 5 | 2 | 7 | 8 | 6 | 0 | 8 | 6 | 7 | 1 | 8 | 6 | 6 | 6 | 6 | 5 | 6 | 8 | 7 | 8 | 9 | 9 | 7 | 5 | 8 | 0 | 5 | 0 | 7 | | | | |
| 5 | 3 | 9 | 9 | 9 | 9 | 9 | 5 | 6 | 0 | 3 | 1 | 7 | 9 | 9 | 2 | 0 | 5 | 7 | 4 | 3 | 0 | 6 | 4 | 8 | 1 | 1 | 9 | 6 | 3 | 4 | 4 | 7 | 2 | 3 | 9 | | | | |
| 6 | 6 | 7 | 7 | 1 | 7 | 7 | 2 | 8 | 0 | 3 | 1 | 6 | 2 | 0 | 9 | 5 | 6 | 9 | 9 | 9 | 5 | 2 | 4 | 8 | 8 | 9 | 2 | 7 | 6 | 0 | 6 | 6 | 2 | 5 | 3 | | | | |
| 7 | 4 | 5 | 5 | 2 | 5 | 2 | 3 | 0 | 8 | 9 | 3 | 9 | 4 | 8 | 0 | 7 | 1 | 3 | 6 | 9 | 6 | 1 | 9 | 0 | 0 | 8 | 2 | 4 | 8 | 0 | 0 | 6 | 5 | 9 | 2 | | | | |
| 8 | 0 | 7 | 9 | 6 | 0 | 3 | 2 | 2 | 4 | 6 | 9 | 4 | 0 | 6 | 4 | 4 | 7 | 1 | 2 | 8 | 5 | 1 | 9 | 4 | 6 | 7 | 5 | 5 | 8 | 3 | 2 | 2 | 7 | 3 | 6 | | | | |
| 9 | 0 | 3 | 8 | 5 | 2 | 0 | 6 | 2 | 7 | 7 | 7 | 9 | 4 | 7 | 7 | 6 | 8 | 4 | 0 | 1 | 0 | 3 | 0 | 8 | 6 | 7 | 4 | 0 | 3 | 3 | 4 | 9 | 4 | 9 | 0 | | | | |
| 10 | 2 | 3 | 7 | 1 | 9 | 0 | 4 | 5 | 1 | 7 | 9 | 0 | 1 | 5 | 3 | 9 | 8 | 7 | 4 | 7 | 5 | 6 | 3 | 8 | 6 | 6 | 2 | 3 | 9 | 5 | 3 | 2 | 0 | 2 | 0 | | | | |
| 11 | 8 | 1 | 8 | 2 | 3 | 7 | 5 | 7 | 6 | 6 | 8 | 4 | 8 | 0 | 8 | 1 | 4 | 8 | 1 | 5 | 7 | 1 | 2 | 3 | 6 | 1 | 3 | 0 | 7 | 5 | 1 | 4 | 7 | 2 | 1 | | | | |
| 12 | 1 | 1 | 6 | 3 | 6 | 1 | 8 | 5 | 5 | 2 | 1 | 2 | 8 | 2 | 8 | 8 | 5 | 6 | 7 | 4 | 3 | 9 | 2 | 1 | 1 | 0 | 8 | 3 | 2 | 6 | 9 | 1 | 4 | 8 | 5 | | | | |
| 13 | 7 | 6 | 6 | 5 | 4 | 6 | 5 | 2 | 9 | 0 | 3 | 9 | 9 | 5 | 9 | 4 | 5 | 8 | 2 | 5 | 3 | 8 | 9 | 6 | 6 | 0 | 0 | 2 | 7 | 1 | 2 | 9 | 4 | 0 | 6 | | | | |
| 14 | 4 | 8 | 7 | 9 | 3 | 0 | 9 | 3 | 6 | 5 | 8 | 1 | 3 | 2 | 6 | 7 | 1 | 0 | 8 | 0 | 9 | 5 | 2 | 7 | 8 | 4 | 5 | 1 | 6 | 0 | 0 | 3 | 6 | 3 | 1 | | | | |
| 15 | 2 | 5 | 9 | 3 | 8 | 0 | 2 | 7 | 0 | 1 | 3 | 8 | 0 | 6 | 7 | 9 | 3 | 2 | 5 | 3 | 0 | 8 | 4 | 1 | 9 | 2 | 3 | 0 | 5 | 0 | 9 | 6 | 9 | 3 | 1 | | | | |
| 16 | 0 | 5 | 3 | 1 | 8 | 9 | 8 | 2 | 4 | 1 | 2 | 1 | 7 | 7 | 4 | 4 | 8 | 2 | 7 | 8 | 5 | 3 | 2 | 7 | 4 | 1 | 4 | 1 | 7 | 1 | 8 | 0 | 5 | 6 | 0 | | | | |
| 17 | 9 | 6 | 8 | 4 | 6 | 4 | 3 | 8 | 5 | 2 | 9 | 5 | 4 | 8 | 8 | 1 | 9 | 1 | 8 | 6 | 8 | 0 | 3 | 8 | 3 | 9 | 9 | 1 | 5 | 6 | 5 | 2 | 4 | 5 | 6 | | | | |
| 18 | 3 | 2 | 1 | 0 | 2 | 3 | 4 | 0 | 3 | 9 | 9 | 6 | 6 | 6 | 8 | 4 | 8 | 0 | 2 | 0 | 6 | 6 | 7 | 1 | 1 | 1 | 4 | 1 | 9 | 0 | 6 | 4 | 9 | 3 | 4 | | | | |
| 19 | 7 | 4 | 7 | 9 | 9 | 7 | 1 | 1 | 3 | 7 | 9 | 3 | 1 | 6 | 9 | 0 | 0 | 3 | 9 | 9 | 3 | 0 | 6 | 6 | 9 | 2 | 4 | 0 | 3 | 5 | 0 | 5 | 1 | 4 | 0 | | | | |
| 20 | 5 | 6 | 9 | 1 | 8 | 3 | 4 | 8 | 8 | 5 | 6 | 5 | 0 | 1 | 5 | 3 | 7 | 5 | 4 | 2 | 8 | 3 | 7 | 7 | 9 | 0 | 6 | 2 | 1 | 3 | 9 | 8 | 9 | 2 | 9 | | | | |

**Flip 8 sets of 3 coins each [24 flips];
A run of three heads is “expected”**

Chance of 3 heads: one chance in eight.

| | | | | | | | | |
|---|---|---|--|--|--|---|---|---|
| 1 | 2 | 3 | | | | 1 | 2 | 3 |
| | | | | | | | | |
| 1 | 2 | 3 | | | | 1 | 2 | 3 |
| | | | | | | | | |
| 1 | 2 | 3 | | | | 1 | 2 | 3 |
| | | | | | | | | |
| 1 | 2 | 3 | | | | 1 | 2 | 3 |

Run of at least three heads: “Expected” in 10 flips of fair coin

| | | | | | | | | | | | |
|-----|--|---|---|---|---|---|---|---|---|---|----|
| 1 | | 1 | 2 | 3 | | | | | | | |
| 2 | | | 2 | 3 | 4 | | | | | | |
| 3 | | | | 3 | 4 | 5 | | | | | |
| 4 | | | | | 4 | 5 | 6 | | | | |
| 5 | | | | | | 5 | 6 | 7 | | | |
| 6 | | | | | | | 6 | 7 | 8 | | |
| 7 | | | | | | | | 7 | 8 | 9 | |
| 8 | | | | | | | | | 8 | 9 | 10 |
| All | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Key is “Overlap”

Error/Bias

Suppose that men make a third more income than women for the same job.

How much of this difference is due to bias?

- Lying or “reaching” by men. Rounding up. Including anticipated bonus/raise.
- Conservatism by women. Rounding down. Quoting regular pay or even take-home pay.

Error/Bias

A recent survey shows that most Republicans surveyed prefer Obama as President.

Question: Who would you prefer as President?

- Barack Obama
- The captain of the Italian liner that crashed
- Charlie Sheehan
- Lady Gaga

Conclusion #1

Most students are statistically illiterate

They don't believe that taking into account a related factor can change an association.

They can't see why coincidences are common. They can't read tables or graphs. They can't describe and compare rates and percentages.

They can't think hypothetically about what might have influenced an association.

They don't see how definitions affect numbers.

Conclusion #2

Graduates in non-quantitative majors are most likely to be the journalists, policy makers and politicians who influence decisions on funding for science, engineering and math.

The less value they see in STEM, the harder it is to get their support.

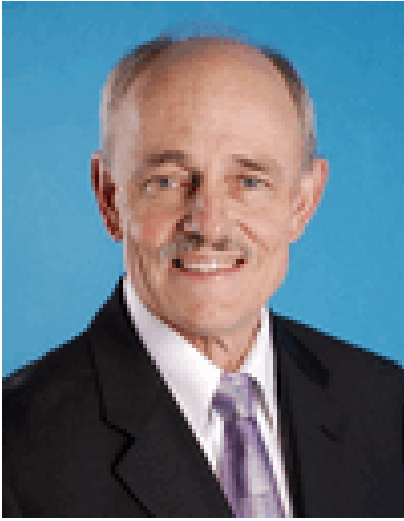
Recommendation

Find Way to Support

Mathematics departments should find ways to support courses and programs involving quantitative or statistical literacy as a form of math-statistics appreciation.

Increased appreciation should be first; understanding principles taught in upper-level math-stat courses should be second.

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Importance of Statistical Literacy

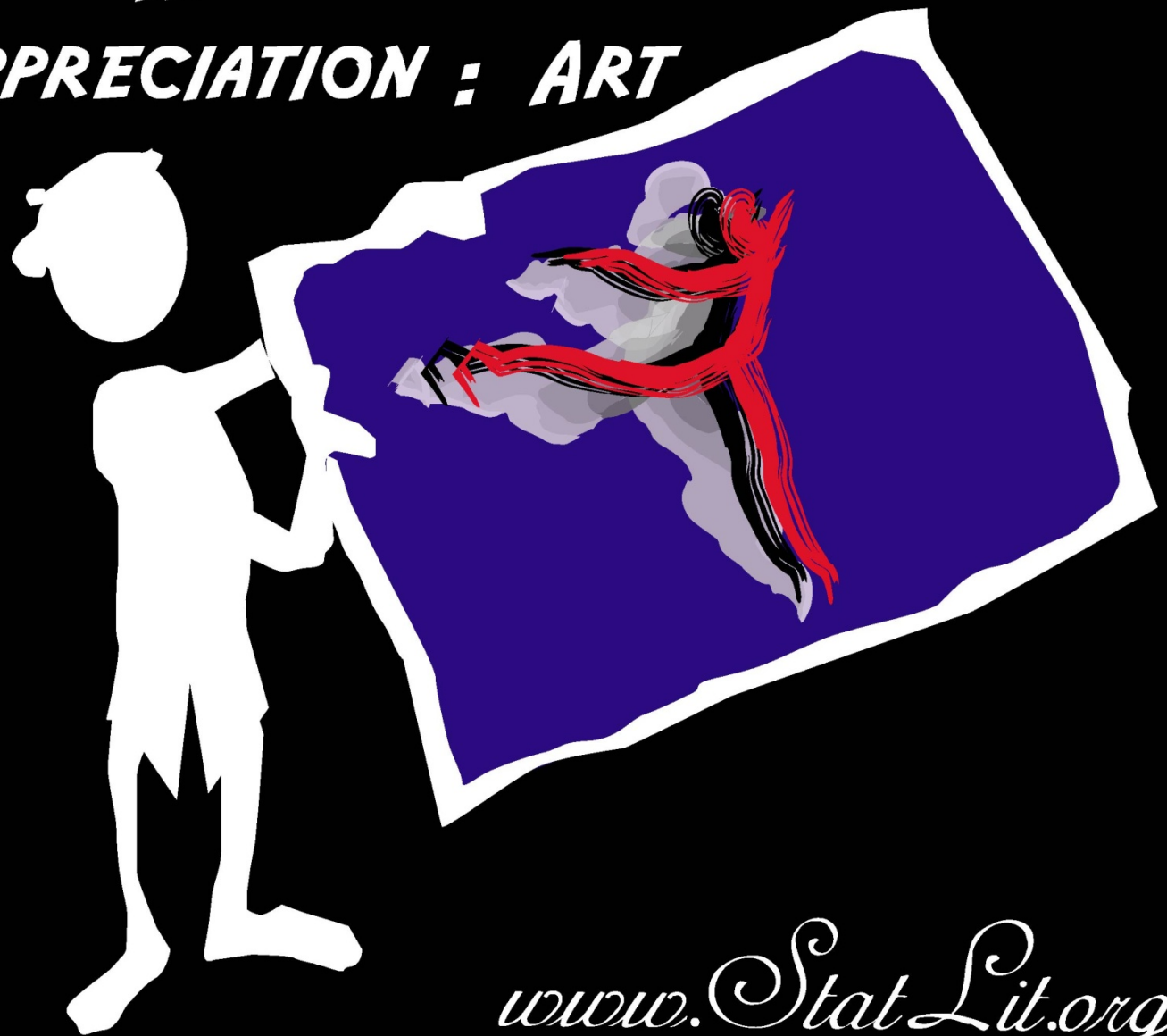
I've been increasingly impressed by how important statistical literacy has become for all of us around the globe.

Statistical literacy has risen to the top of my advocacy list, right alongside numeracy, and perhaps even ahead of "algebra for all."

J. Michael Shaughnessy, NCTM President

www.StatLit.org/pdf/2010Shaughnessy-StatisticsForAll-NCTM.pdf

STATISTICAL LITERACY : STATISTICS
AS
ART APPRECIATION : ART



www.StatLit.org

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