

EVIDENTIAL STATISTICS

*Reforming the Introductory Course
in Applied Statistics
for Non-Majors*

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APPLIED INTRODUCTORY STATISTICS

**Many have said that introductory statistics
has problems and must be reformed.**

Bob Hogg

**"I'm tired of hearing about
problems in introductory statistics.**

**I know there are problems
with introductory statistics;
I defy anyone to identify
what is wrong and
what we must do to fix it."**

JSM-95 Orlando FL.

**The problem is that
introductory statistics is
"designed like a human anatomy course,
and not a human physiology course.**

**So much time is spent trying to get these
students to understand
where the basic organs are
in the Statistical body,
that they never get a chance to understand
how the organs function together
to maintain homeostasis."**

From "Testing basic statistical concepts." Posted to sci.stat.edu news-group on 2 June, 1997 by Robert Schilling, MPH at Loma Linda, CA. Email to rschill718@aol.com.

**Introductory statistics is
like micro-economics.**

**Lot's of detail!
Good solid conceptualization
at the detail level!**

**But no overarching integration...
No indication of how to use the tools
for broader ends...**

**We need a
macro component
in introductory statistics!**

M. Schield

**We must identify
the primary goal
of introductory statistics.**

Studying statistical inference

**is too abstract (pure probability)
and too limited (purely deductive)**

Studying data is a fair goal

**It emphasizes our subject as being real.
But it makes data our end rather than a means.**

Reducing variation is a better goal

**This emphasizes an intermediate goal;
but it makes this our ultimate end
rather than a means to that end.**

Studying statistics as evidence is the best goal.

**This specifies the ultimate goal of statistics
as being something that may be outside statistics.**

Evidential statistics

**uses traditional statistics as evidence
in arguments with non-statistical conclusions.**

Macro-Statistics	Evidential Statistics
Micro-Statistics	Inferential Statistics
	Descriptive Statistics
Theory / Basis	Probability

Evidential statistics

is macro-statistics:

**a mixture of traditional statistics
philosophy of science, and
critical thinking (inductive reasoning)**

Evidential statistics

**is the key to reforming
statistical education!**

ISSUES IN EVIDENTIAL STATISTICS

1.

The closer a quantile-normal plot is to a straight line, the more one is justified in concluding the sample came from a normal population.

2.

The smaller the p-value in a classical test of hypothesis, the more one is justified in rejecting the truth of the null.

3.

The greater the confidence level, the more one is justified in treating the parameter as being in that confidence interval.

ISSUES IN EVIDENTIAL STATISTICS

4.

**The greater the relation between 2 variables
the less one is justified in saying
the relation is due to chance.**

5.

**In an observational study, the longer a
relationship persist as we take into account
relevant potential confounders,
the more one is justified in saying that
the relationship is causal**

6.

**If the risk in group #2 is twice that in #1.
and if subject in group 2 moves to group 1,
they may (or may not) be justified in saying
they have cut their risk in half.**

Evidential statistics is concerned with **BIAS**

the most serious threat to the progress of science...comes from bias, not random variation

John Bailar, Chair, Board of Trustees NISS

[Amstat News, Nov., 1997 p. 5]

**What you take into account (control for)
can change both
the magnitude and the direction
of an association between two variables.**

**What a thing is determines
what it can do
(and what one should control for)**

Evidential statistics is concerned with
GRAMMAR AND MEANING

"The % of A who are B"
is not the same as "The % of B who are A"
but is the same as "The % of B among A".

"X times as much as"
is not the same as "X times more than"
but is the same as "X-1 times more than".

What is "most likely" (relative: highest rank)
can be "highly unlikely" (absolute: << 50%).

Evidential statistics is concerned with **STATEMENTS OF ASSOCIATION**

**The following are
descriptions (associations)
-- not inferences about causation.**

"A is linked to (related to) B"

"A is a factor in relation to B"

"B is determined by A"

"B is explained by A"

"There is more risk with B than with A"

"B is positively associated with A"

Evidential statistics is concerned with
ASSOCIATION versus CAUSATION
in observational studies.

**Assuming A and B are positively associated,
these are often taken as asserting causality.**

"As A is *increased*, B should increase",

"As A *increases*, B tends to increase"

"*Increasing* A should increase B".

"Subjects *with* more B will have more A"

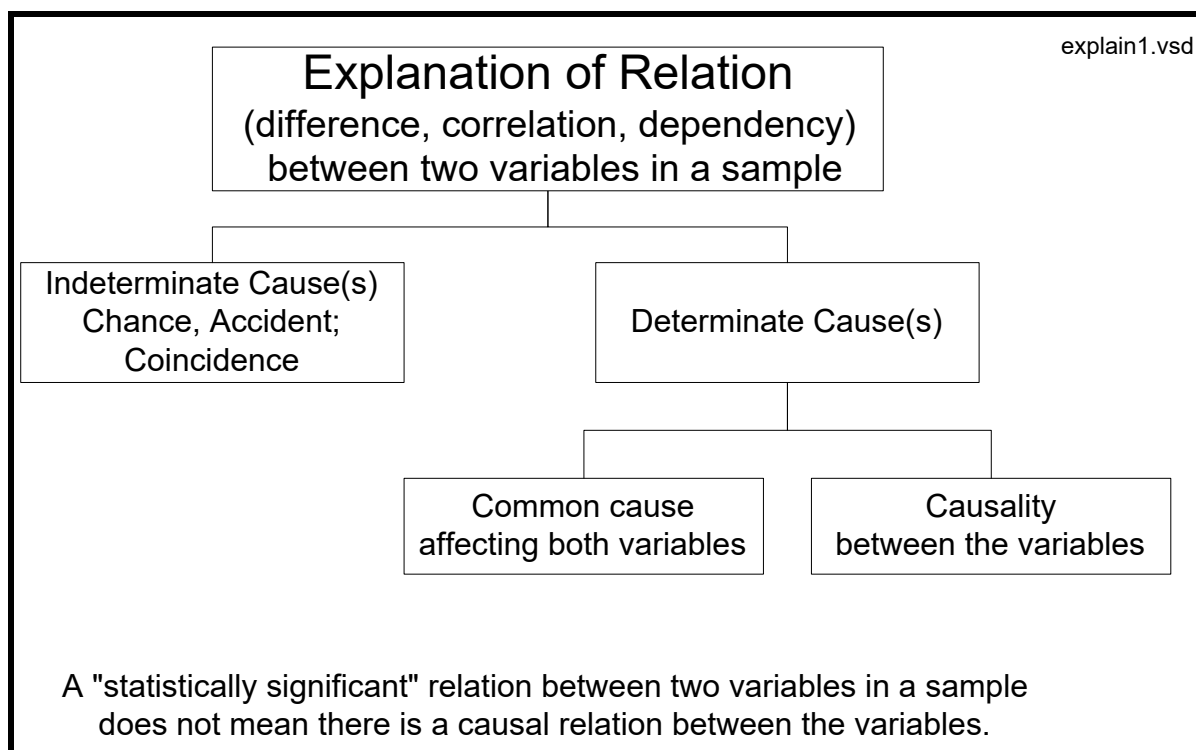
**Assuming A and B are positively associated,
the following is not justified:**

**"If you *increase* A within a subject,
you can expect to increase B in that subject."**

"*Attributable* to" is descriptive;

"attributed to" asserts causality.

Evidential statistics is concerned with **SUPPORTING CAUSAL EXPLANATIONS**



**Our goal is to help others use statistics
to identify determinate causes
and eliminate confounding factors.**

Evidential statistics is concerned with **SUPPORTING CAUSATION**

Step 1. Measure influence of chance.

Identify probability if due solely to chance.

Step 2: Eliminate chance as a cause

Since this is highly unlikely if due to chance,
this is highly unlikely to be due to chance.

Step 3: Eliminating confounding factors

[See section on BIAS]

IDENTIFY THE SOURCE OF THE DATA

In presenting regression and ANOVA,
we don't spend much time concerning the source
(experimental or observational)
since the source doesn't affect the statistics.
But the source affects the statistics as evidence!

**President David Moore wants statistics
to become a "Guide to Public Policy".**

To do this, we must offer Evidential Statistics

Many public policy issues involve statistics.

**Are airbags a safety hazard
for small women and children?**

Do car phones cause accidents?

What about The Bell Curve?

Remember:

**"Public policy is a series of uncontrolled,
[unrepeatable] experiments."**

David Pavelchek. JSM-95. Session 172. Orlando, FL

Florence Nightingale

the passionate statistician,
used statistics as evidence
to support her claim that
improved medical care would save lives.

Statistic #1

Crimea, 1859: For every soldier killed in battle,
seven died after the battle.

Statistic #2

The death rate for young soldiers in peacetime
was double that of the general population.

(Brown, 1988 *People Who Have Helped the World, Florence Nightingale*, p. 44)

Florence introduced many techniques designed to take into account (control for) confounding factors. She compared cases (soldiers in barracks) with civilian controls. She noted that mortality statistics should be age-specific and that crude death rates can be misleading.

Johnson & Kotz, 1997 *Leading Personalities in Statistical Sciences*. Wiley-Interscience

EVIDENTIAL STATISTICS

**Statistics began as the queen
of the social sciences.**

**It is time to reclaim
our heritage**

OBJECTIONS TO TEACHING EVIDENTIAL STATISTICS

- 1. Dilution of our strength**
 - a. Statistics is applied mathematics
 - b. Statistics is deductive.

- 2. Evidential statistics is discipline specific.**
 - a. Boundary crossing
 - b. Requires specific context of knowledge

- 3. Hubris: we can't teach everything at once.**
 - a. Teach philosophy of science
 - b. Teach critical thinking
 - c. Teach argumentation
 - d. Teach writing and speaking

Evidential statistics

Science of Method	METHOD OF REASONING	
Content	DEDUCTIVE	INDUCTIVE
WORDS/quality	Logic	Critical Thinking
NUMBERS/quantity	Mathematics/	Statistics

**tougher to teach,
but
more satisfying
because it is more
valuable to students.**

EVIDENTIAL STATISTICS

REWARDS OF TEACHING

**It is good when your best students say,
"I'm seeing statistical inferences in the news"**

**It is better when your good students say,
"I'm more skeptical about statistics now."**

**It is best when your average students say,
"Now I can tell the difference between
statistics as facts , statistics as conclusions,
and statistics as evidence**

**It is pure gold when your poor students say,
"I'm learned more about thinking
in this class than I ever dreamed possible.
Thanks!"**

**Studying statistics
is like studying
Accounting 1 (Bookkeeping)
without studying
Accounting 2 (Financial statements)**

**Studying statistics is like
learning how to ice skate,
when what you really wanted to learn
was how to play hockey.**

**Studying statistics is like
going food shopping
when what you really wanted to learn
was how to do French cooking**

KEY QUESTIONS

**Why do other disciplines require
a course in statistics for their majors?**

THOUGHT FOR THE DAY

**What would happen
to statistics teachers
if statistics
was not
a required course?**

Evidential statistics is concerned with INADEQUATE EXPLANATIONS

1. Non-material

- a. Simply restates the relationship**
- b. Gives just a formal 'explanation'**
- c. Explains as due to chance**

2. Explain too little

- a. Doesn't explain at all**
- b. Can't explain change without using change**
- c. Explains just a part**

3. Explain only weakly

- a. Ambiguous or incomplete**
- b. Lacking in evidence for truth**
- c. No way to test**

4. Explain too much

- a. Makes unverified predictions**
- b. Too ad hoc (too much of a 'cludge')**
- c. Contradicts data**