

# METHOD, NOT METHODS

## TEACHING A THEORY OF APPLIED STATISTICS

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(AND JOCK MACKAY)

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UNIVERSITY OF WATERLOO

UNIVERSITY OF WESTERN ONTARIO  
FEBRUARY 21, 2008

# OUTLINE

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- CAN YOU PASS STAT 231?
- WHAT'S NEW?
- WHAT HAPPENED?



COULD YOU PASS STAT 231?

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Name: \_\_\_\_\_

I.D. #: \_\_\_\_\_

# COULD YOU PASS STAT 231?

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University of Waterloo

**STATISTICS 231**

**Final Examination**

Wednesday April 10, 2002.

7 - 10 PM

Instructor (check one)

M. Zhu (8:30 - 10:30)

W. H. Cherry (10:30 - 12:30)

R.W. Oldford (12:30 - 2:30)

C. C. Springer (2:30 - 4:30)

Time: 3 hours

## Instructions

1. Calculators and dictionaries **are** permitted (subject to inspection). Probability tables are provided separately. There are 13 pages including this one.
2. Answer:
  - in the space provided. Use the back of the preceding page if necessary. No extra paper is necessary.
  - in the language of the course. **Be precise and clear.**
  - There is one idea or point you should make for each mark. Part marks will be available.
3. Context:
  - There are two: Airbags (questions 1 to 3; pp. 2 to 9) and Stock prices (quest. 4 and 5; pp. 10 to 13).
  - Background material is distinguished by a different font.
  - Numbered questions have essentially independent contexts. Relevant context appears on the first page associated with each numbered question (you might want to turn the top corner of each relevant page). Question 4 (pages 10-11) can be answered without reference to the context. Question 5 uses the context (and mathematical results) of Question 4.



# WHAT'S NEW?

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- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND PROACTIVE
- ...

# CONTEXT

---

## WHY?

- MOTIVATE STATISTICAL METHOD
- BE INTERESTING ACROSS A BROAD RANGE
- UNDERLINE THE IMPORTANCE
- BE RELEVANT

## WHAT'S NEW?

- CONTEXT**
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# CONTEXT

---

## HOW?

- FULL STORY ...
- PERSONAL CONSULTING/COLLABORATIVE EXPERIENCE ...
- PHYSICAL LABORATORIES
- MEDIA FOR TOPIC, NOT FOR INFORMATION
- OMNIPRESENT IN THE COURSE ...

## WHAT'S NEW?

- CONTEXT**
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# CONTEXT

---

## RESULT?

- HELPED DETERMINE THE QUESTION, THE MODEL, ...
- ESTIMATE/CONFIDENCE INTERVAL NOT THE ANSWER ...
- MEASUREMENT SYSTEMS ARE IMPORTANT
- DEEPER UNDERSTANDING OF THE INFERENCE
- MEDIA FOR TOPIC, NOT FOR INFORMATION

## WHAT'S NEW?

- CONTEXT**
- LANGUAGE
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- POSITIVE AND



# LANGUAGE

---

# LANGUAGE

As I expect you know, up to well within the last 15 years writers on statistics were accustomed to be extremely careless in confusing that which is estimated with our estimate of it. The same terms and the same symbols were used for both without distinction. In 1921, in a paper of the *Phil. Trans.* [CP 18], aimed at clarifying some of the contradictions and paradoxes of the subject, I introduced two new terms, intended to be antithetical, namely, 'parameter', used to specify the parent population, and 'statistic', calculated from the observed sample. I was quite deliberate in choosing unlike words for these ideas which it was important to distinguish as clearly as possible. That work has now been largely done, so far as concerns the better writers on the

NEW?

EXT

LANGUAGE

TION

ATION, ...

PPDAC

POSITIVE AND



# LANGUAGE

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- EMPIRICAL PROBLEM SOLVING, ESTIMATE VERSUS ESTIMATOR, STUDY AND TARGET POPULATIONS, VARIATES, ATTRIBUTES (NUMERICAL, GRAPHICAL, FUNCTIONAL, ...), FOCAL VARIATES, LIMITATIONS, ERROR, BIAS, FISHBONE DIAGRAM, GAUGE, OPERATOR, METHOD, MEASUREMENT SYSTEM, PROTOCOLS, CAUSATIVE ASPECT, PPDAC, OBSERVATIONAL VERSUS EXPERIMENTAL, CONFOUNDING, BLOCKING, REPLICATION, . . .

## WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# LANGUAGE

---

EMPIRICAL PROBLEM SOLVING, ESTIMATE VERSUS ESTIMATOR, STUDY AND TARGET POPULATIONS, VARIATES, ATTRIBUTES (NUMERICAL, GRAPHICAL, FUNCTIONAL, ...), FOCAL VARIATES, LIMITATIONS, ERROR, BIAS, FISHBONE DIAGRAM, GAUGE, OPERATOR, METHOD, MEASUREMENT SYSTEM, PROTOCOLS, CAUSATIVE ASPECT, PPDAC, OBSERVATIONAL VERSUS EXPERIMENTAL, CONFOUNDING, BLOCKING, REPLICATION, . . .

NEW LANGUAGE NECESSARY

NEEDED FOR PRECISION

GLOSSARY NEEDED

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# INDUCTIVE INFERENCE

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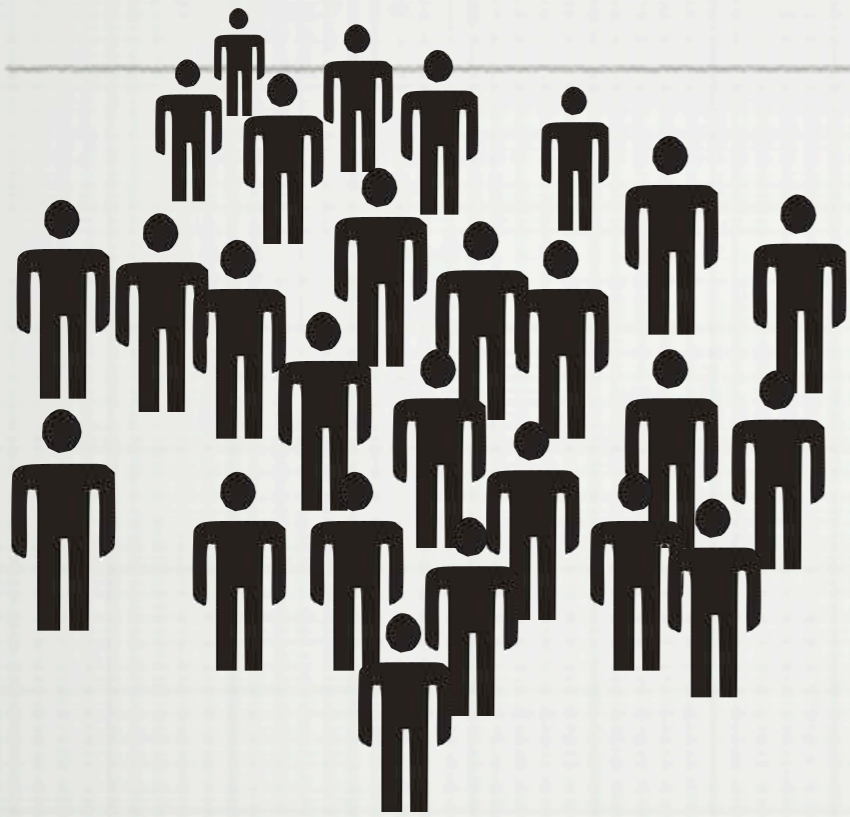
TARGET  
POPULATION

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# INDUCTIVE INFERENCE

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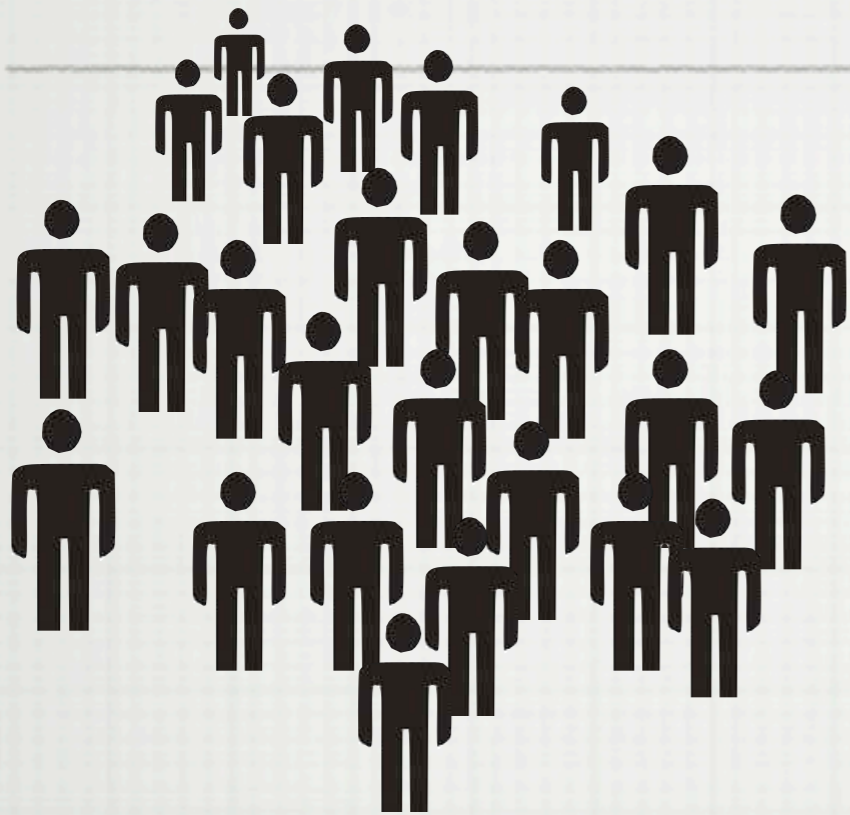
WHAT'S NEW?

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- CAUSATION, ...
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# INDUCTIVE INFERENCE

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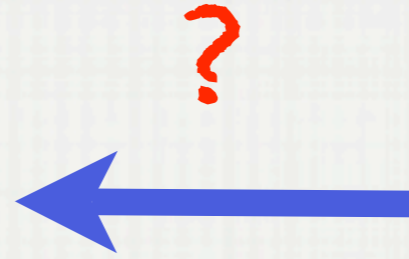
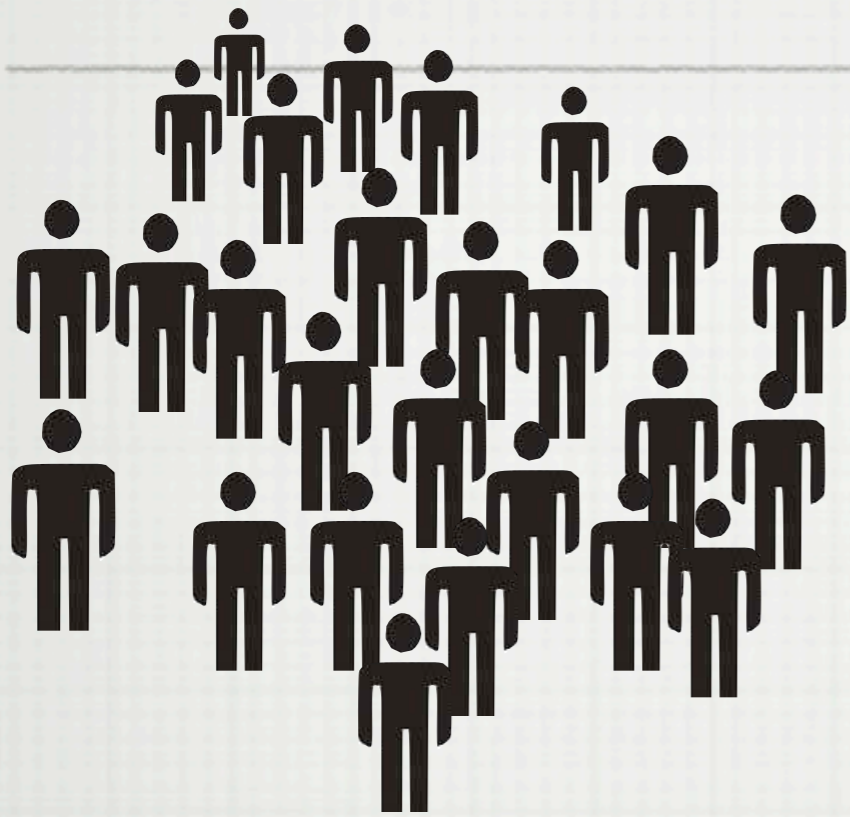


WHAT'S NEW?

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- CAUSATION, ...
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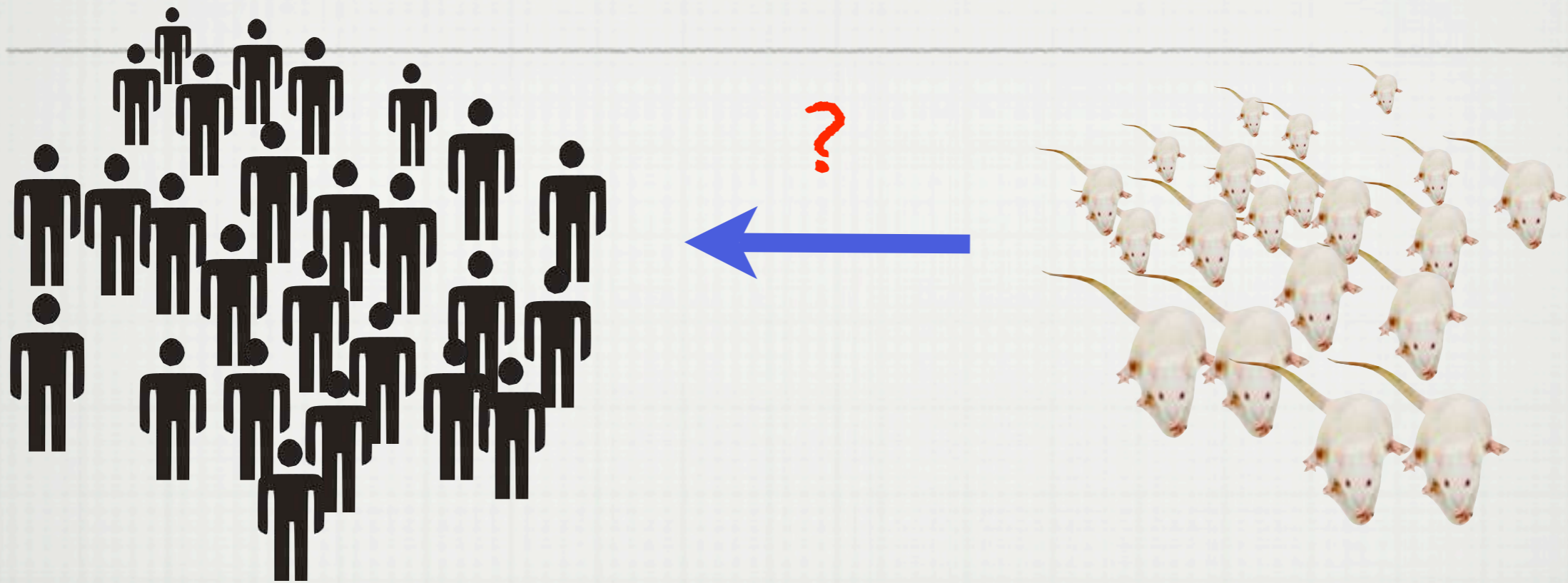


WHAT'S NEW?

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# INDUCTIVE INFERENCE

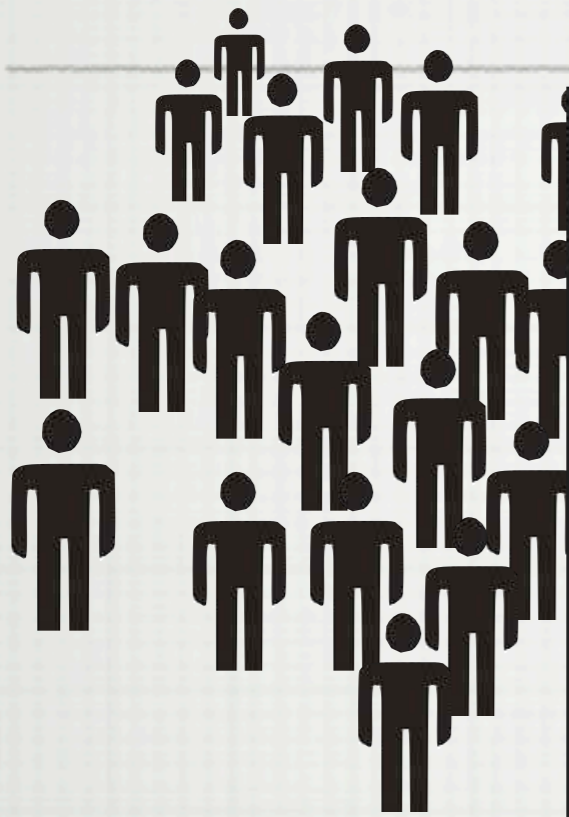


WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION**
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# INDUCTIVE INFERENCE



How do you expect to have a good army?  
You have only rats in the ranks!...

WHAT'S NEW?

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# INDUCTIVE INFERENCE



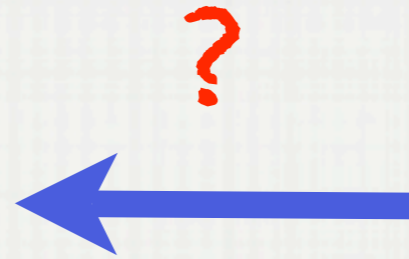
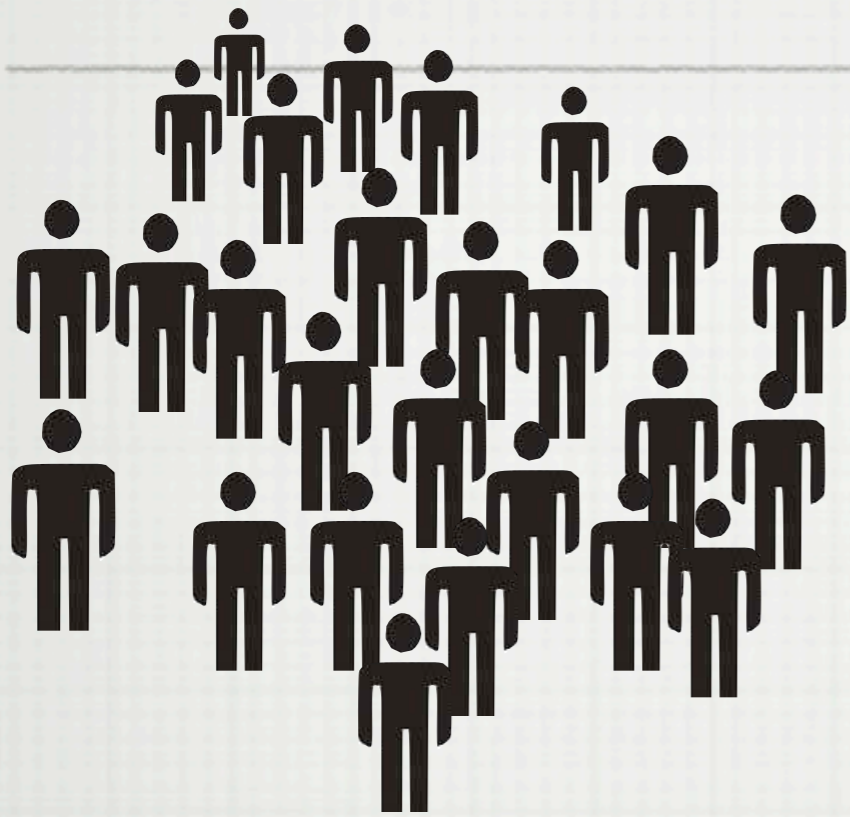
"The research proves tall rats are more confident than short rats. At least I think it does. I've never been good at this."

WHAT'S NEW?

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# INDUCTIVE INFERENCE

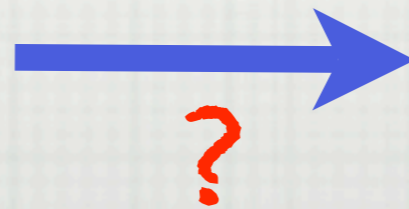
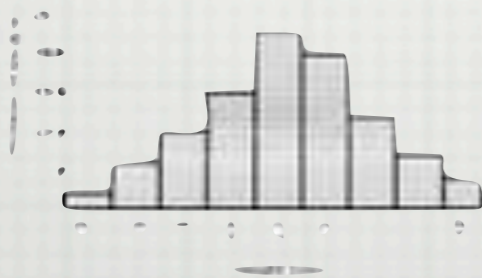
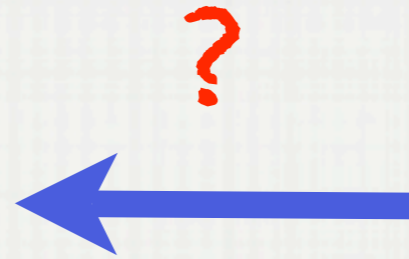
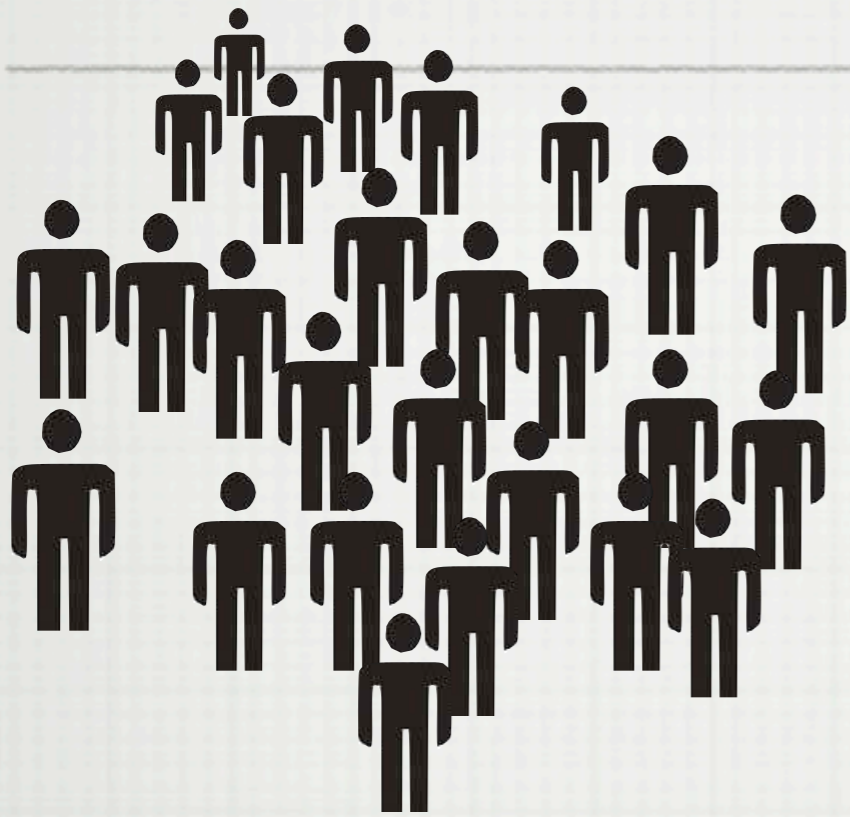


WHAT'S NEW?

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# INDUCTIVE INFERENCE

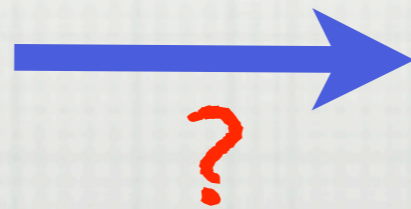
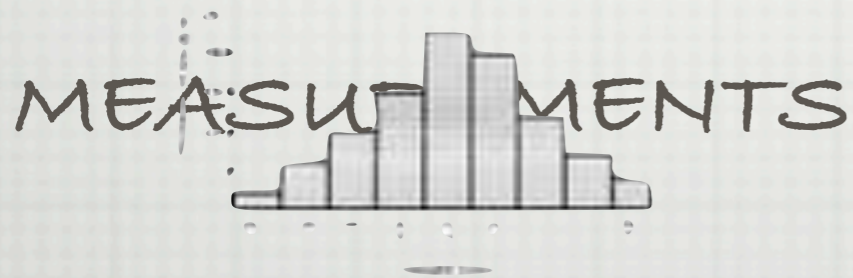
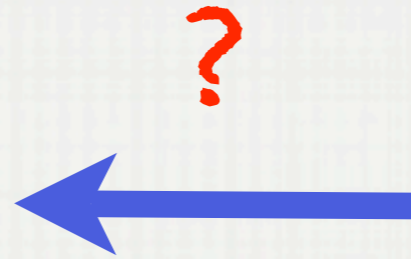
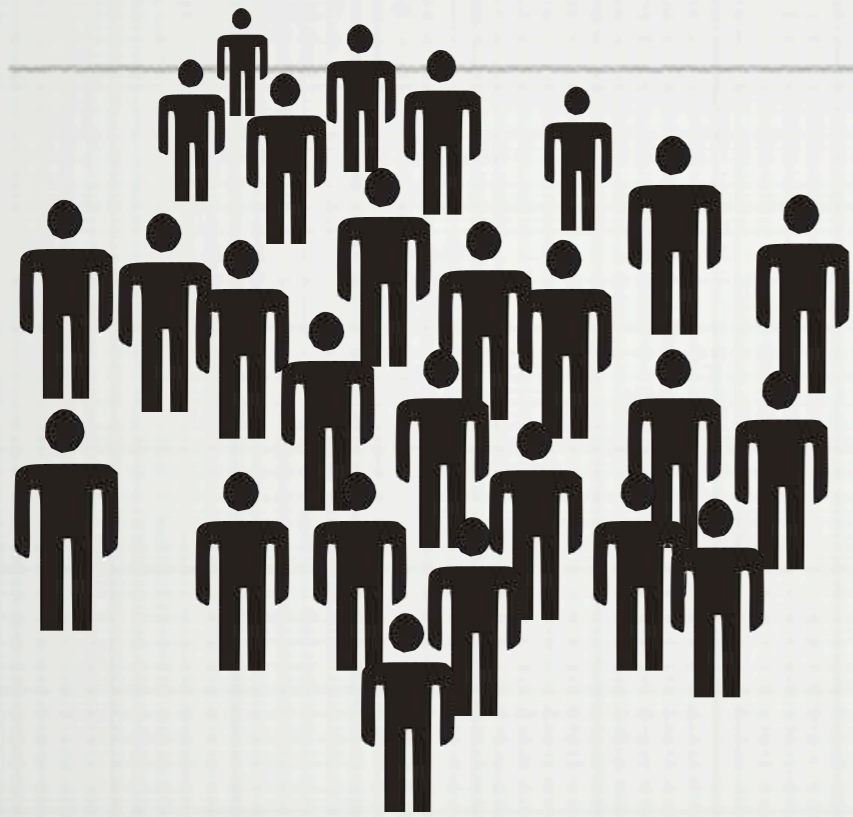


WHAT'S NEW?

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- PPDAC
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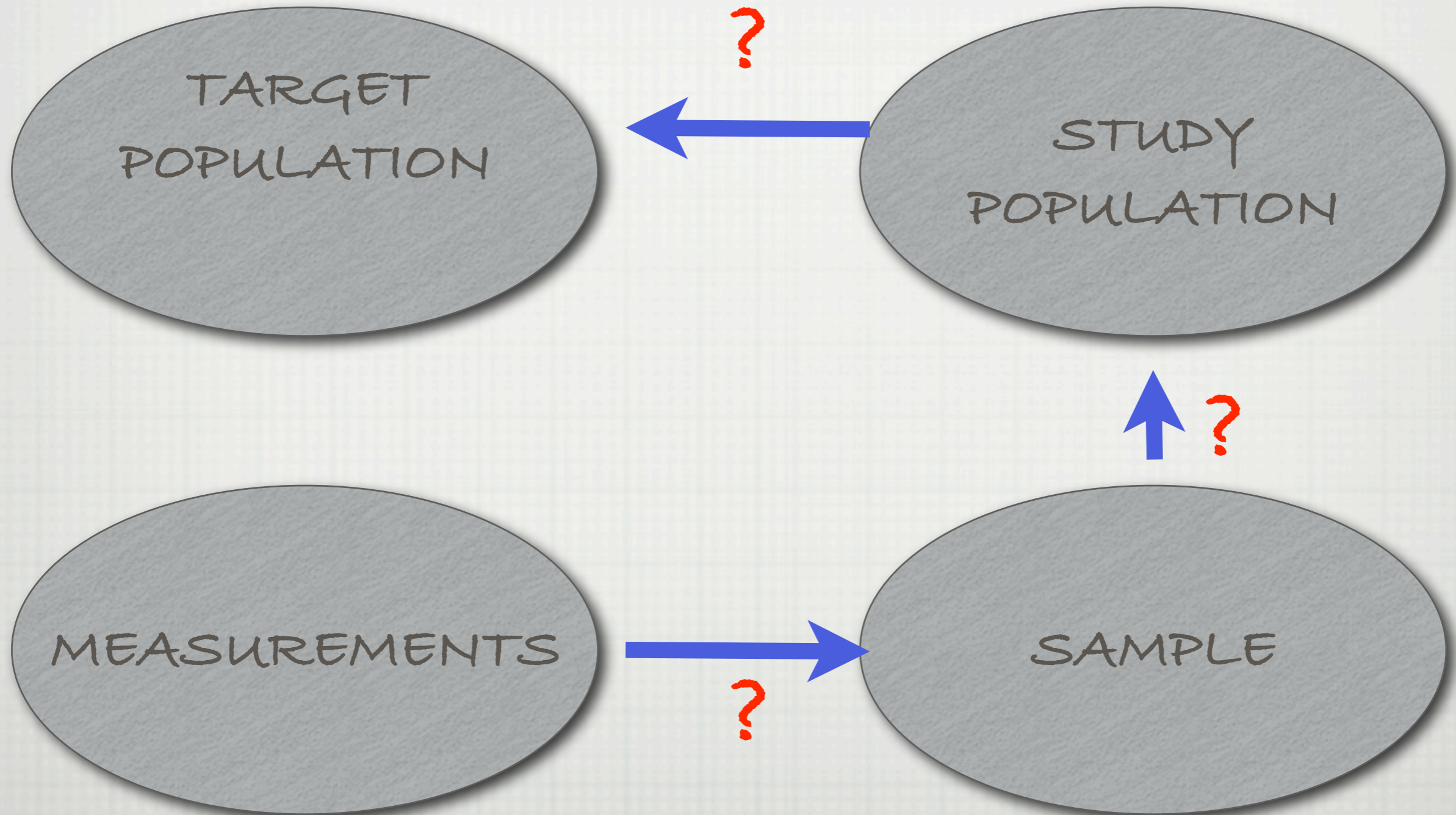
# INDUCTIVE INFERENCE





# INDUCTIVE INFERENCE

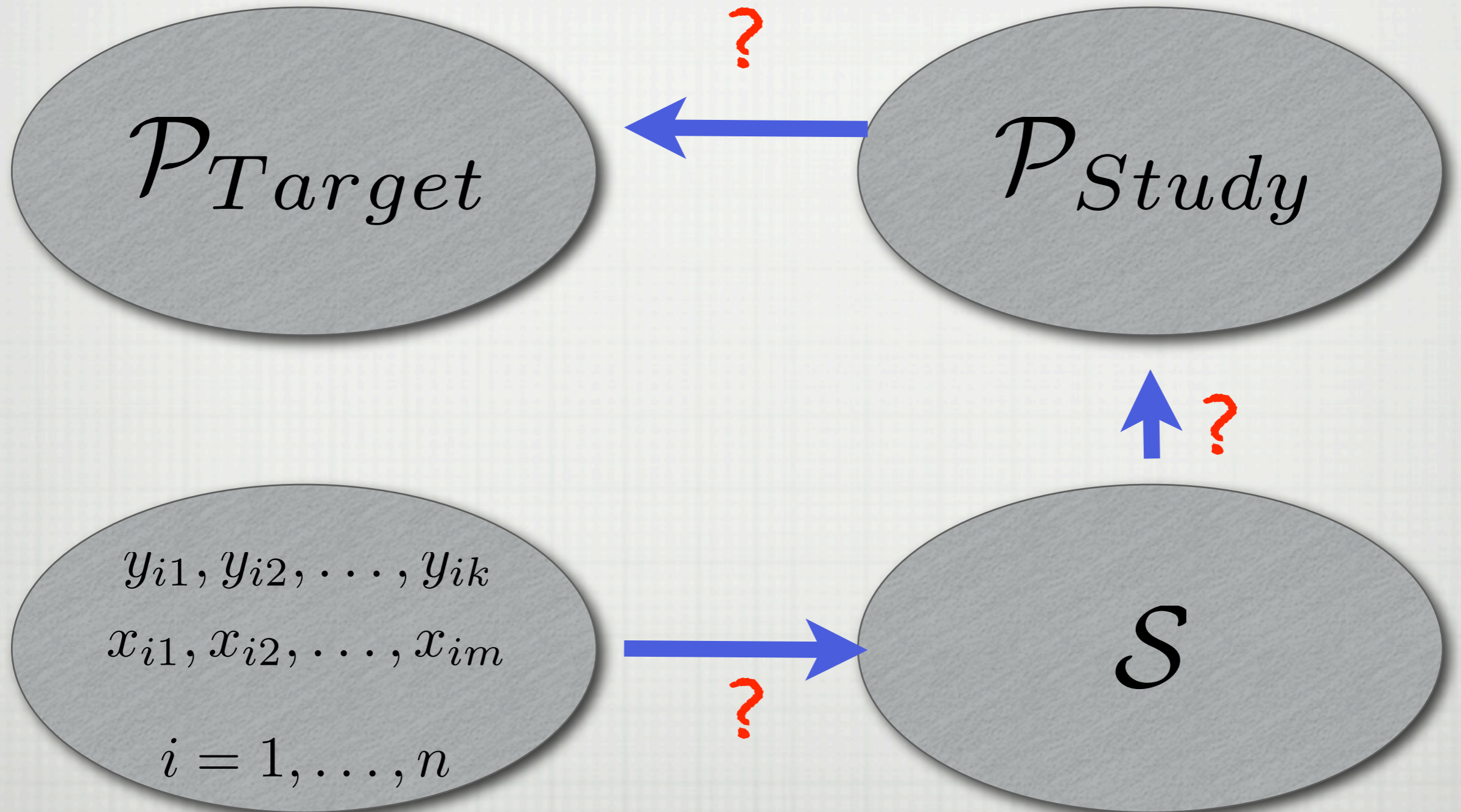
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# INDUCTIVE INFERENCE

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# ATTRIBUTES

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$a(\mathcal{P}_{Target})$

$a(\mathcal{P}_{Study})$

$a(\mathcal{S})$

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# ATTRIBUTES

---

$$a(\mathcal{P}_{Target}) \quad Ave_{\mathcal{P}_{Target}}(Y)$$

$$a(\mathcal{P}_{Study}) \quad Ave_{\mathcal{P}_{Study}}(Y)$$

$$a(\mathcal{S}) \quad Ave_{\mathcal{S}}(Y)$$

WHAT'S NEW?

- CONTEXT
- LANGUAGE
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# ATTRIBUTES

---

$$a(\mathcal{P}_{Target}) \quad MAD_{\mathcal{P}_{Target}}(Y)$$

$$a(\mathcal{P}_{Study}) \quad MAD_{\mathcal{P}_{Study}}(Y)$$

$$a(\mathcal{S}) \quad MAD_{\mathcal{S}}(Y)$$

WHAT'S NEW?

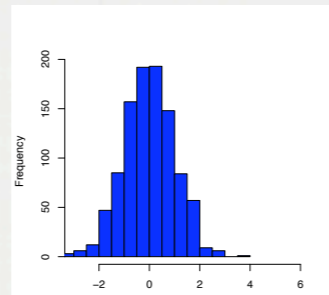
- CONTEXT
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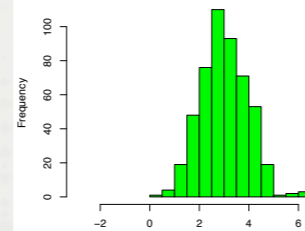
# ATTRIBUTES

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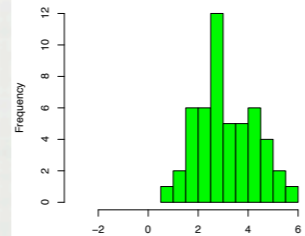
$a(\mathcal{P}_{Target})$



$a(\mathcal{P}_{Study})$



$a(\mathcal{S})$



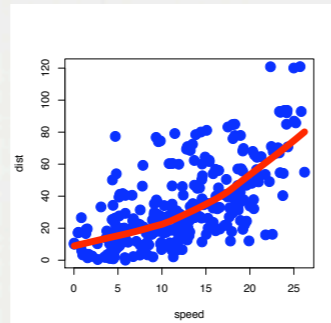
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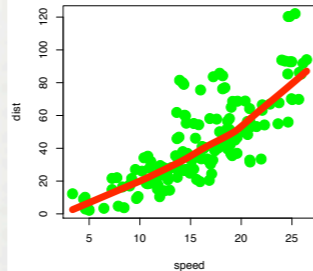


# ATTRIBUTES

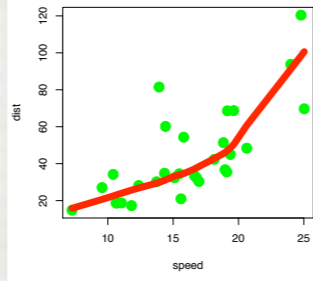
$a(\mathcal{P}_{Target})$



$a(\mathcal{P}_{Study})$



$a(\mathcal{S})$



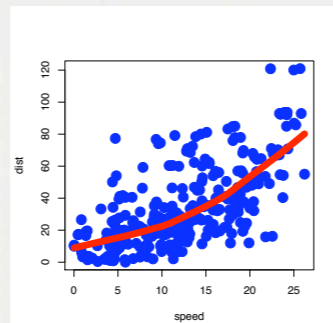
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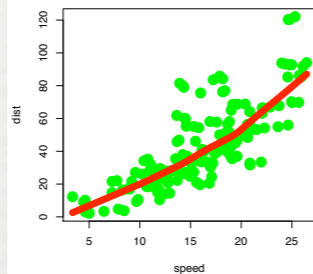


# ATTRIBUTES

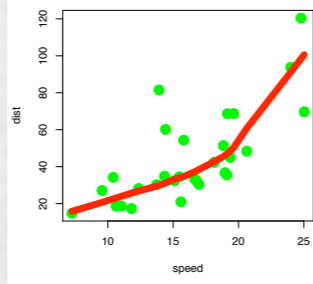
$$a(\mathcal{P}_{Target})$$



$$a(\mathcal{P}_{Study})$$



$$a(\mathcal{S})$$



STUDY ERROR

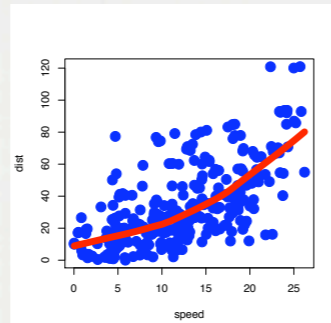
$$a(\mathcal{P}_{Study}) - a(\mathcal{P}_{Target})$$

WHAT'S NEW?

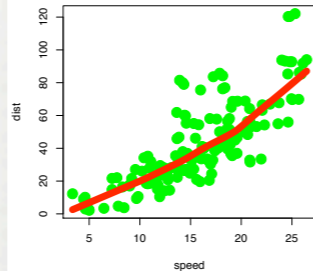
- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# ATTRIBUTES

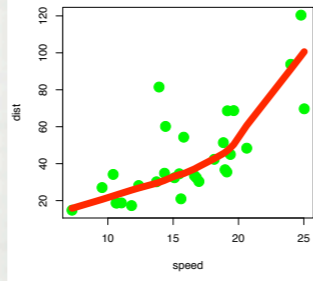
$$a(\mathcal{P}_{Target})$$



$$a(\mathcal{P}_{Study})$$



$$a(\mathcal{S})$$



STUDY ERROR

$$a(\mathcal{P}_{Study}) - a(\mathcal{P}_{Target})$$

SAMPLE ERROR

$$a(\mathcal{S}) - a(\mathcal{P}_{Study})$$

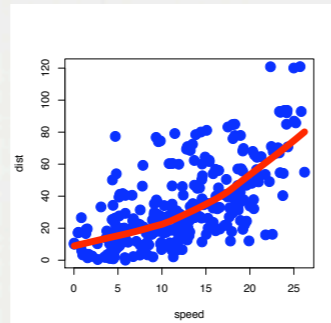
WHAT'S NEW?

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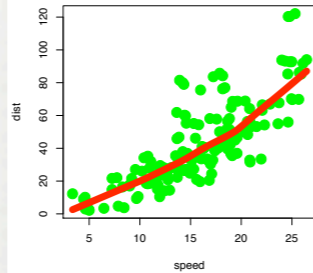
# ATTRIBUTES

$a(\mathcal{P}_{Target})$



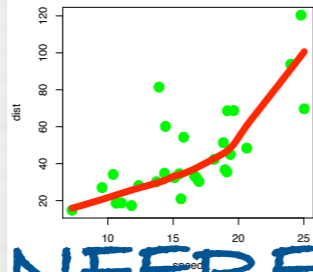
STUDY ERROR  
 $a(\mathcal{P}_{Study}) - a(\mathcal{P}_{Target})$

$a(\mathcal{P}_{Study})$



SAMPLE ERROR  
 $a(\mathcal{S}) - a(\mathcal{P}_{Study})$

$a(\mathcal{S})$



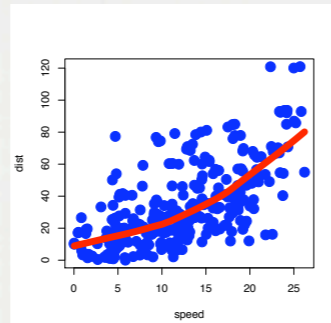
STATISTICAL INFERENCE

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# ATTRIBUTES

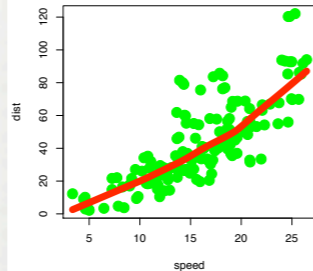
$$a(\mathcal{P}_{Target})$$



STUDY ERROR

$$a(\mathcal{P}_{Study}) - a(\mathcal{P}_{Target})$$

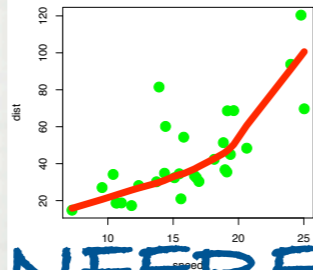
$$a(\mathcal{P}_{Study})$$



SAMPLE ERROR

$$a(\mathcal{S}) - a(\mathcal{P}_{Study})$$

$$a(\mathcal{S})$$



STATISTICAL INFERENCE

$$a(\mathcal{S}_1) a(\mathcal{S}_2) a(\mathcal{S}_3) \cdot \cdot \cdot a(\mathcal{S}_K)$$

$$p_1 \quad p_2 \quad p_3 \quad \cdot \cdot \cdot \quad p_k$$

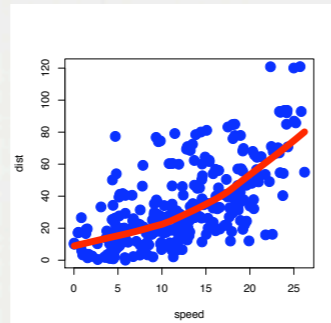
WHAT'S NEW?

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# ATTRIBUTES

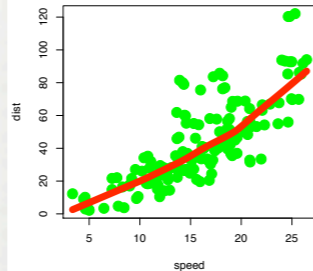
$$a(\mathcal{P}_{Target})$$



STUDY ERROR

$$a(\mathcal{P}_{Study}) - a(\mathcal{P}_{Target})$$

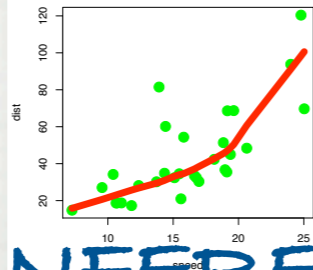
$$a(\mathcal{P}_{Study})$$



SAMPLE ERROR

$$a(\mathcal{S}) - a(\mathcal{P}_{Study})$$

$$a(\mathcal{S})$$



STATISTICAL INFERENCE

SAMPLING

$$a(\mathcal{S}_1) a(\mathcal{S}_2) a(\mathcal{S}_3) \cdot \cdot \cdot a(\mathcal{S}_K)$$

$$p_1 \quad p_2 \quad p_3 \quad \cdot \cdot \cdot \quad p_k$$

$$E(a(\mathcal{S})) - a(\mathcal{P}_{Study})$$

$$SD(a(\mathcal{S}))$$

- VIRTUALLY NEW
- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

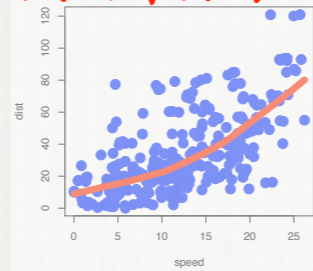


# ATTRIBUTES

ALL OF OUR MODELS ARE UNDERSTOOD

WITHIN THIS FRAMEWORK

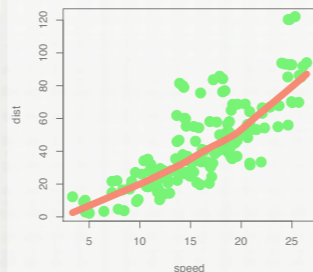
$$a(\mathcal{P}_{Target})$$



STUDY ERROR

$$a(\mathcal{P}_{Study}) - a(\mathcal{P}_{Target})$$

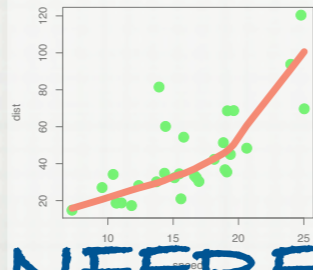
$$a(\mathcal{P}_{Study})$$



SAMPLE ERROR

$$a(\mathcal{S}) - a(\mathcal{P}_{Study})$$

$$a(\mathcal{S})$$



STATISTICAL INFERENCE

SAMPLING

$$a(\mathcal{S}_1) a(\mathcal{S}_2) a(\mathcal{S}_3) \cdot \cdot \cdot a(\mathcal{S}_K)$$

$$E(a(\mathcal{S})) - a(\mathcal{P}_{Study})$$

$$p_1 \quad p_2 \quad p_3 \quad \cdot \cdot \cdot \quad p_k$$

$$SD(a(\mathcal{S}))$$

- VIRTUALLY NEW
- CONTEXT
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# CAUSATION

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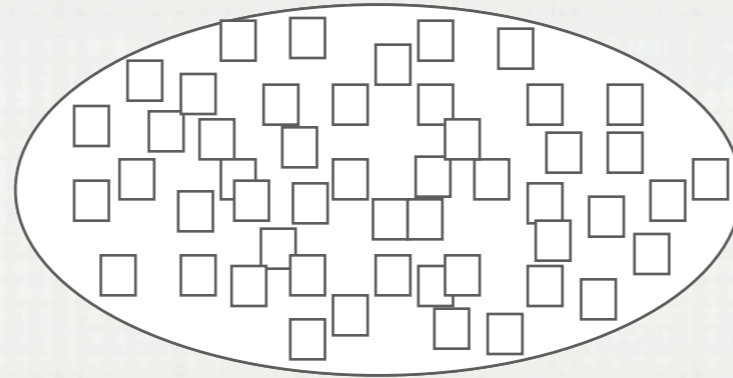
- IMPORTANT, COMMON
- UNCLEAR, TYPICALLY GIVEN LIP-SERVICE, UNDEFINED ...
- NEED A WORKING DEFINITION

## WHAT'S NEW?

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# CAUSATION

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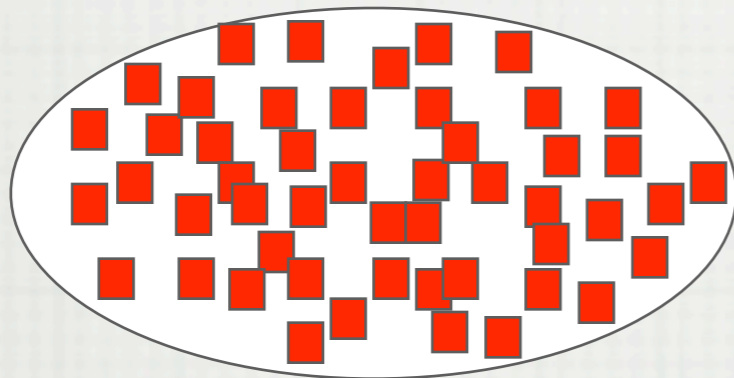
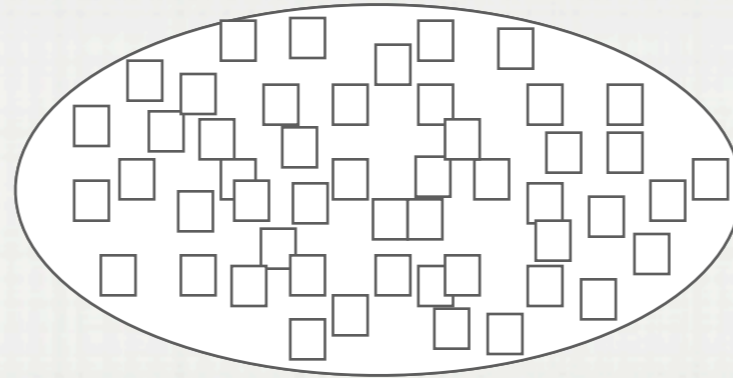
- CONTEXT
- LANGUAGE
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# CAUSATION

---

SET X VALUES

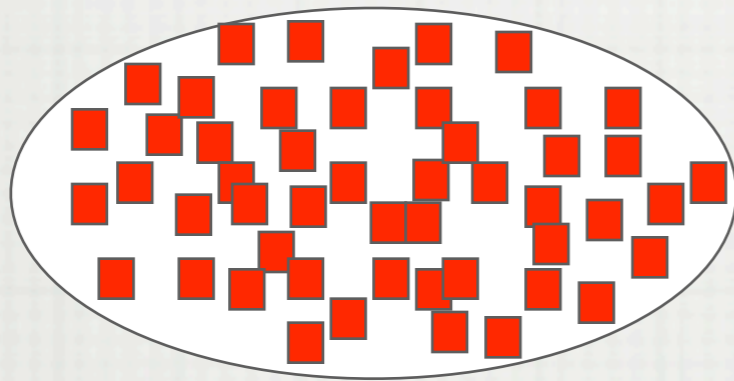
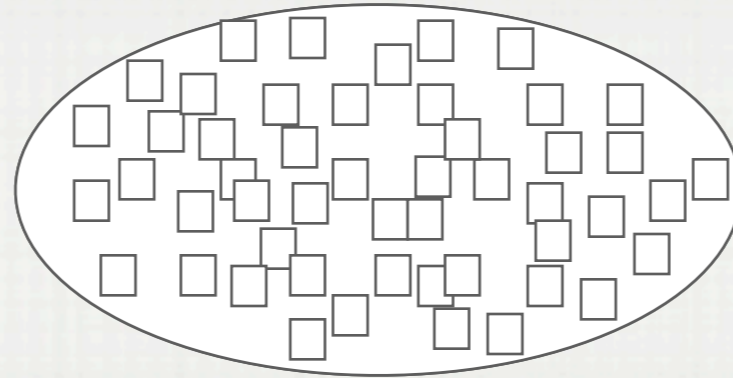


- CONTEXT
- LANGUAGE
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# CAUSATION

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SET X VALUES



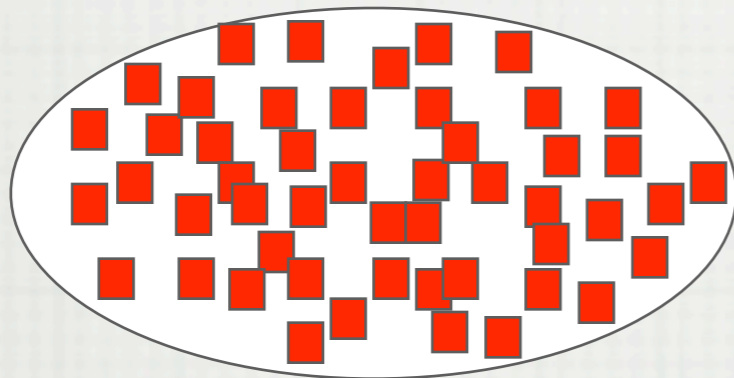
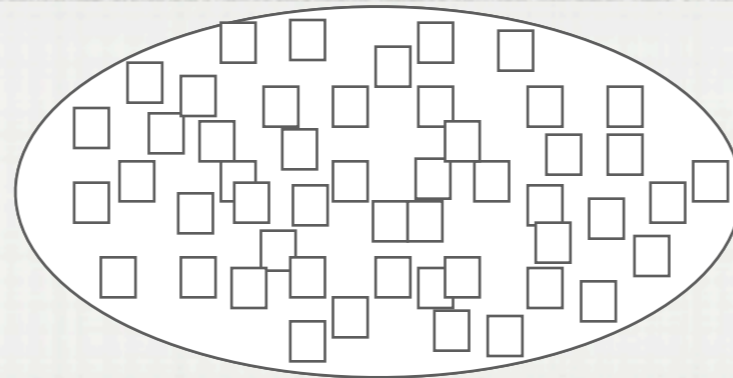
$$a(\mathcal{P} \mid x \leftarrow \text{"red"})$$

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

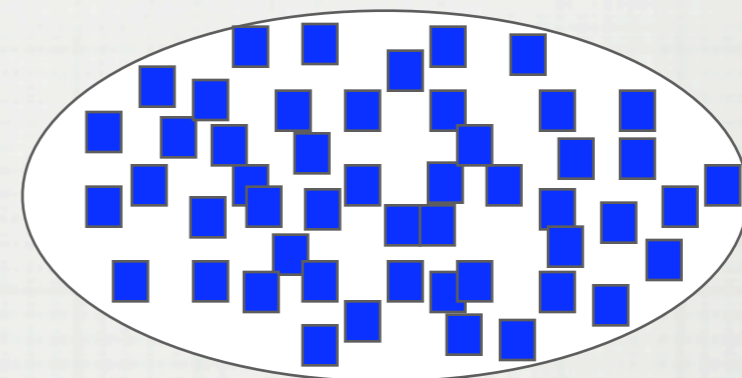


# CAUSATION

SET X VALUES



$$a(\mathcal{P} \mid x \leftarrow \text{"red"})$$

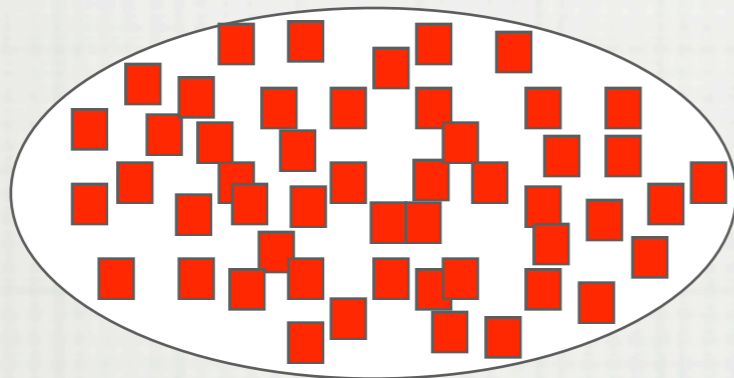
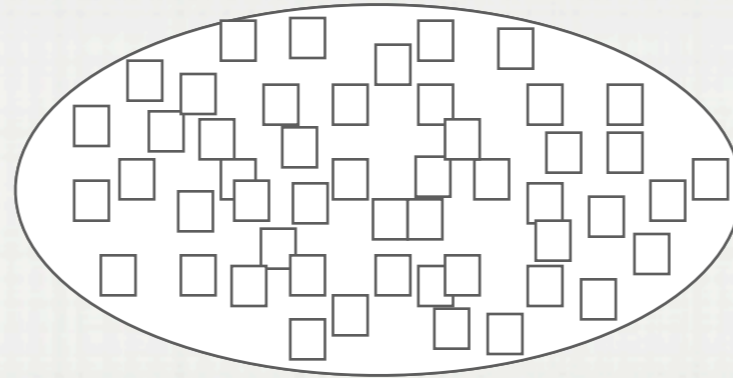


$$a(\mathcal{P} \mid x \leftarrow \text{"blue"})$$

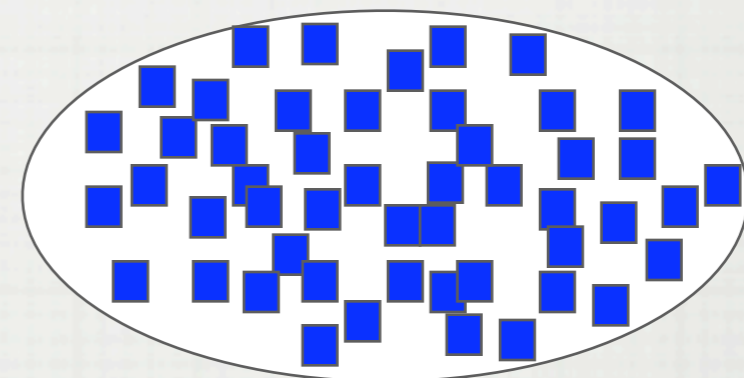
- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# CAUSATION

SET X VALUES



$$a(\mathcal{P} \mid x \leftarrow \text{"red"})$$



$$a(\mathcal{P} \mid x \leftarrow \text{"blue"})$$

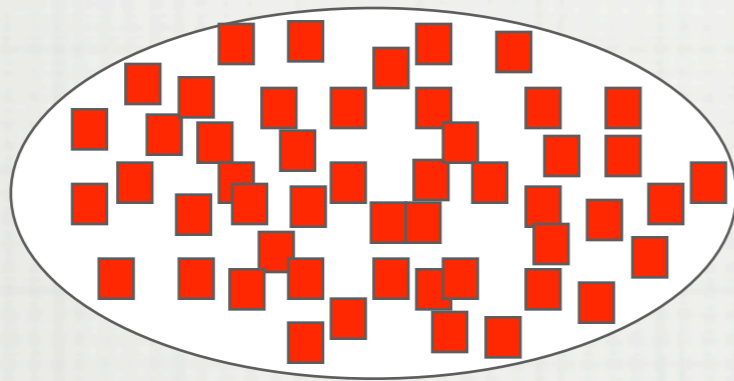
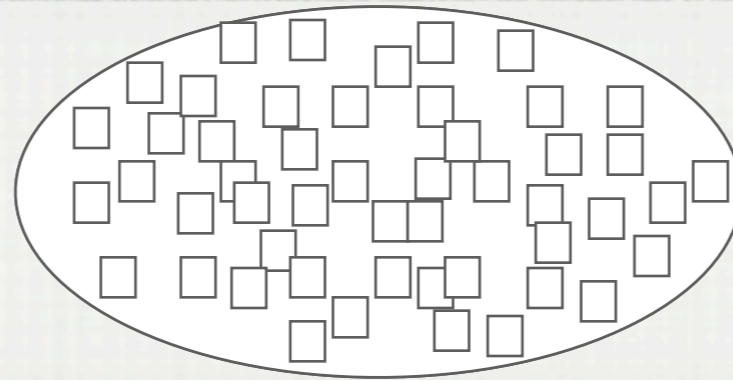
$$\Delta x \implies a(\mathcal{P} \mid \text{"red"}) \neq a(\mathcal{P} \mid \text{"blue"})$$

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

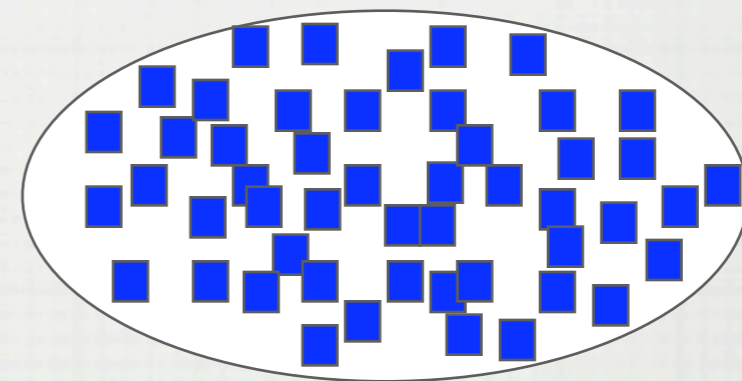


# CAUSATION

SET X VALUES



$$a(\mathcal{P} \mid x \leftarrow \text{"red"})$$



$$a(\mathcal{P} \mid x \leftarrow \text{"blue"})$$

$$\Delta x \implies \Delta a(\mathcal{P})$$

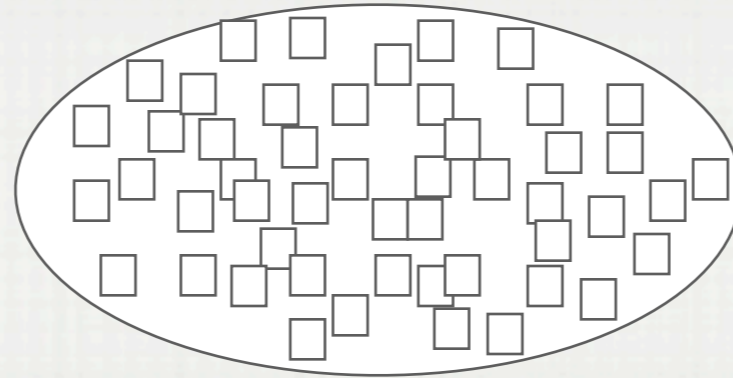
WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# CAUSATION

---

$\mathcal{P}$



WHAT'S NEW?

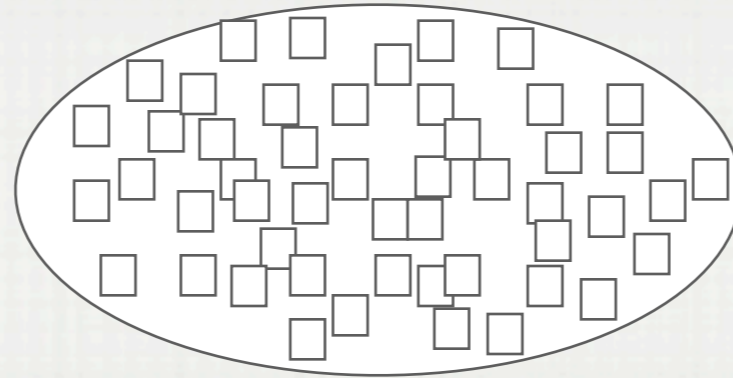
- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



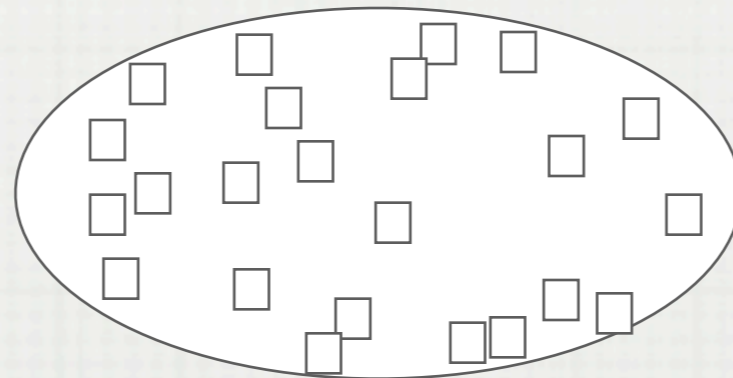
# CAUSATION

---

$\mathcal{P}$



$\mathcal{S}$



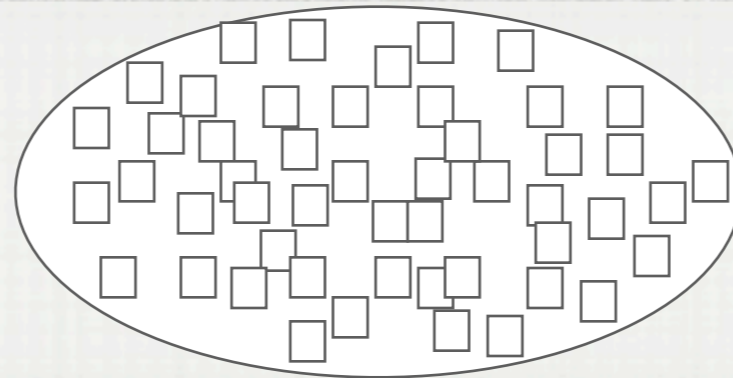
WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

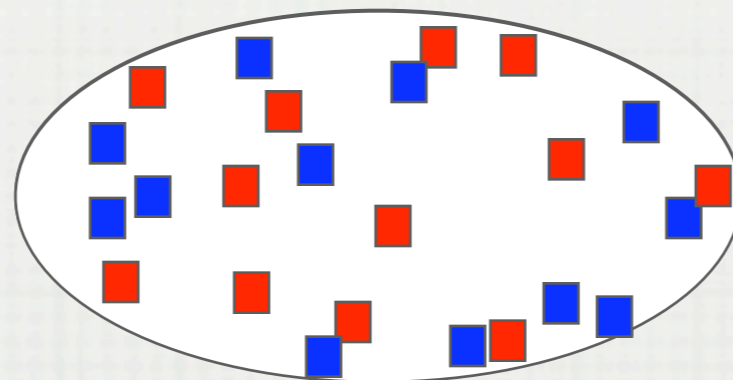
# CAUSATION

---

$\mathcal{P}$



$\mathcal{S}$



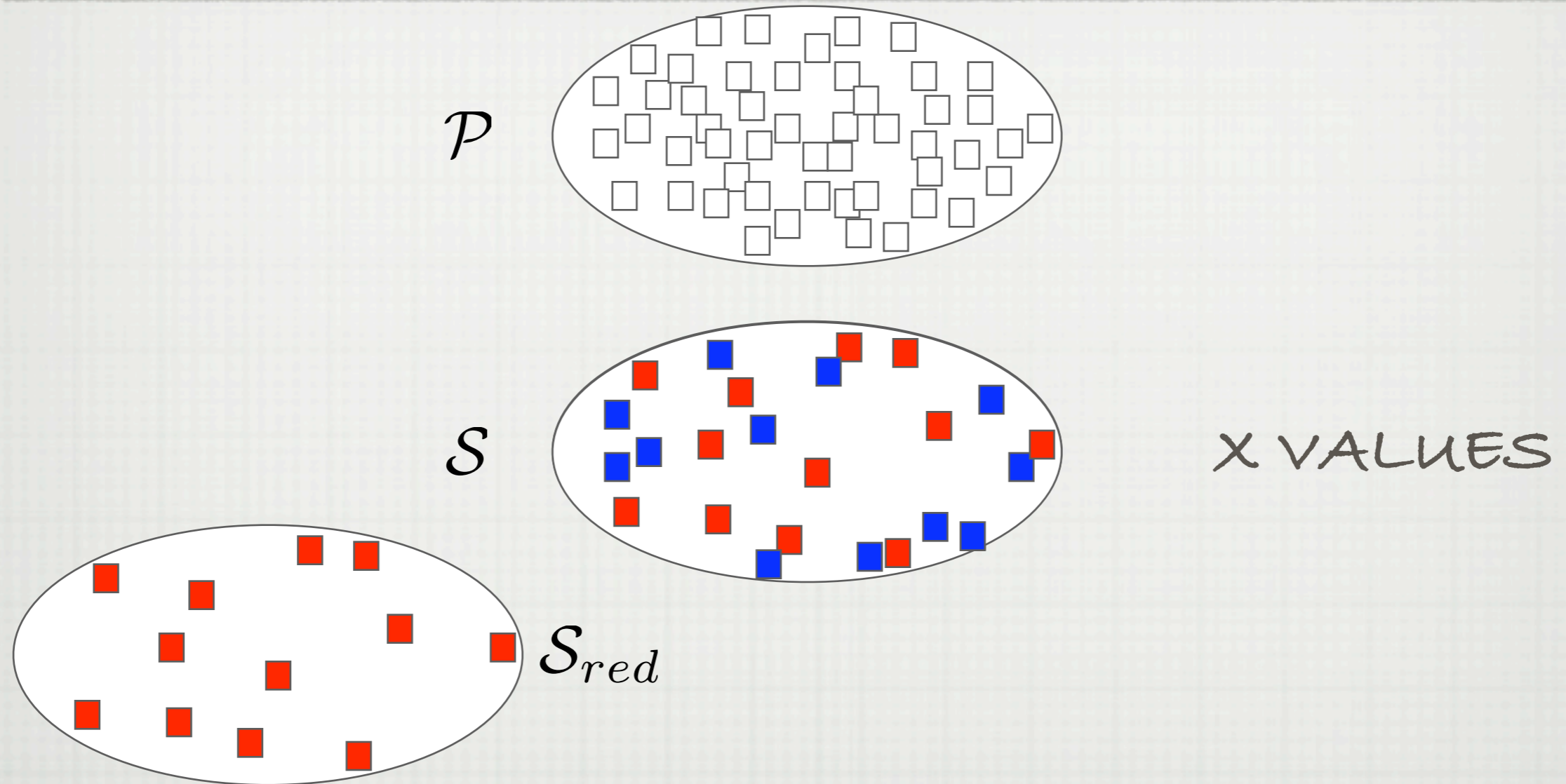
X VALUES

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# CAUSATION

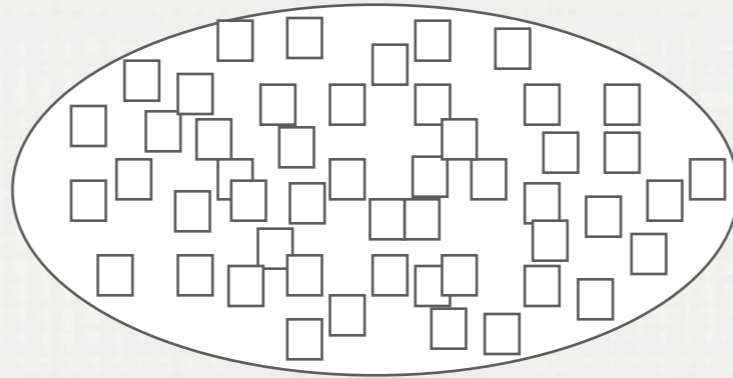


WHAT'S NEW?

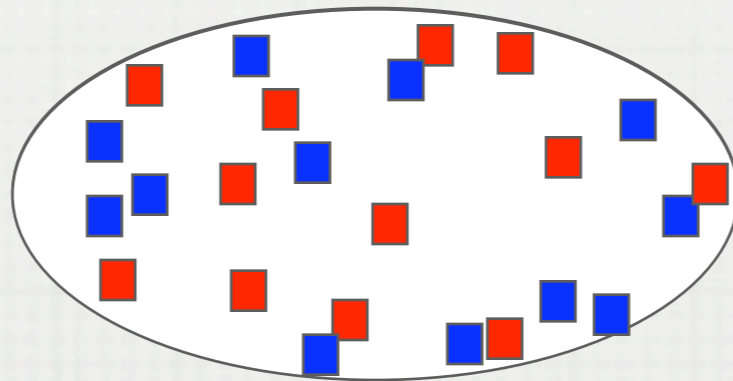
- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# CAUSATION

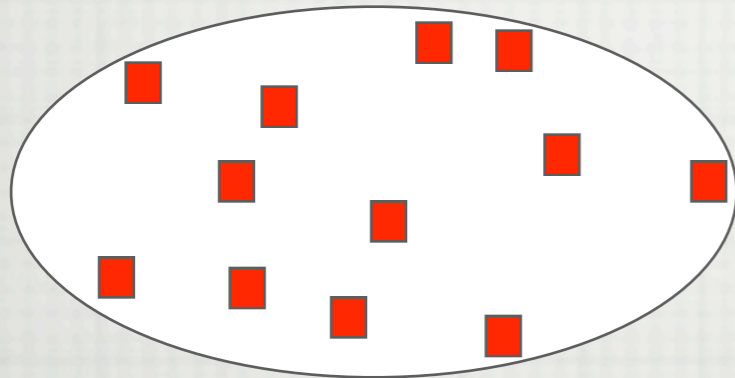
$\mathcal{P}$



$\mathcal{S}$

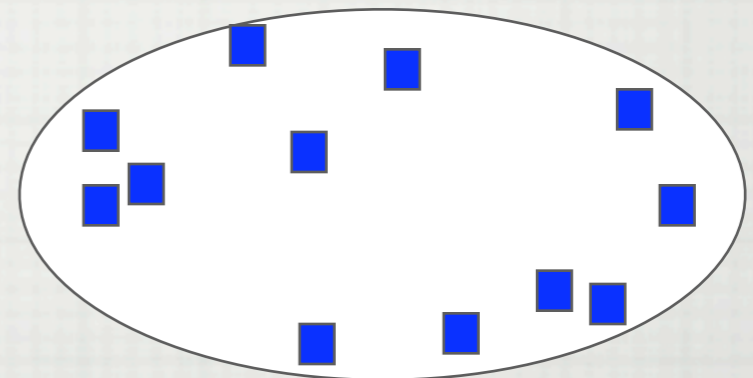


X VALUES



$S_{red}$

$S_{blue}$



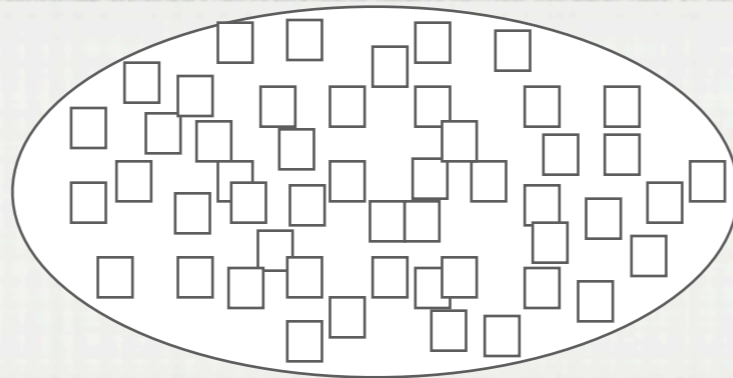
WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

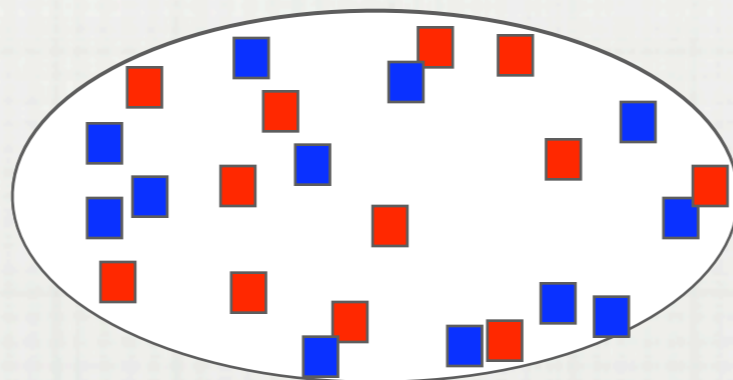


# CAUSATION

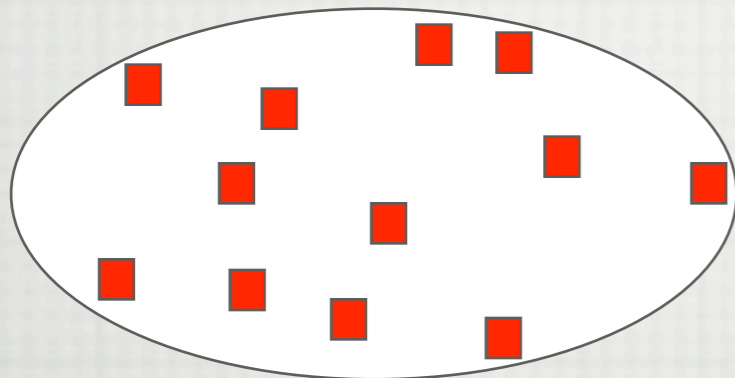
$\mathcal{P}$



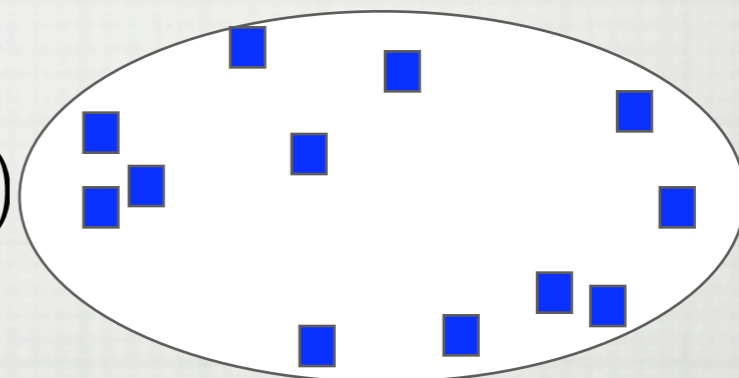
$\mathcal{S}$



X VALUES



$$a(S_{red}) - a(S_{blue})$$

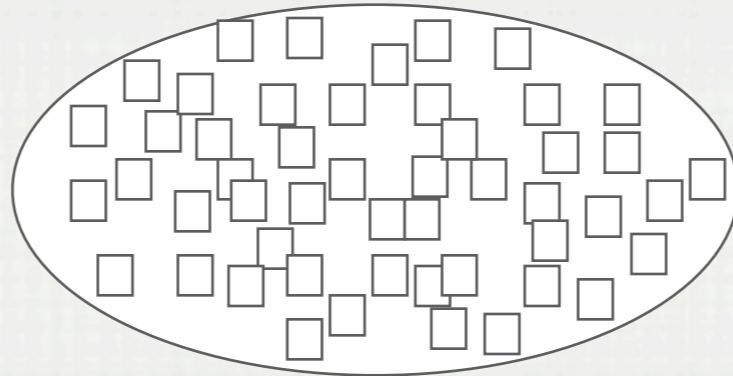


WHAT'S NEW?

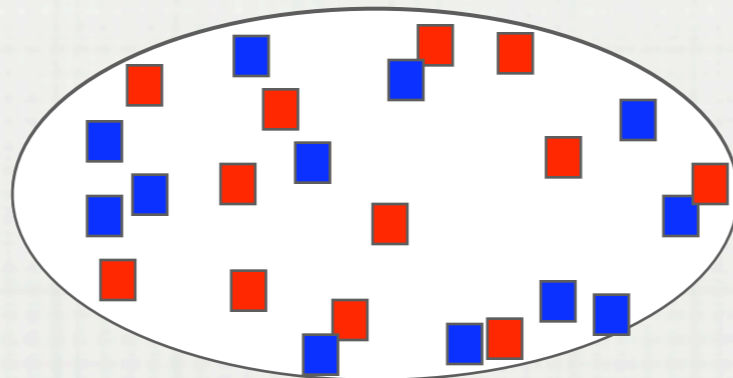
- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# CAUSATION

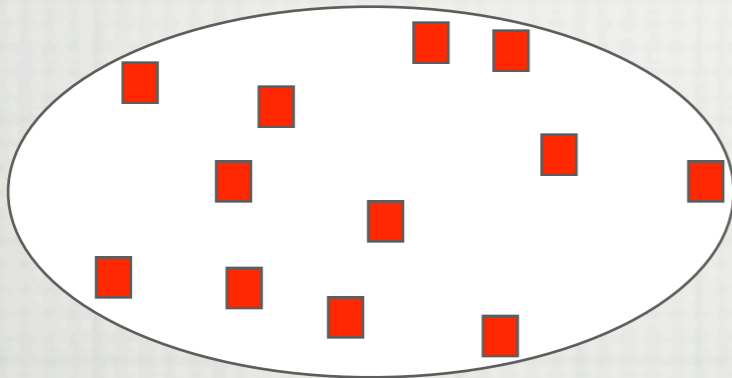
$\mathcal{P}$



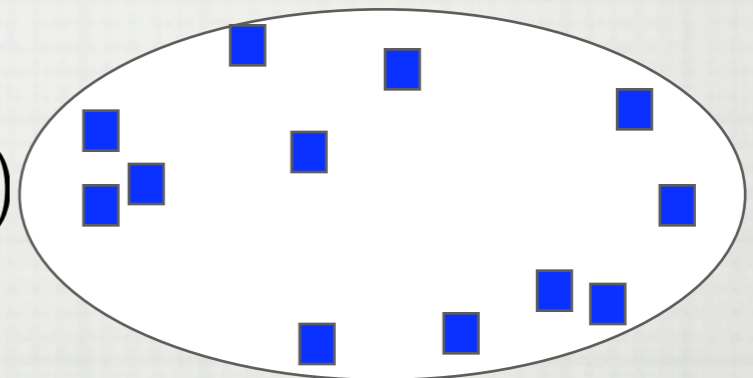
$\mathcal{S}$



X VALUES



$$a(\mathcal{S}_{red}) - a(\mathcal{S}_{blue})$$



COMPARED TO

$$a(\mathcal{P} \mid x \leftarrow red) - a(\mathcal{P} \mid x \leftarrow blue)$$

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# CAUSATION

---

- DISTINGUISHES EXPERIMENTAL AND OBSERVATIONAL STUDIES
- MAKES IDEAS LIKE CONFOUNDING, BLOCKING/ MATCHING, RANDOM ALLOCATION, RANDOM SELECTION, REPLICATION, EASY TO EXPLAIN.

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# CAUSATION

---

- DISTINGUISHES EXPERIMENTAL AND OBSERVATIONAL STUDIES
- MAKES IDEAS LIKE CONFOUNDING, BLOCKING/ MATCHING, RANDOM ALLOCATION, RANDOM SELECTION, REPLICATION, EASY TO EXPLAIN.

## WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# PPDAC

---

## WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# PROBLEM

# PPDAC

- TARGET POPULATION/PROCESS
    - COLLECTIVE AND UNITS
- 

- VARIATES (RESPONSE AND EXPLANATORY)
- ATTRIBUTES
- PROBLEM ASPECT(S)
  - CAUSATIVE, ...

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# PPDAC

PROBLEM

PLAN

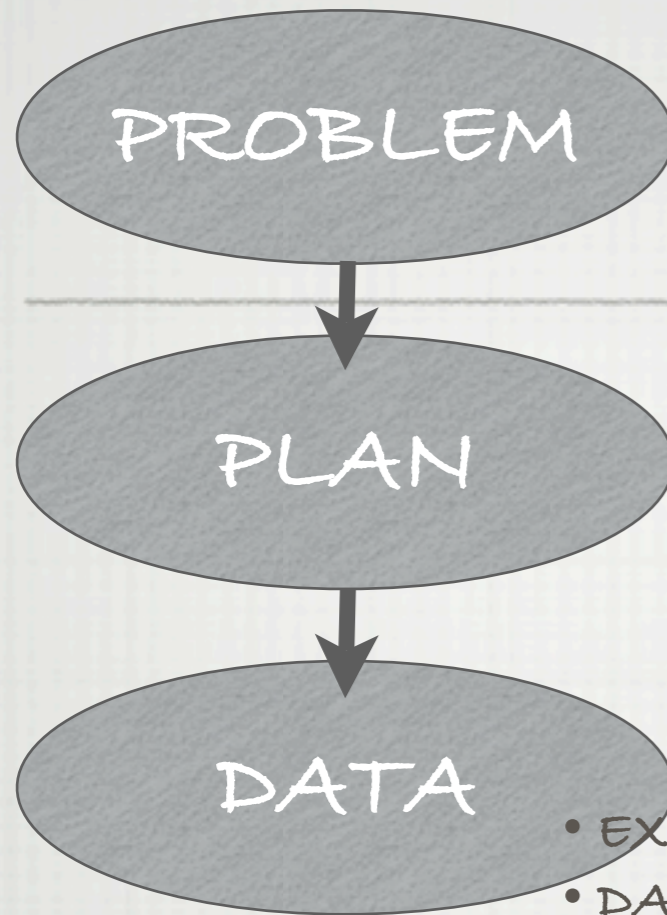
- STUDY POPULATION, ATTRIBUTES, VARIATES
- DEALING WITH VARIATES
  - SELECTING RESPONSE, CONTROLLING EXPLANATORY, FISHBONE DIAGRAM, ...
- SAMPLING PROTOCOL
- MEASURING PROCESSES
- DATA COLLECTION PROTOCOL

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# PPDAC



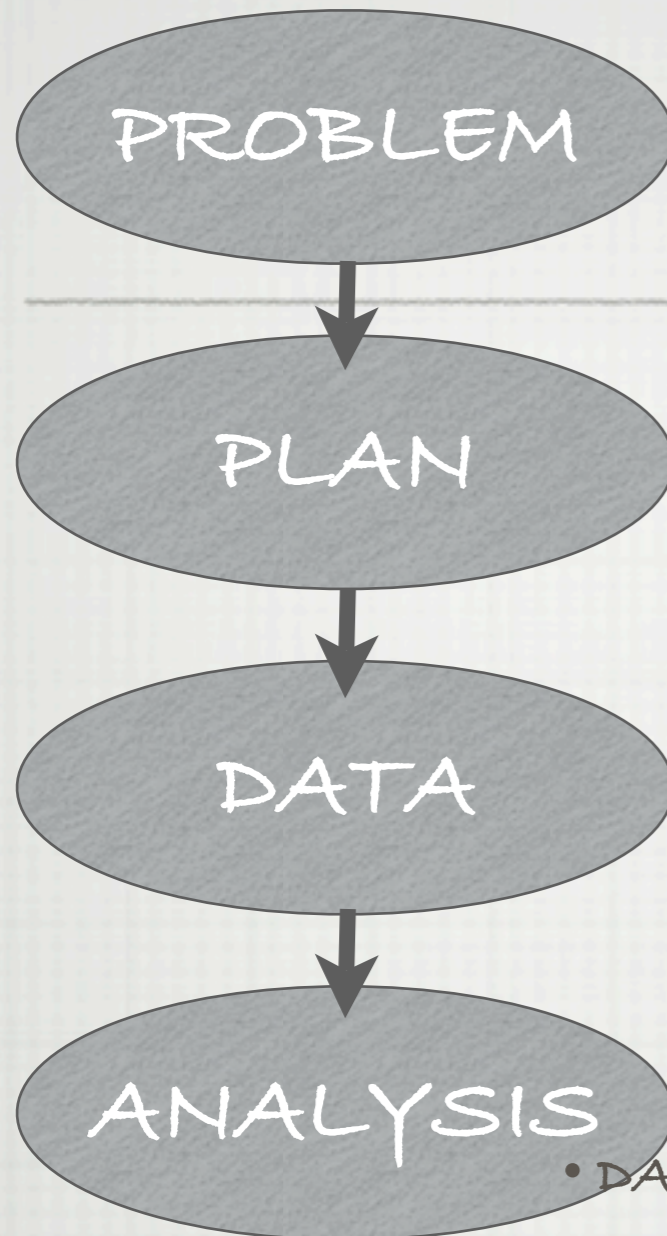
- EXECUTE THE PLAN (RECORD DEPARTURES)
- DATA MONITORING
- DATA EXAMINATION (INTERNAL CONSISTENCY)
- DATA STORAGE

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# PPDAC



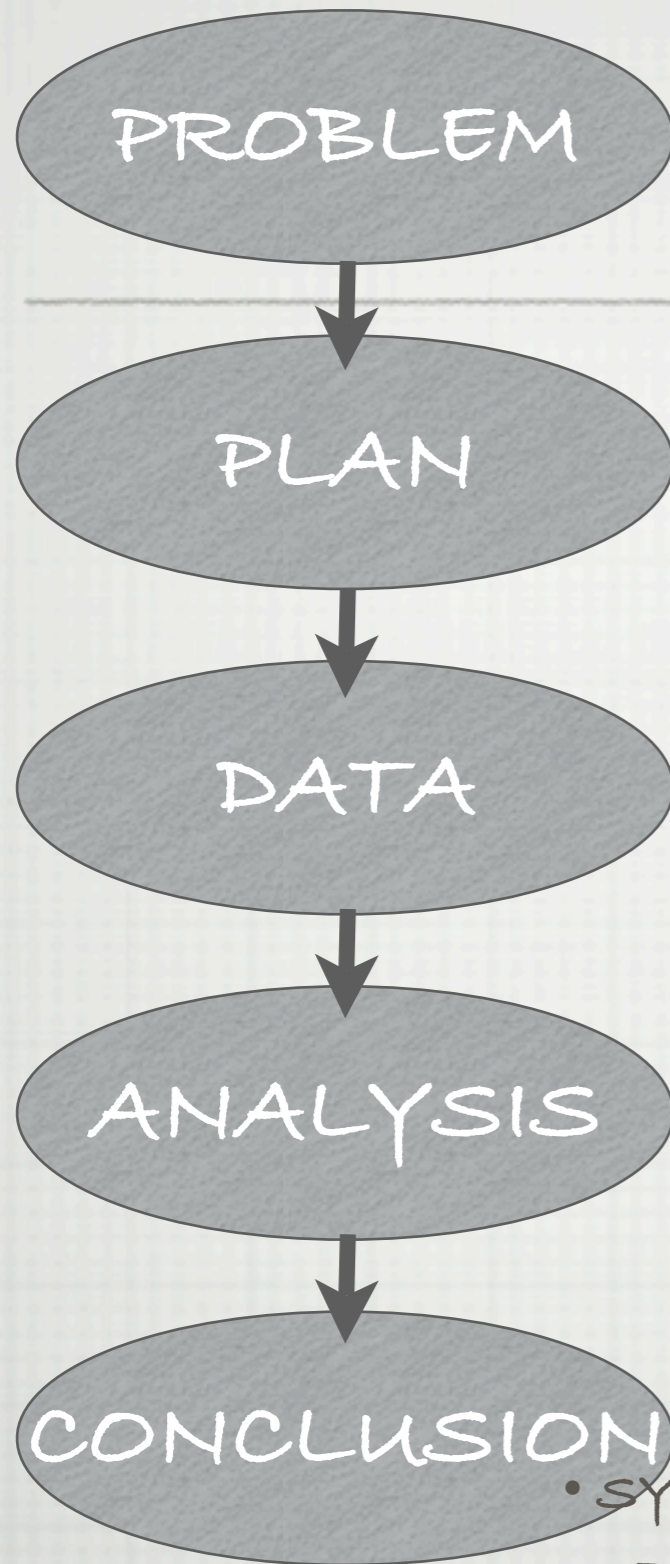
- DATA SUMMARY
  - NUMERICAL AND GRAPHICAL
- MODEL CONSTRUCTION
  - BUILD, FIT, CRITICIZE CYCLE
- FORMAL ANALYSIS

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# PPDAC

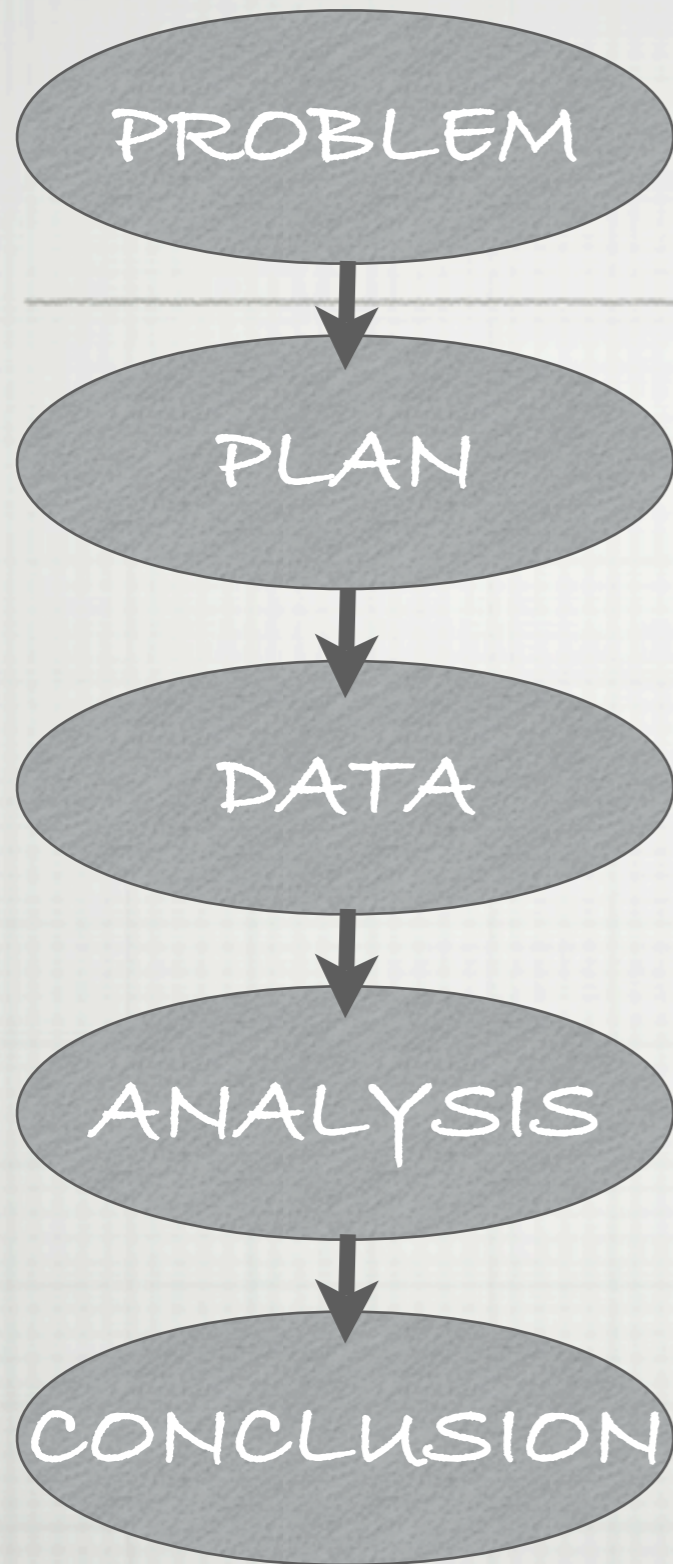


- SYNTHESIS
  - PLAIN LANGUAGE, PRESENTATION GRAPHICS,
- LIMITATIONS
  - DISCUSSION OF POTENTIAL ERRORS

- WHAT'S NEW?
- CONTEXT
  - LANGUAGE
  - INDUCTION
  - CAUSATION, ...
  - PPDAC
  - POSITIVE AND



# PPDAC



- THE STATISTICAL METHOD
- ORGANIZATIONAL TOOL
- PRESCRIPTIVE AND DESCRIPTIVE
- ALWAYS** FOLLOWED ...  
IN EVERY EXAMPLE,  
INTRODUCING EVERY  
MODEL, ...
  - CONTEXT
  - LANGUAGE
  - INDUCTION
  - CAUSATION, ...
  - PPDAC
  - POSITIVE AND



# POSITIVE AND PROACTIVE

---

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# POSITIVE AND PROACTIVE

---

- PPDAC TO PRODUCE AND ANALYZE EMPIRICAL STUDIES
- POSITIVE CONCLUSIONS EMPHASIZED (WITH LIMITATIONS NOTED)
- RANDOM SELECTION DESIRABLE BUT NOT NECESSARY NOR SUFFICIENT
- RANDOM ALLOCATION DESIRABLE BUT NOT NECESSARY NOR SUFFICIENT

WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# WHAT'S NEW? MISCELLANEA

---

- FIVE PHYSICAL LABORATORIES (EQUIPMENT, ...)
- NOTATION INNOVATION
- NEW DISTRIBUTIONS USED AS STANDARD
- ...

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND



# WHAT'S NEW? MISCELLANEA

---

- FIVE PHYSICAL LABORATORIES (EQUIPMENT, ...)
- NOTATION INNOVATION
- NEW DISTRIBUTIONS USED AS STANDARD
- ...

## WHAT'S NEW?

- CONTEXT
- LANGUAGE
- INDUCTION
- CAUSATION, ...
- PPDAC
- POSITIVE AND

# WHAT HAPPENED?

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- LOTS OF FUN, FOUNDATIONAL ARGUMENTS, CLARIFIED STATISTICAL CONCEPTS FOR U.S, CONTINUAL IMPROVEMENT
- MIXED STUDENT REACTION
- MIXED REACTION FROM COLLEAGUES (MARKING, TEACHING, DISCIPLINE, EFFORT, ...)
- HAD LITTLE IMPACT ON SUBSEQUENT COURSES
- COULD NOT ASSIGN VISITING FACULTY/GRAD STUDENTS TO TEACH



# POST MORTEM

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- RICH IN IDEAS
- DIFFERENT
- WORK
- DEVELOPERS MOVED ON, NEW PEOPLE ARRIVED

# AND SO ...

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- THEORY OF APPLIED STATISTICS
  - INDUCTIVE INFERENCE
  - CAUSATION
  - THE STATISTICAL METHOD
- WE HAVE TAKEN THIS THEORY OF APPLIED STATISTICS WITH US.
- CONSULTING, TEACHING, GRAD COURSES ... SERVICE COURSES, RESEARCH.



# THANK YOU

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## SOME READING:

- MACKAY & OLDFORD (2000) "SCIENTIFIC METHOD, STATISTICAL METHOD, AND THE SPEED OF LIGHT", STATISTICAL SCIENCE, 15, PP. 254-278.
- OLDFORD (1995) "A PHYSICAL DEVICE FOR DEMONSTRATING CONFOUNDING, BLOCKING, AND THE ROLE OF RANDOMIZATION IN UNCOVERING A CAUSAL RELATIONSHIP", THE AMERICAN STATISTICIAN, 49, PP. 210-16.  
(SEE ALSO PEARL'S LETTER IN 1996, P. 388)
- MACKAY & OLDFORD (1994-2002) "STAT 231 COURSE NOTES".