# Causality and experiments

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## Clicker Question

Which of Mill's methods is illustrated in this example:

You have three flashlights. One shines brightly, one shines weakly, and the third is barely visible. You take out the batteries from the three flashlights and test them. The first registers a full charge, the second a medium charge, and the third has nearly no charge.

- Method of agreement
- Method of difference
- Method of residues
- Method of concomitant variation

## Clicker Question

Which causal fallacy does this example illustrate?

Whenever the power goes out, your Dad starts beating on the wall. The power comes back on and he takes credit for getting it on again.

- Ignoring a common cause
- Post hoc, ergo propter hoc
- Confusing cause and effect
- None of the above

## Clicker Question

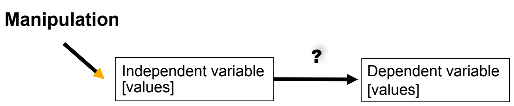
What causal fallacy is illustrated in this example:

Mindy has a car accident. When the police arrive, they find a lot of empty beer cans in the passenger seat. They conclude that the empty beers cans caused the accident.

Ignoring a common cause
Treating coincidence as a cause
Post hoc, ergo propter hoc
Confusing cause and effect

## The basic idea of an experiment

- If the independent variable is the cause of the dependent variable, then a manipulation of the independent variable should produce a change in the value of the dependent variable
  - And if it were not the cause, we would not expect such a result from manipulation




## Clicker Question

To avoid affirming the consequent, which premise should one use to confirm a hypothesis?

If X is the cause of Y, then Y will change as X changes
If X is the cause of Y, then Y will not change as X changes
If X is not the cause of Y, then Y will change as X changes
If X is not the cause of Y, then Y will not change as X changes

# Contributory Causes

- If we are dealing with a sufficient or a necessary cause, then we can make predictions about individual events
- But most causal relations involve contributory causes
  - Whether the effect will occur depends on factors other than the putative effect itself
    - Whether a given smoker develops lung cancer depends on a variety of other causal factors
      - her genetics
      - other things she did
  - The same individual may respond differently on different occasions
    - Reaction time will differ depend on other causal factors: time of day, how much a person had to drink, etc.



# Experiments on Contributory Causes

- Challenge: how to detect causal relations in the face of multiple causal factors?
- With contributory causes
  - Researchers cannot simply do an experiment on one instance and draw a conclusion about the whole population
  - Rather they must work with samples and draw conclusions based on statistical analysis
    - Are the differences in the values of the dependent variable greater than expected by chance?



# Confounding Variables

- Other causal factors (variables) that are related to the effect of interest are referred to as **extraneous variables**
- If not appropriately controlled for, these variables may result in misleading tests of causal claims
  - When such variables are correlated with the putative cause and may actually be responsible for the effect produced in the study, they are called **confounds**
- Two kinds that are particularly important:
  - **Subject variable confounds**:
    - Differences between subjects or items investigated in the study
  - **Procedural variable confounds**:
    - Differences in the way different subjects or items are treated
- If a confounding variable is not controlled for, the experiment is **confounded**
  - one cannot tells which variable is responsible for the effect

## Clicker Question

A confound is

- The dependent variable in an experiment
- An extraneous variable that may produce the effect on the independent variable
- An extraneous variable that may produce the effect on the dependent variable
- The independent variable in an experiment

## Strategies for controlling confounding variables

- Locking
  - Most commonly used to control confounding procedural variables
- Randomization
  - Most commonly used to control confounding subject variables
- Matching subjects
  - A less preferred strategy for controlling confounding subject variables
    - Only works for known confounds
- Making confounding variables into studied variables



## Procedural variable confounds

- When you conduct a manipulation, generally more than one thing will be changed
  - These variables will then be correlated with the independent variable but with respect to the independent variable being tested are **extraneous**
  - If one of the other variables is causally related to the effect of interest, it rather than the variable you are considering may be the cause
    - it is then a **confound** and the experiment is confounded

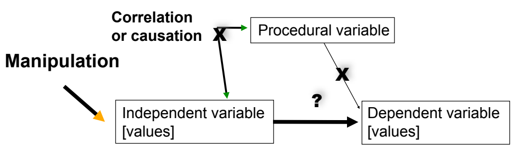
# Confounding Procedural Variables

- The president of the AGL corporation wanted to get his workers to be more productive
  - She found that when each employee
  - was presented with a jar of jellybeans,
  - productivity increased

- Was it the jellybeans that caused the increased productivity? Or was it:
  - Novelty of the situation
  - Attention from the president



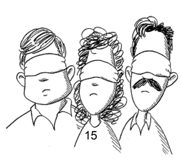
# Controlling confounding procedural variables




Strategy: break the correlation—thereby breaking the effect of the confounding variable
Commonly achieved via **locking**

# Demand characteristics can create procedural confound

- People may change their behavior when they are being studied (recall: Reactivity Bias)
  - People want to be liked (or not!)
  - People want to be helpful (or not!)
  - People want to be thought of as intelligent and normal (not crazy, stupid or obsessed)
- Problem if subjects figure out the point of an experiment
  - Solutions:
    - Keep subjects blind as to the point of the experiment or what is being studied (single-blind experiment)
    - Make sure procedure is locked so all subjects are affected the same



# Experimenter Bias Can Create Procedural Confound

- Danger that experimenters will see what they want to see (a former of observer bias)
  - Mendel’s data is too perfect—there should be more variability
    - Most likely explanation is that he reported the best cases and subjectively biased his counting of plants
- Keep the data-tabulator blind as to which group different subjects are in
  - Double-blind study

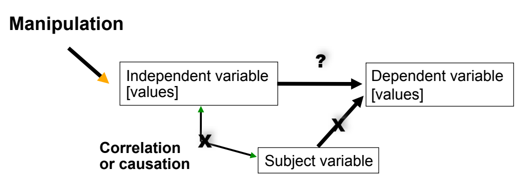


# Subject Variable Confounds

- Subjects in an experiment may have different values on other variables than the independent variable
  - People of different ages sleep different amounts
  - Women might be affected differently than men
- If these aren’t the independent or dependent variable, these variables are extraneous
- If there is a correlation between these variables and the independent variable,
  - they, rather than the variable you are focusing on, may be what produce the change in the dependent variable
  - Such variables are confounds



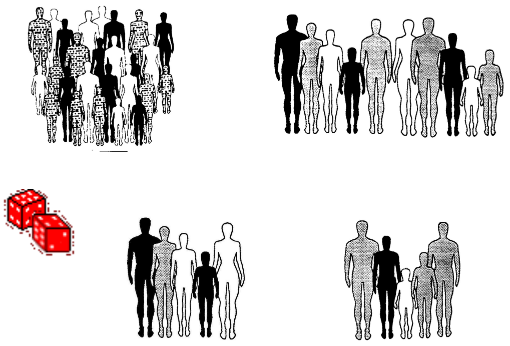
# Controlling confounding subject variables



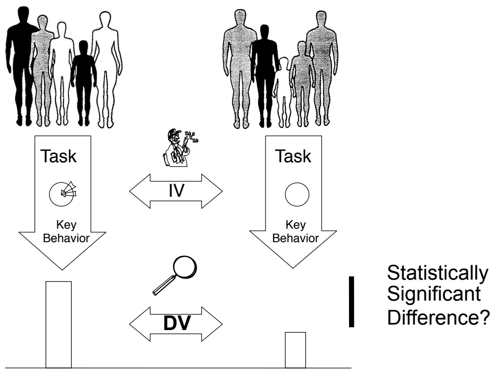

Strategy: break the correlation—thereby breaking the effect of the confounding variable

Random assignment of subjects is a strategy for breaking the correlation

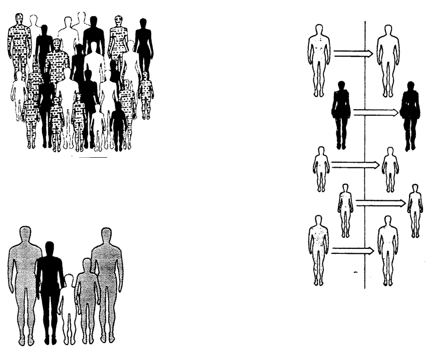
## Controlling subject confounds: ***Between subjects*** randomization



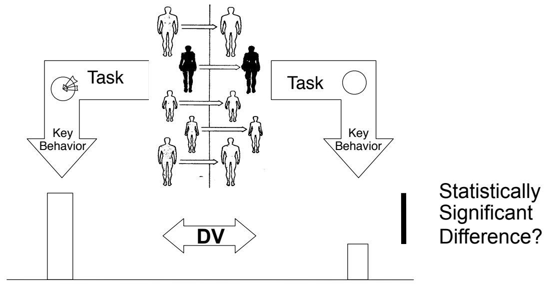
## Manipulate independent variable




## Controlling subject confounds: **Within subjects** design



## Subjects serving as own control




## Between-subject design

- **GOOD NEWS:**
  - Participants are not “contaminated” in one condition as a result of having participated in the other
- **BAD NEWS:**
  - Requires a larger number of participants
  - Runs the risk of non-equivalence of subject groups

## Within-subjects designs

**GOOD NEWS:**

- Requires a smaller number of participants
- Rules out any differences between subjects

**BAD NEWS:**

- Potential “contamination” of participants’ behavior from previous trial: *carryover effect*
- Subjects might learn from one condition and that could alter their behavior in the second condition
  - *Practice effect*
  - *Fatigue effect*

These are additional confounds that must be controlled for.

## Clicker Question

A within-subjects design

- Uses participants as their own controls
- Requires fewer participants than a between subjects design
- Runs the risk of a carryover effect
- All of the above

## Counterbalancing

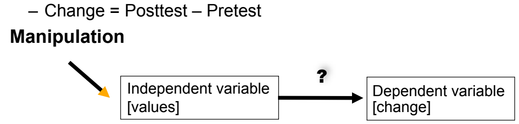
- Goal: eliminate confounds in within-subjects design
- Within subject counterbalancing
  - Reversing order: ABBA
- Across subject counterbalancing
  - Complete: every possible sequence of conditions—requires n!
  - Partial
    - Random
    - Latin Square:
      - each condition appears once and only once in a given ordinal position
      - no two conditions are juxtaposed in the same order more than once

| | | | | |
|---|---|---|---|---|
| Order 1: | A | B | D | C |
| Order 2: | B | C | A | D |
| Order 3: | C | D | B | A |
| Order 4: | D | A | C | B |



## Pretest—Posttest Design

- There is always a danger in an experiment that the members of the two (or more) groups being studied already differ on the dependent variable
- Best control is to focus on change, not raw value of the dependent variable
  - Pretest: measure the dependent variable before the intervention
  - Posttest: measure the dependent variable after the intervention
  - Change = Posttest – Pretest



# Limitations of pretest-posttest design

- Just measuring change in one group using a pretest and a posttest allows for confounds
  - Time has elapsed and subjects have gotten older (maturation)
  - Events occurring between the pretest and posttest could affect the dependent variable (history)
  - Experience with previous test may change performance
  - Pretest and posttest may vary in difficulty
- Use of pretest-posttest does not obviate the need for a control group

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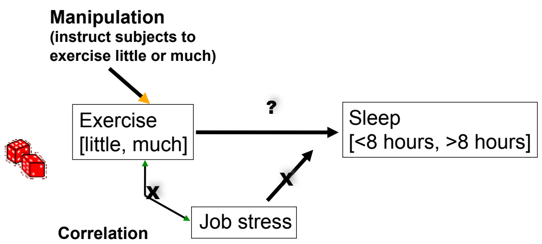
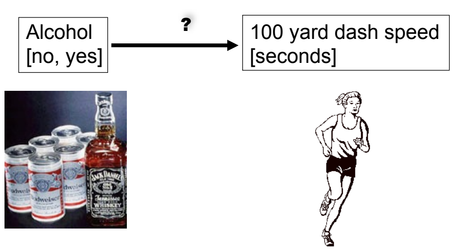
# Example: Exercise and sleep

- Is there a causal relation between exercise and sleep?




# Example: alcohol and running speed



# Between subjects or within subjects

- Between-subjects design
  - Different subjects would be used for the no-alcohol and alcohol condition, and each would be tested only once
- Within-subjects design
  - Each subject would be tested both under the no-alcohol and alcohol condition



# Between subjects

- **Jim**
- **Angela**
- **Megan**
- **Peter**

**Roger**

**Shane**

**Sara**

**Jessica**

# Within subjects

| | |
|---|---|
| **Jim** | **Jim** |
| **Angela** | **Angela** |
| **Megan** | **Megan** |
| **Peter** | **Peter** |

## Counterbalance

| Alcohol condition | rest | No-alcohol condition |
|---|---|---|
| **Jim**<br>**Angela** | | **Jim**<br>**Angela** |

| No-alcohol condition | rest | Alcohol condition |
|---|---|---|
| **Megan**<br>**Peter** | | **Megan**<br>**Peter** |

## Internal validity

- An experiment is internally valid if it was in fact the manipulation of the independent variable that produced the change in the dependent variable
  - Are the effects on the dependent variable due solely to the manipulation of the independent variable?
  - Was there a confounding subject variable that did not get controlled?
  - Was there a confounding procedural variable that did not get controlled?

## Clicker Question

Which of the following is not a threat to internal validity

The independent variable is only a contributory cause

The existence of a confounding procedural variable

The existence of a confounding subject variable

All of the above

# Planning an experiment

Say the color the following words are written in

| | |
|---|---|
| **Blue** | **Pink** |
| **Brown** | **Yellow** |
| **White** | **Orange** |
| **Red** | **Green** |

Does it seem harder to name the colors when the words name a different color?

# Planning an experiment - 2

| | | |
|---|---|---|
| BLUE | GREEN | YELLOW |
| PINK | RED | ORANGE |
| GREY | BLACK | PURPLE |
| TAN | WHITE | BROWN |

- How might we test the claim that it is the meaning of the word that makes it harder to say the color it is written in?
- Operationalize the notion of being hard to read
  - Longer reading time
  - More reading errors
- Identify a sample population
  - College undergraduates in psychology courses
- Pick study design
  - Between subject
  - Within subject

# Controlling subject variable confounds

| | | |
|---|---|---|
| BLUE | GREEN | YELLOW |
| PINK | RED | ORANGE |
| GREY | BLACK | PURPLE |
| TAN | WHITE | BROWN |

- What subject variables might you have to worry about as confounds?
- How to control for these confounds
- If between subject
  - Randominze
- If within subject
  - Counterbalance

| | | |
|---|---|---|
| BLUE | GREEN | YELLOW |
| PINK | RED | ORANGE |
| GREY | BLACK | PURPLE |
| TAN | WHITE | BROWN |

# Controlling for procedural variables

- What procedural variables should be controlled to avoid confounds?
  - Context of presentation
  - Illumination of the stimuli
  - Length of words
  - Familiarity and frequency of words

- Need to lock these variables so that they do not vary across conditions