Lab 05

Experimental Research

Applied statistics and experiments
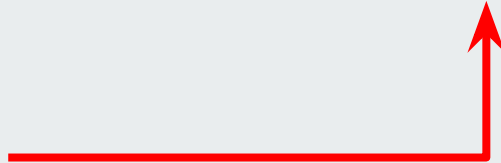
Agenda

1. Experimental research
2. Variables in experimental research
3. Threats to internal validity of experiments

Lecture Recap

https://quizizz.com/join

Join and enter
game code

Experimental research

➢ is a scientific approach to research in which the researcher manipulates one or more variables, and controls and measures any change in other variables.

➢ An experiment conducted to bring out the **cause-effect relationship** between those variables.

➢ The experiment has two groups, **a treatment (experimental) group, and a control group**.

➢ A researcher starts an experiment by keeping a problem statement in mind, and that includes a **control variable**.

➢ The treatment group undergoes the changes that the researcher wants to experiment with, and the control group doesn't go through any treatment.

➢ At the end of the experiment, the researcher concludes how the **independent variable** affects the **dependent variable**.

4

Control variable: is anything that is held constant in a study to prevent it from interfering with the results

Variables in experimental research

- **Independent variable (IV):**
  - what you manipulate
- **Dependent variable (DV):**
  - what change due to the change in independent variables
- **Confounder:**
  - is a variable that influences both the DV and the IV, causing a false association.

- **Covariate:**
  - is a variable that influences only the DV.
- **Moderator:**
  - is a variable that affects the strength and direction of the relationship between DV and IV.
- **Mediator ("middle man"):**
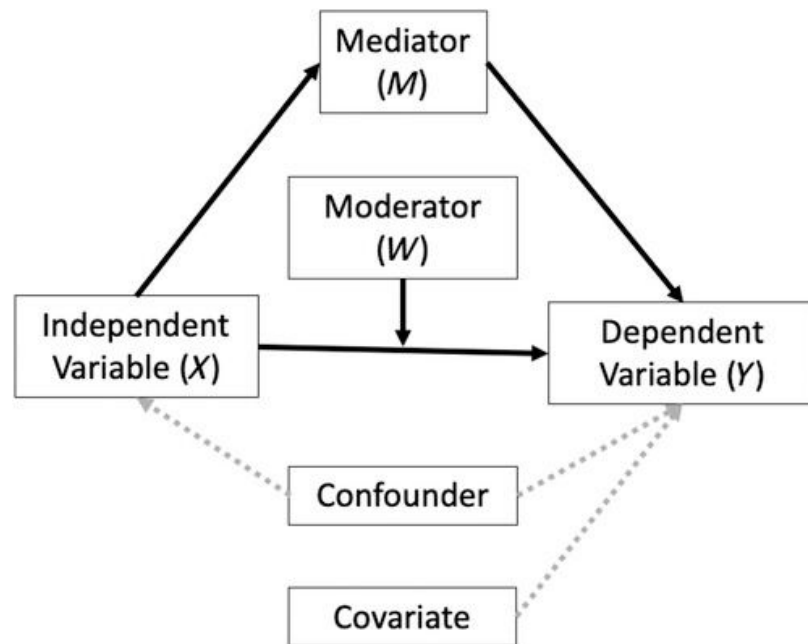 - is a variable that explains how the IV and DV are related.
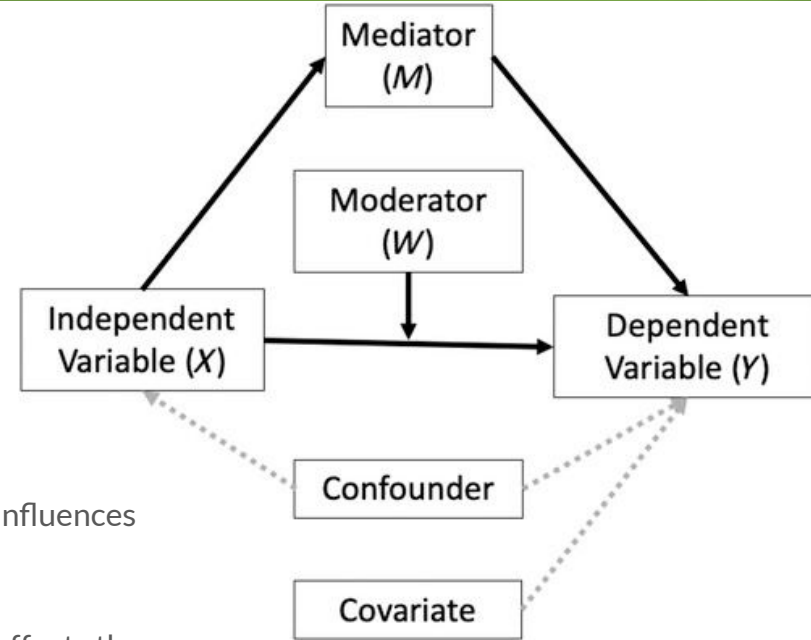
5

Variables in experimental research

A study wants to test the cause-effect relationship between time spent studying per day (e.g. 1 hour, 2 hours, ...etc) and exam scores.

- **Independent variable (IV):**
  - Time spent studying per day
- **Dependent variable (DV):**
  - Exam scores
- **Confounder:**
  - Study techniques used
- **Covariate:**
  - Sleep quality on exam day

Variables in experimental research

A study wants to test the cause-effect relationship between time spent studying per day (e.g. 1 hour, 2 hours, ...etc) and exam scores.
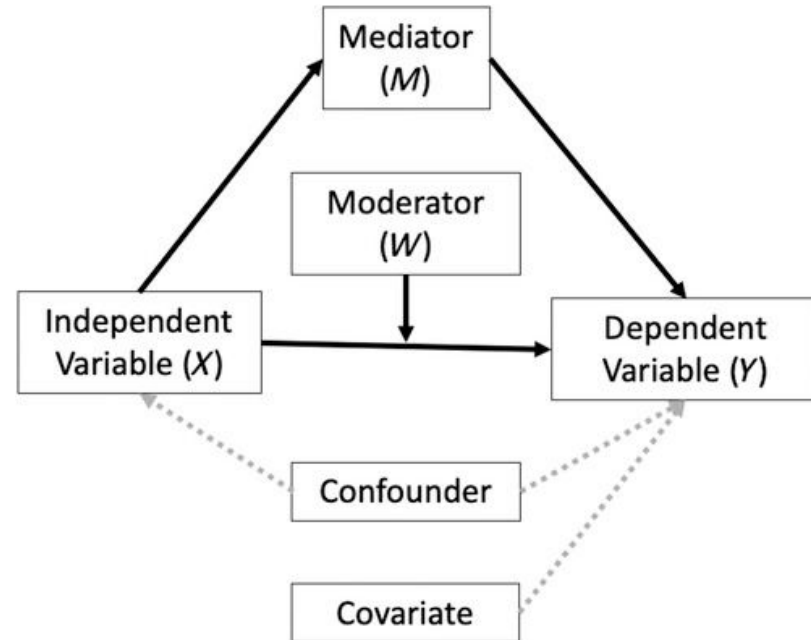
- **Moderator:**
  - Motivation
    - The effect of different study times on exam scores may vary depending on the participants' level of motivation. For example, highly motivated individuals may perform better with longer study times while less motivated individuals may not see much improvement
- **Mediator:**
  - Knowledge
    - The effect of different study times on exam scores may be mediated by the participants' knowledge about the exam. Those who study more, can increase their knowledge which may lead to higher exam scores.

7
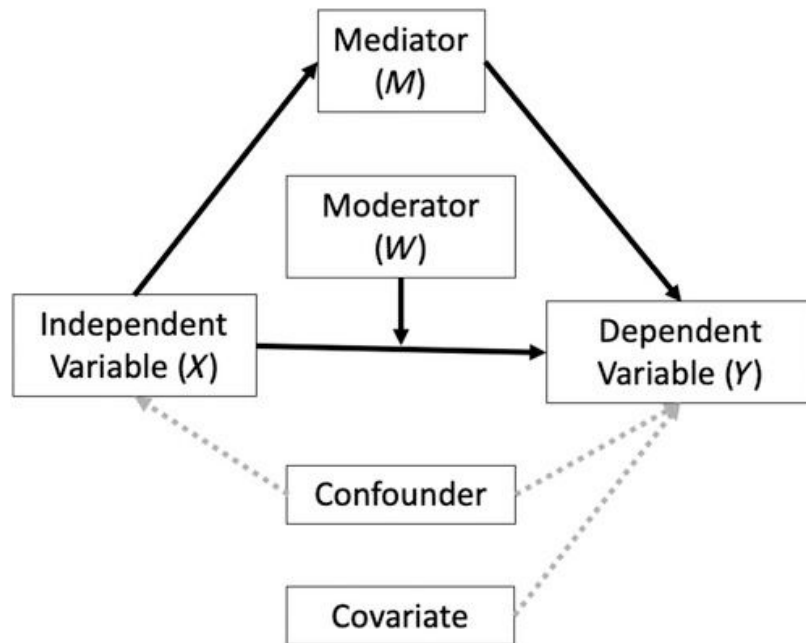
Variables in experimental research

Practice

- Suggest an experimental research you plan to conduct and identify an example for each variable shown on the right.

Steps in conducting experimental research
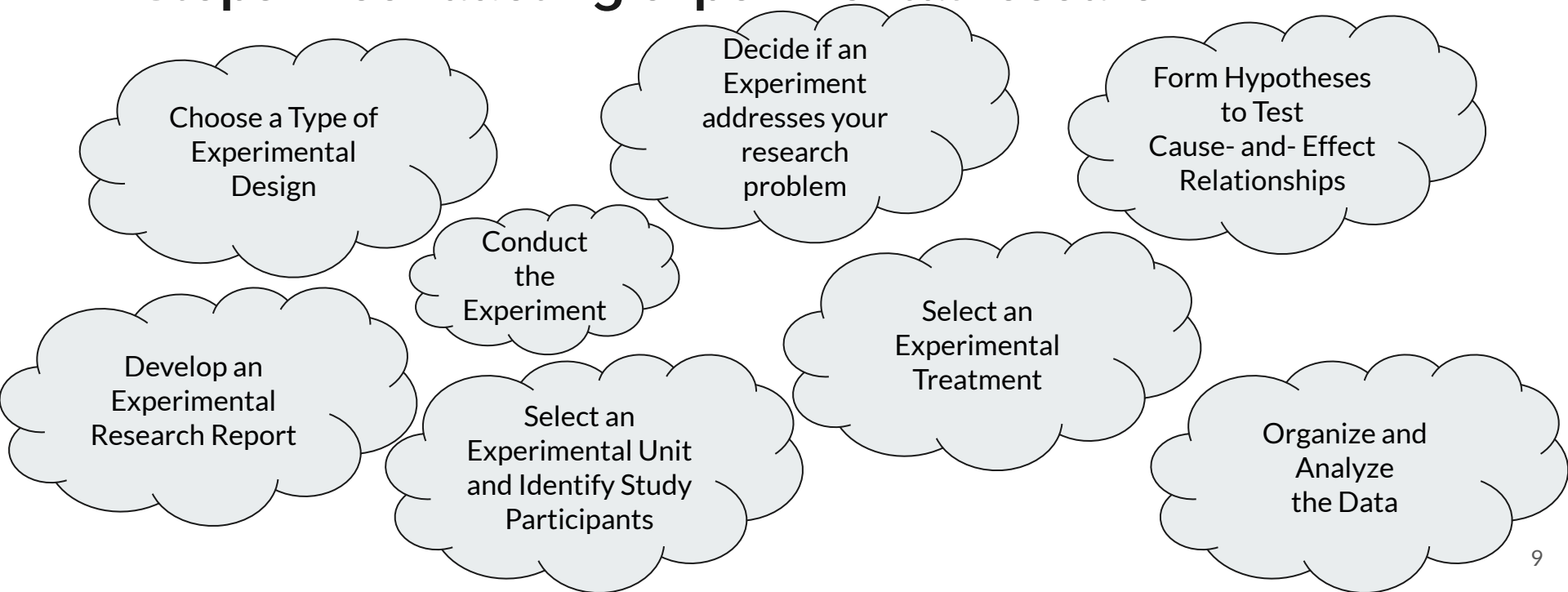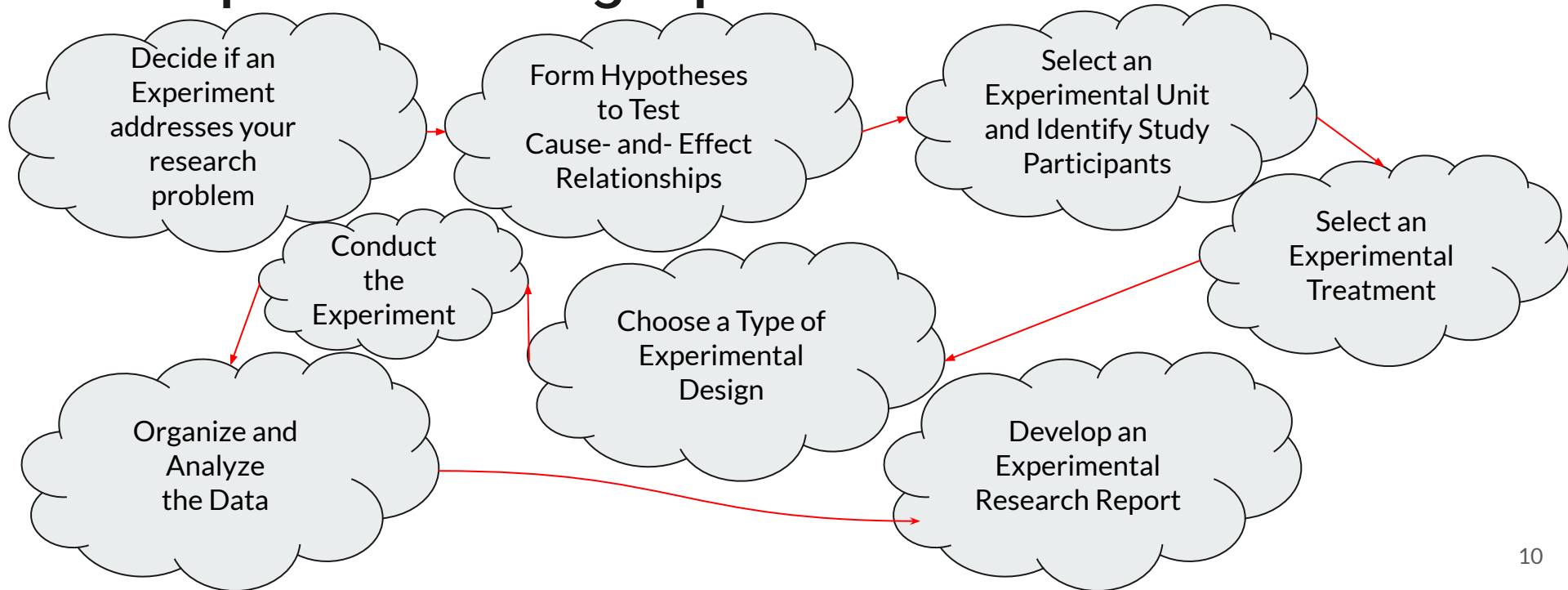
Choose a Type of Experimental Design

Decide if an Experiment addresses your research problem

Form Hypotheses to Test Cause- and- Effect Relationships

Conduct the Experiment

Select an Experimental Treatment

Develop an Experimental Research Report

Select an Experimental Unit and Identify Study Participants

Organize and Analyze the Data

Steps in conducting experimental research

Decide if an Experiment addresses your research problem

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Organize and Analyze the Data

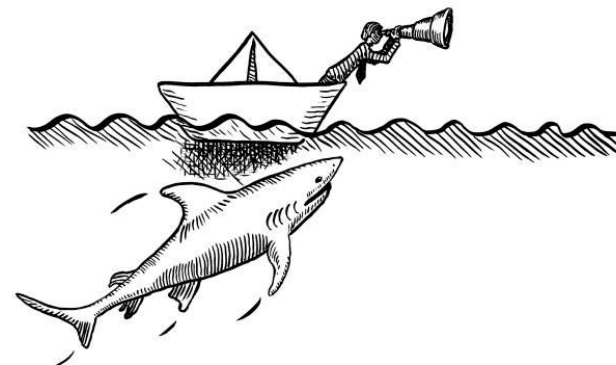Develop an Experimental Research Report

Example 1

John Smith has been hired by the city of Virginia Beach to investigate the recent shark attacks off the resort's coast (there is a claim that this is caused by number of elephant seals on the coast). He has a budget of $40,000, a 25-foot boat, and three graduate student assistants to help him. A helicopter has also been donated by a local television station, should he need one.

1. List 2 hypotheses John and his crew may have come up with for the recent shark attacks.
   a. If_____, then _____
   b. If_____, then _____
2. Pick one of the two hypotheses and determine the following:
   a. Control Group
   b. Experimental Group:
   c. Dependent Variable
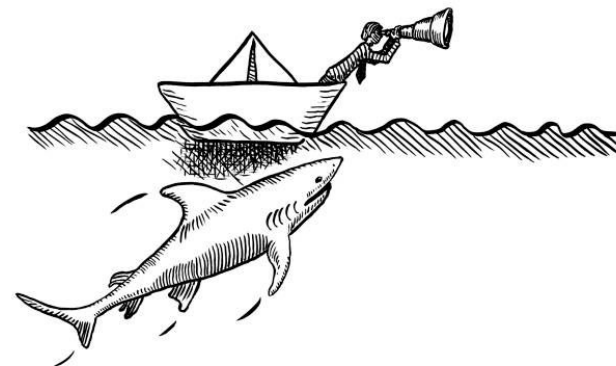   d. Independent Variable

Example 1

John Smith has been hired by the city of Virginia Beach to investigate the recent shark attacks off the resort's coast (there is a claim that this is caused by number of elephant seals on the coast). He has a budget of $40,000, a 25-foot boat, and three graduate student assistants to help him. A helicopter has also been donated by a local television station, should he need one.

1. List 2 hypotheses John and his crew may have come up with for the recent shark attacks.

If shark attacks are related to the number of elephant seals in a certain area, then shark attacks will increase as elephant seal numbers increase.

2. Pick one of the two hypotheses and determine the following:
   a. Control Group: **time of year when elephant seals are not present on the coast**
   b. Experimental Group: **times when elephant seals vary**
   c. Dependent Variable: **# of shark attacks**
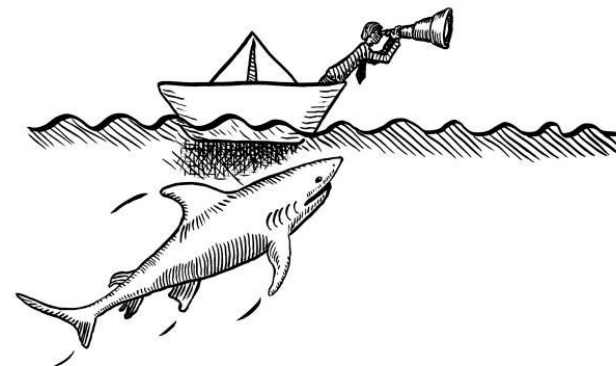   d. Independent Variable: **# of elephant seals**

Example 1

John Smith has been hired by the city of Virginia Beach to investigate the recent shark attacks off the resort's coast (there is a claim that this is caused by number of elephant seals on the coast). He has a budget of $40,000, a 25-foot boat, and three graduate student assistants to help him. A helicopter has also been donated by a local television station, should he need one.

3. What type of data do you think John will collect (What will be the results of the experiment)?

Shark attacks (distance from shore) vs number of elephant seals (mature and juvenile)

4. What conclusions will John be able to make from the results of the experiment?

More elephant seals increase in number the more shark attacks are expected.

13

Example 2 – practice

A study was created to test the effects of fear in children. The hypothesis of the experimenters was that if babies were exposed to fuzzy bunnies and at the same time a loud cymbal was struck close behind them, then that child would be afraid of all fuzzy things. Another group of children would be exposed to bunnies without any loud noises. The study was carried out as planned and as a result, hundreds of young children developed fear of all cute furry bunny rabbits.

Dependent Variable: _____ **Control Group:** _____

Independent Variable: _____ **Experimental Group:** _____

14

Example 2 – practice

A study was created to test the effects of fear in children. The hypothesis of the experimenters was that if babies were exposed to fuzzy bunnies and at the same time a loud cymbal was struck close behind them, then that child would be afraid of all fuzzy things. Another group of children would be exposed to bunnies without any loud noises. The study was carried out as planned and as a result, hundreds of young children developed fear of all cute furry bunny rabbits.

Dependent Variable: Response to bunnies

Independent Variable: Cymbal or no cymbal

Control Group: Played w/ bunnies w/ no cymbal

Experimental Group: Played w/ bunnies w/ cymbal

Example 3 – practice

A study was created to test the effects of jazz on people's sleep patterns. The hypothesis of the experiment was that if people listened to jazz music as they fall asleep, they will sleep for longer periods of time. For the experiment, 2 groups of people were created. One group was placed in a quiet room where they went to sleep, and they were timed on how long they slept. The other group was placed in a room where jazz music played softly as they began to sleep and played throughout the night. As each group awoke, their sleep times were monitored.

Dependent Variable: _____ **Control Group:** _____

Independent Variable: _____ **Experimental Group:** _____

Example 3 – practice

A study was created to test the effects of jazz on people's sleep patterns. The hypothesis of the experiment was that if people listened to jazz music as they fall asleep, they will sleep for longer periods of time. For the experiment, 2 groups of people were created. One group was placed in a quiet room where they went to sleep, and they were timed on how long they slept. The other group was placed in a room where jazz music played softly as they began to sleep and played throughout the night. As each group awoke, their sleep times were monitored.

Dependent Variable: Sleep length

Independent Variable: Music Played

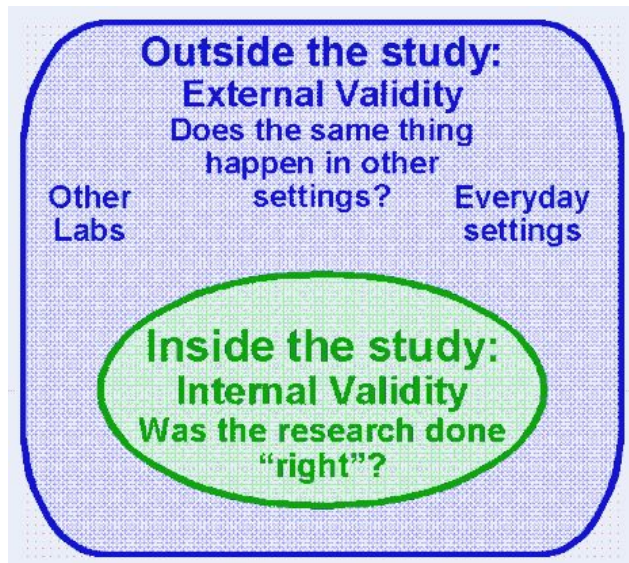**Control Group: No jazz while sleeping**

Experimental Group: Listened to jazz while sleeping

17

Validity of experimental research

Internal validity

the degree to which we can appropriately conclude that the changes in IV caused the changes in DV.

Outside the study:
External Validity
Does the same thing happen in other settings?

Other Labs

Everyday settings

Inside the study:
Internal Validity
Was the research done "right"?

External validity

It relates to the breadth of the population we have sampled and how well we can justify extending our results to an even broader population. (generalizability)

18

Validity of experimental research

Internal validity

- Conclusions are warranted
- Controls extraneous variables
- Eliminates alternative explanations
- Focus on accuracy and strong research methods

Generalization

Truth in the study

Truth in real life

Internal validity
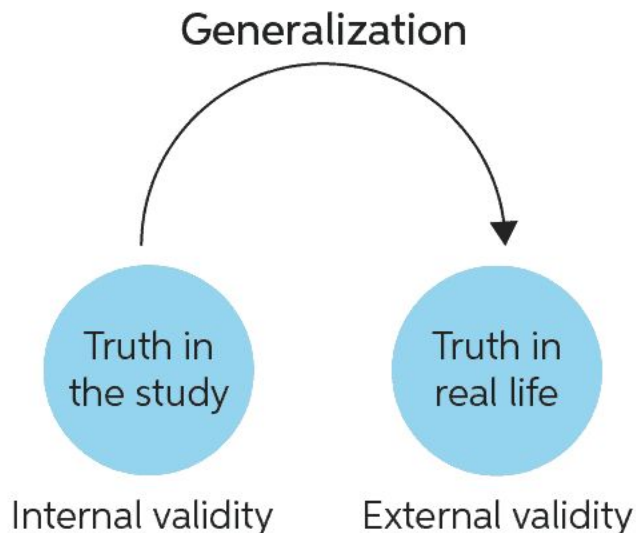
External validity

External validity

- Findings can be generalized
- Outcomes apply to practical situations
- Results apply to the world at large
- Results can be translated into another context

19

Threats to Internal Validity

1. History
2. Maturation
3. Mortality
4. Statistical regression to the mean
5. Selection
6. Repeated testing
7. Instrumentation

Experimental study – example

A research team wants to study whether having indoor plants on office desks boosts the productivity of IT employees from a company. The researchers give each of the participating IT employees a plant to place by their desktop for the month-long study. All participants complete a timed productivity task before (pre-test) and after the study (post-test).

- Independent variable: having indoor plants on office desks
- Dependent variable: productivity of IT employees in the company
- Treatment group: Employees who have indoor plants on office desks
- Control group: None

History – Internal validity – practice

- **Meaning**
  - An unrelated event influences the outcomes.
  - Any event that occurs while the experiment is in progress might be an alternative explanation.
- **Example**
  - A week before the end of the study, all employees are told that there will be layoffs. The participants are stressed on the date of the post-test, and performance may suffer.

History – Internal validity – practice

Threats associated with participants

- **Meaning**
  - An unrelated event influences the outcomes.
  - Any event that occurs while the experiment is in progress might be an alternative explanation.
- **Your example?**
  - ???

Maturation – Internal validity

- **Meaning**
  - The outcomes of the study vary as a natural result of time.
- **Example**
  - Most participants are new to the job at the time of the pre-test. A month later, their productivity has improved as a result of time spent working in the position.

Maturation – Internal validity – practice

- **Meaning**
  - The outcomes of the study vary as a natural result of time.
- **Your example?**
  - **???**

Testing – Internal validity

- **Meaning**
  - The pre-test influences the outcomes of the post-test.
- **Example**
  - Participants showed higher productivity at the end of the study because the same test was administered. Due to familiarity, or awareness of the study's purpose, many participants achieved high results.

Instrumentation – Internal validity

- **Meaning**
  - Different measures are used in pre-test and post-test phases.
- **Example**
  - In the pre-test, productivity was measured for 15 minutes, while the post-test was over 30 minutes long.

Experimental study – example

A researcher wants to compare whether a phone-based app or traditional flashcards are better for learning vocabulary for the SAT. They divide 11th graders from one school into three groups based on baseline (pre-test) scores on vocabulary. For 15 minutes a day, Group A uses the phone-based app, Group B uses flashcards, while Group C spends the time reading as a control. Three months later, post-test measures of vocabulary are taken.
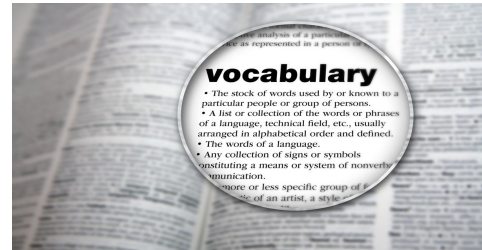
- Independent variable 1: using a phone-based app
- Independent variable 2: using a flashcard app
- Dependent variables: learning vocabulary for the SAT
- Treatment group 1: students who are learning by using phone-based app
- Treatment group 2: students who are learning by using flashcards
- Control group: students who are learning by reading

Selection – Internal validity

- **Meaning**
  - Groups are not comparable at the beginning of the study.
- **Example**
  - Low-scorers were placed in Group A, while high-scorers were placed in Group B. Because there are already systematic differences between the groups at the baseline, any improvements in group scores may be due to reasons other than the treatment.
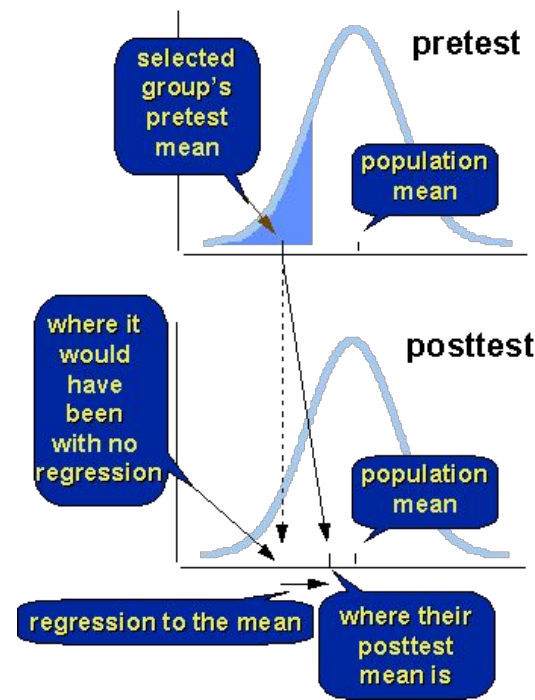
Regression to the mean – Internal validity

- **Meaning**
  - There is a statistical tendency for people who score extremely low or high on a test to score closer to the middle the next time.
  - if a random outcome of the pre-test is extreme, the pos-test will be less extreme. That is, it will be close to the mean or center of the population distribution.
- **Example**
  - Because participants are placed into groups based on their initial scores, it's hard to say whether the outcomes would be due to the treatment or statistical norms.

Regression to the mean – Internal validity *Threats associated with* *measurement*

- **Example**
    - Francis Galton first discovered regression to the mean in 1886.
    - As an example, consider his experimental study.
    - Galton recorded the height of a specific number of children and their parents and computed the mean height of the parents. He discovered that when the parents' average height was higher than the population's mean, the children appeared shorter than the parents. Similarly, when the parents' average height was lower than the population's mean, the children were taller than their parents. Galton first described this phenomenon as regression to mediocrity, today known as regression to the mean.

Regression to the mean – Internal validity Threats associated with measurement

- **Estimation formula**

$$Prm = 100(1 - r)$$

  - ○ Prm = the percent of regression to the mean
  - ○ r = the correlation between the two measures (before and after treatment)
  - ○ Consider the following four cases:
    - ■ if r = 1, there is no (i.e., 0%) regression to the mean
    - ■ if r = .5, there is 50% regression to the mean
      - ● the sampled group moves 50% of the distance from the no-regression point to the mean of the population
    - ■ if r = .2, there is 80% regression to the mean
    - ■ if r = 0, there is 100% regression to the mean
      - ● the sample will "regress" all the way back to the population mean

Mortality – Internal validity

- **Meaning**
  - Dropout of participants from the experiment.
- **Example**
  - 20% of participants provided unusable data. Almost all of them were from Group C. As a result, it's hard to compare the two treatment groups to a control group.
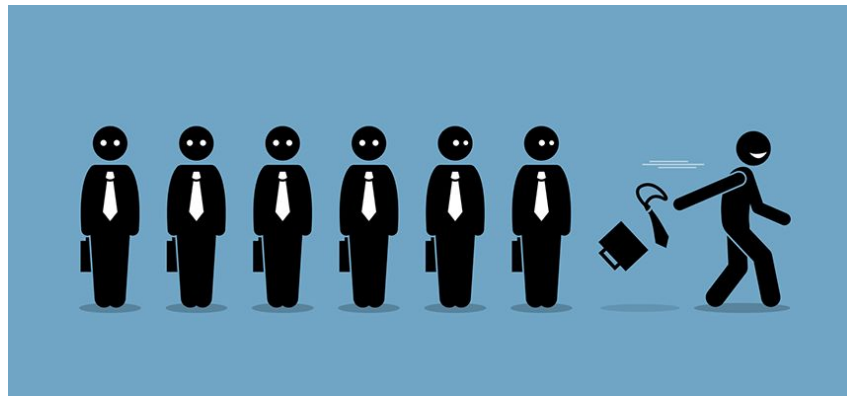
33

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 1 – Threats to validity of experimental research

A study compares two methods to teach students at a school to speak a second language, in this case, Modern Greek. The first group is to learn Greek words and grammar in a classroom over a period of several weeks. The second group goes on a field trip to Greece for the same period of time, during which students have to converse in the target language. The total time spent on language study is the same for both groups. Afterwards, it turns out that the second groups' language ability is higher than that of the first group. Was this difference in the dependent variable's value indeed caused by the teaching method (independent variable)?
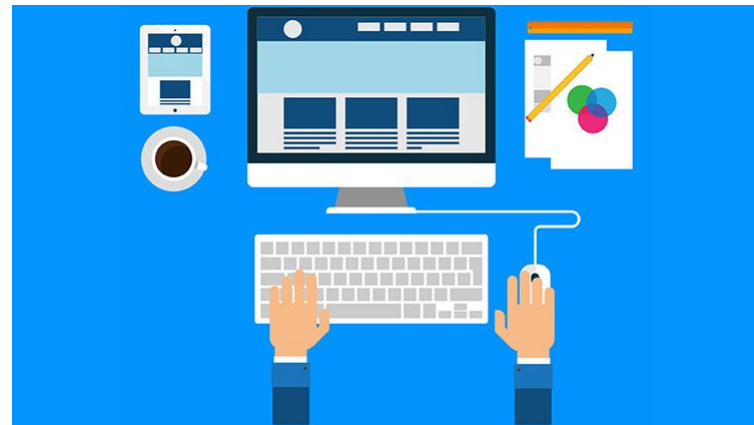
History

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 2 – Threats to validity of experimental research

In a Web-based instruction project, it started with 161 subjects and only 95 of them completed the entire module. Those who stayed in the project all the way to end may be more motivated to learn and thus achieved higher performance

Mortality

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 3 – Threats to validity of experimental research

Those students who score in the bottom 10% academically in a school in an economically depressed area are selected for a special program of enrichment. The program includes special games, extra materials, special "snacks," specially colored materials to use, and new books. The students score substantially higher on achievement tests 6 months after the program is instituted.
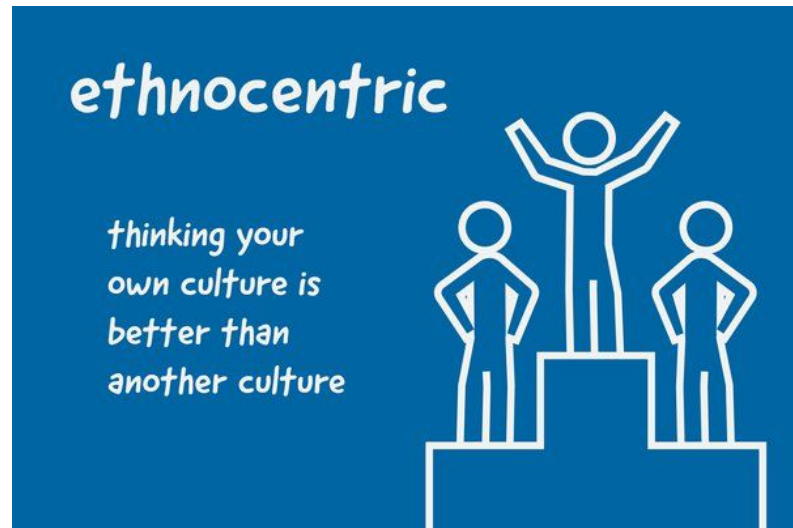
Statistical Regression

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 4 – Threats to validity of experimental research

A researcher designs a study to investigate the effects of simulation games on ethnocentrism. She plans to select two high schools to participate in an experiment. Students in both schools will be given a pretest designed to measure their attitudes toward minority groups. School A will then be given the simulation games during their social studies classes over a three day period while school B sees travel films. Both schools will then be given the same test to see if their attitude toward minority groups has changed. the researcher conducts the study as planned, but a special, unplanned documentary on racial prejudice is shown in school A between the pretest and the posttest.

ethnocentric

thinking your
own culture is
better than
another culture

Selection

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 5 – Threats to validity of experimental research

In an experiment of surveying methods, several people failed to return the control group survey.

Mortality

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 6 – Threats to validity of experimental research

A researcher tests a group of students enrolled in a special class for "students with artistic potential" every year for six years, beginning when they are aged five. She finds that their drawing ability improves markedly over the years.

Maturation

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 7 – Threats to validity of experimental research

Professor Beach wanted to demonstrate to his cognitive psychology class how using retrieval cues can improve memory. First, he read a list of 16 words in random order to his class, and immediately afterwards he had them write down all the words they could remember. On average, they recalled about seven words. Then, he told them that the words could be sorted into four categories: automobiles, cutting instruments, sports, and fruits. Professor Beach encouraged his students to do this in their minds while listening to the list again, after which they would be given another chance to recall the words. On the second test of recall, students remembered, on average, 14 words. Professor Beach told his students that this proves the effectiveness of using retrieval cues as a mnemonic strategy.

Testing

40

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 8 – Threats to validity of experimental research

A researcher uses the same set of problems to measure change over time in student ability to solve mathematics word problems. The first administration is given at the beginning of a unit of instruction; the second administration is given at the end of the unit of instruction, three weeks later. Improvement scores result.

Maturation

41

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 9 – Threats to validity of experimental research

Concerned about pretest **sensitization**, a researcher constructs a test that is extremely difficult, and that is not content valid, and administers it to both the experimental and control groups. The posttest used to measure gains in achievement is not as difficult, and the experimental group shows a slight larger improvement over the control group.

Instrumentation

42

Decide whether or not the following experiment is internally valid.
If not, identify the source of threat to its internal validity.

Example 10 – Threats to validity of experimental research

A researcher decides to try a new mathematics curriculum in a nearby elementary school and to compare student achievement in math with that of students in another elementary school using the regular curriculum. The researcher is not aware, however, that the students in the "new curriculum" school have computers to use in their classrooms.
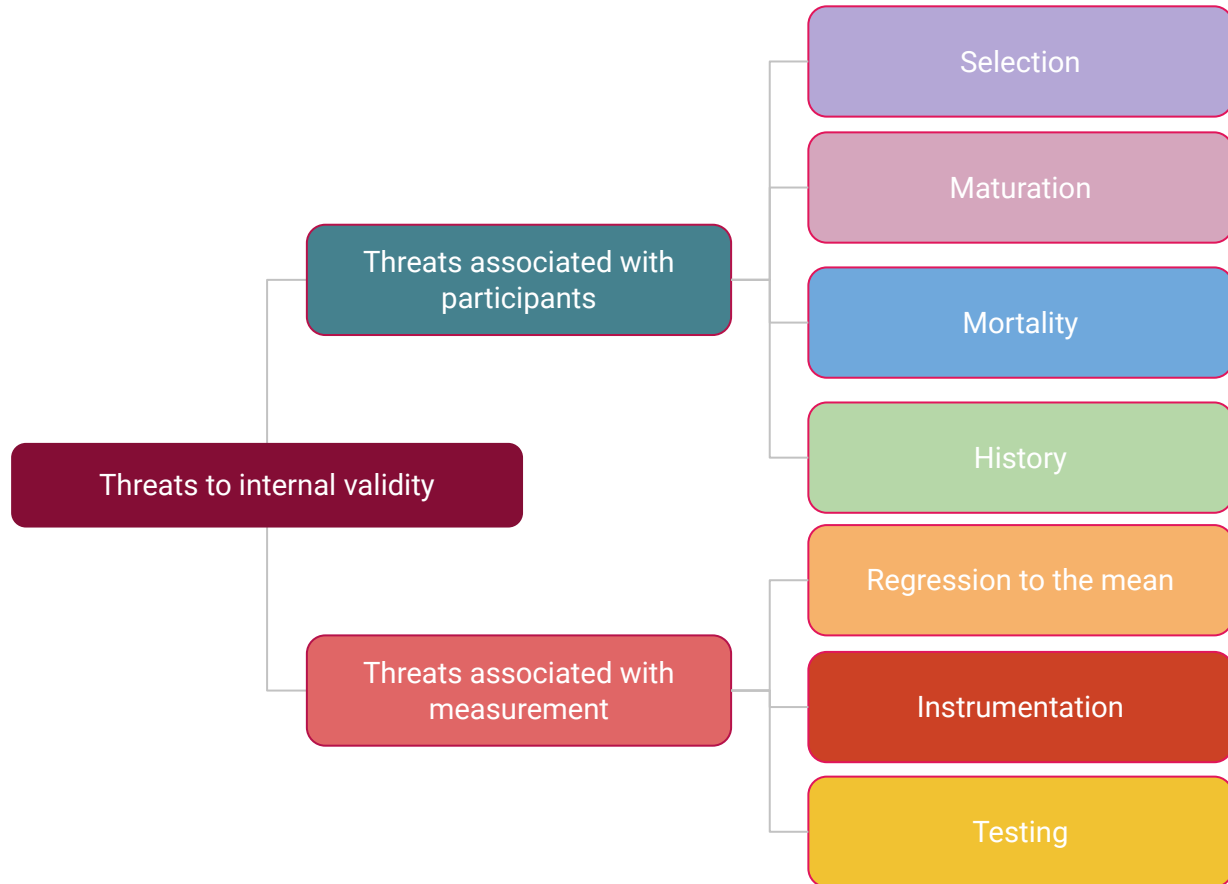
History

43

Practice

Propose an experimental research you plan to conduct and identify the following items:

1. *Dependent and Independent variables;*
2. *Experimental group;*
3. *Control group;*
4. *Threats to its internal validity*

```
Threats to internal validity
├── Threats associated with participants
│   ├── Selection
│   ├── Maturation
│   ├── Mortality
│   └── History
└── Threats associated with measurement
    ├── Regression to the mean
    ├── Instrumentation
    └── Testing
```

References

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- https://researchmethod.net/external-validity/

Attendance
https://baam.duckdns.org

Questions?