Week 5: The Independent Variable

Dr. T. Kody Frey
Assistant Professor | School of Information Science

Overview

- BRIEF review
- Research approaches in general (Ch. 4)
- Experimental designs (Chs. 5-6)
- Nonexperimental designs (Ch. 7)
- Discussion: The Independent Variable
- Workshop: Codebooks and Power! Oh my!

Brief Review

Key Terms

What is the difference between a conceptual definition and an operational definition?

These are *not* interchangeable

- **Concept** (Theoretical concept) - a mental representation (more abstract than a construct)
- **Construct** - a set of operational measures that allow for the study of a theoretical concept (less abstract than a concept)

What is the difference between an independent and a dependent variable?

Independent Variable	Dependent Variable

"variables thought to influence changes in another variable (the dependent variable)."
Known as the IV (sometimes called explanatory variable or PREDICTOR variable in non-experimental research)
When more than two independent variables are used in a "factorial design" the IVs are referred to as factors.
"variables are thought to be changed by another variable (the independent variable)."
Know as the DV (sometimes called outcome variable or CRITERION variable in non-experimental research)

What is the difference between experimental research and survey research?

Experimental research	Survey research

- Purpose is to discover causal relationships between variables - Central characteristic is control
- Purpose is to discover how large groups of people think and act
- Describes the characteristics of the respondents and the populations they were chosen to represent
- Focus is on beliefs, attitudes, and behaviors

Why is quantitative research important to the communication discipline?
Among other reasons…

- Allows us to empirically test for patterns, causality, group differences, and theoretical propositions
- May not explain *why* a communicative phenomena occurred, but they do explain human behavior to fullest extent possible
- Allows us to explain, predict, control, and describe communication behavior
- Turn broad ideas in specific theoretical propositions
- Generalize findings to larger populations of people
- Allows us to control variables with a level of objective specificity that simply cannot be achieved through other approaches
- Reduce complex phenomena to measurable variables

Internal Validity

Characteristics

What are the two characteristics used to evaluate internal validity?
Internal validity refers to the extent that the independent variable, treatment, or intervention caused the change in the dependent variable. We evaluate it based on…

- Equivalence of groups on participant characteristics
- Control of extraneous experiences and environment variables

Threats

What are the broad threats to internal validity?

- How the research is conducted (e.g., the tools or instruments used)
- The research participants (e.g., were they randomly assigned)
- The researchers themselves (e.g., how do independent raters judge behavior)

External Validity

Sampling

What are the characteristics of a sample frame researchers should evaluate in determining its usefulness?
The sampling frame represents an exhaustive list of the participants that a researcher could realistically access for a study.

- Is the frame representative of the theoretical population?
- Does the frame include an exhaustive list of potential participants?
- How was the frame obtained?

What are the *two* types of external validity?

External validity is the extent to which samples, settings, and variables can be generalized bey

Population external validity	**Ecological external validity**

- Was the *sampling frame* representative of the theoretical pop?
- Was the *selected sample* representative of the population?
- Was the *actual sample* representative of the population?

Whether the conditions, settings, times, testers, or procedures are rep of natural conditions
AKA is the research environment similar to the natural environment? Does the manipulation

Application

Let's say your group wants to study men and womens' reactions to violent crime shows on na

- What is the IV? DV? Constant?
- Is this an active or attribute IV?
- Is this an experimental or nonexperimental approach?
- If experimental, which kind? If nonexperimental, which kind?
- What would be an appropriate sampling technique for your group?
- What are some problems that could affect *internal* validity?
- What are some problems that could affect *external* validity?

GML Chapter 4

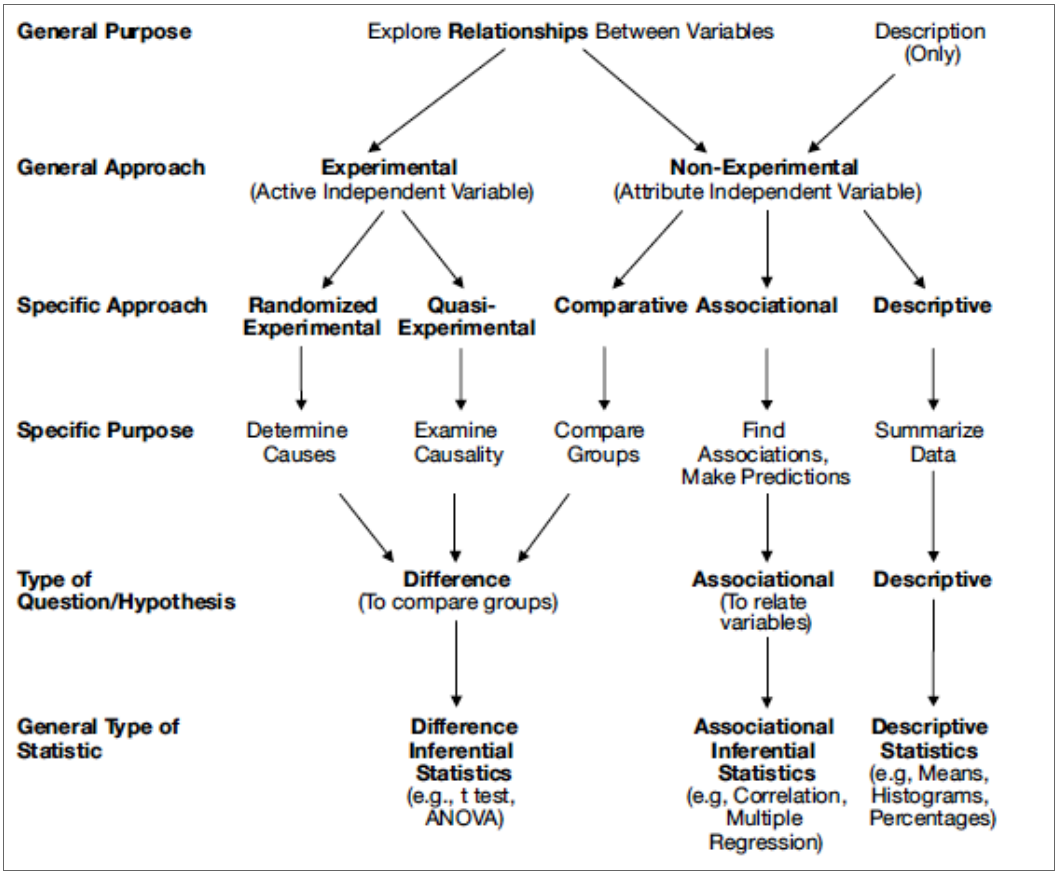
Research Approaches

Experimental | **Nonexperimental** | **Descriptive**

- Has *active* independent variable (intervention, new curriculum, treatment)
- Randomized Experimental
- Quasi-Experimental

- Has *attribute* independent variable (e.g., gender, GPA)
- Comparative
- Associational

- No IV!
- Describes current sample
- Often formative or exploratory


General Purpose
Explore Relationships Between Variables
Description (Only)
General Approach
Experimental (Active Independent Variable)
Non-Experimental (Attribute Independent Variable)
Specific Approach
Randomized Experimental
Quasi-Experimental
Comparative
Associational
Descriptive
Specific Purpose
Determine Causes
Examine Causality
Compare Groups
Find Associations, Make Predictions
Summarize Data
Type of Question/Hypothesis
Difference (To compare groups)
Associational (To relate variables)
Descriptive
General Type of Statistic
Difference Inferential Statistics (e.g., t test, ANOVA)
Associational Inferential Statistics (e.g, Correlation, Multiple Regression)
Descriptive Statistics (e.g, Means, Histograms, Percentages)

Criteria	Randomized Experimental	Quasi-Experimental	Comparative	Associational	Descriptive
Random assignment of participants to groups by Investigator	Yes	No	No	No (only one group)	No groups
Independent variable is active	Yes	Yes	No (attribute)	No (attribute)	No Independent variable
Independent variable is controlled *by the Investigator*[a]	Usually	Sometimes	No	No	No
Number of levels of the Independent variable[b]	Usually 2-4	Usually 2-4	Usually 2-4	Usually 5 or more ordered levels	No Independent variable
Relationships between variables or comparison of groups	Yes (comparison)	Yes (comparison)	Yes (comparison)	Yes (relationship)	No

Experimental

Randomized Experimental Approach | **Quasi-Experimental Approach**

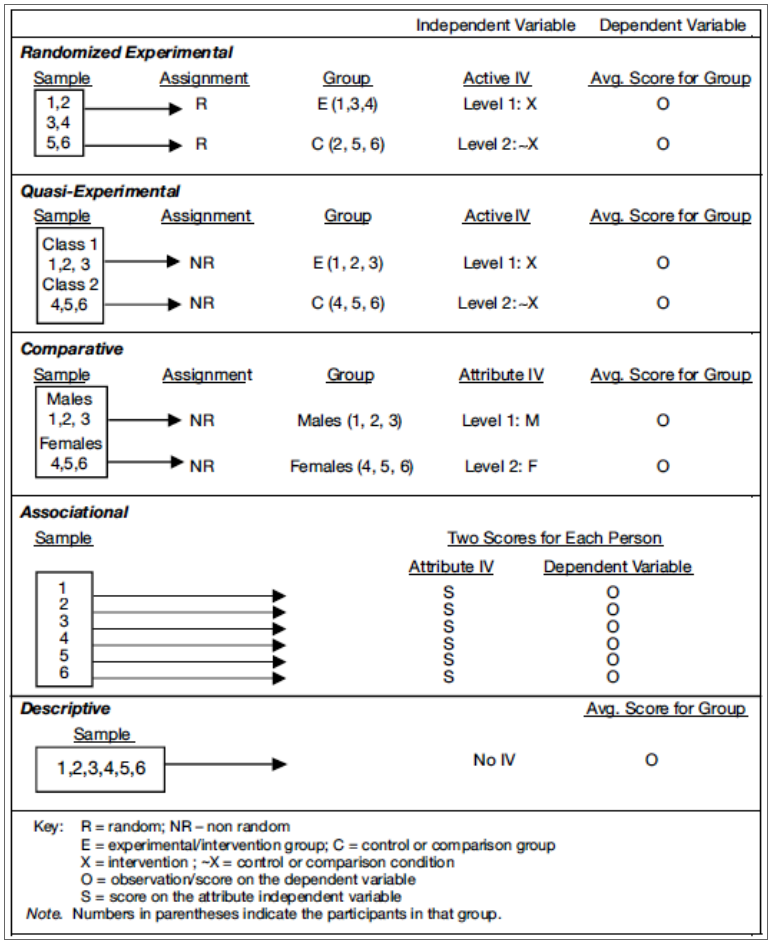
- Must randomly assign participants to groups or conditions
- The IV must be ACTIVE
  - The researcher can control or manipulate levels of the IV
  - Attribute IV: Cannot be manipulated
- Fails to satisfy condition of random assignment of participants to groups
- Typically see researchers assign *treatments* to groups

Figure 8.1 A comparison of full experiments, quasi-experiments, and preexperiments

Type of Experiment	Manipulation of Independent Variable	Random Assignment	Experimental Groups	Control of Extraneous Variables
Full experiment	Manipulate	Yes	Equivalent	High
Quasi-experiment	Manipulate or observe	No	Quasi-equivalent or multiple intragroup comparisons	Moderate
Preexperiment	Manipulate or observe	No	Nonequivalent or no comparison group	Low

Additional Notes

- Randomness implies there is no bias
- Random sampling comes *before* random assignment


Independent Variable
Dependent Variable
Randomized Experimental
Sample
Assignment
Group
Active IV
Avg. Score for Group
1,2
3,4
5,6
R
R
E (1,3,4)
C (2, 5, 6)
Level 1: X
Level 2: ~X
O
O
Quasi-Experimental
Sample
Assignment
Group
Active IV
Avg. Score for Group
Class 1
1,2, 3
Class 2
4,5,6
NR
NR
E (1, 2, 3)
C (4, 5, 6)
Level 1: X
Level 2: ~X
O
O
Comparative
Sample
Assignment
Group
Attribute IV
Avg. Score for Group
Males
1,2, 3
Females
4,5,6
NR
NR
Males (1, 2, 3)
Females (4, 5, 6)
Level 1: M
Level 2: F
O
O
Associational
Sample
Two Scores for Each Person
Attribute IV
Dependent Variable
1
2
3
4
5
6
S
S
S
S
S
S
O
O
O
O
O
O
Descriptive
Avg. Score for Group
Sample
1,2,3,4,5,6
No IV
O
Key: R = random; NR – non random
E = experimental/intervention group; C = control or comparison group
X = intervention ; ~X = control or comparison condition
O = observation/score on the dependent variable
S = score on the attribute independent variable
Note. Numbers in parentheses indicate the participants in that group.

Listed below are some differences among the five approaches to research. Match the descrip

- a. Experimental
- b. Quasi-experimental
- c. Comparative
- d. Associational
- e. Descriptive

- A. Compares groups
- B. Asks questions that describe the data
- C. Examines causality
- D. Associates the many levels of one variable with the many levels of another
- E. Randomized assignment, tries to determine causality

GML Chapter 5

Types of Randomized and Quasi-Experimental Designs

A specific research design helps us visualize the independent variables of the study, the levels within these independent variables, and when measurement of the dependent variable will take place.

Quasi-Experimental with Major Limitations

- One-Group Posttest-Only Design (p. 70)
- One-Group Pretest-Posttest Design (pp. 70-71)
- Posttest-Only Nonequivalent Groups Design (pp. 72-73)


You want to test treatment effects
You only include the treatment group
Your ability to conclude changes are due to the treatment
imgflip.com

Better Quasi-Experimental Designs

- Pretest-Posttest Nonequivalent Comparison Group Designs
- Issues that determine strength of Quasi-Experimental Designs
  - Strong: Treatment randomly assigned
  - Moderate: Researcher takes advantage of existing situation
  - Weak: Participants assign themselves!

	Assign.	Grp.	Pre.	I.V.	Post.
Quasi-experimental designs with Major Limitations					
One-group posttest-only design	NR	E:		X	O
One-group pretest-posttest design	NR	E:	O	X	O
Posttest-only nonequivalent groups design	NR	E:		X	O
	NR	C:		~X	O
Better Quasi-experimental designs					
Pretest-posttest nonequivalent comparison-group designs	NR	E:	O	X	O
	NR	C:	O	~X	O
Single-group time-series designs	NR	E:	OOO	X	OOO
With temporary treatment					
With continuous treatment	NR	E:	OOO	XOXO	XOXO
Multiple-group time-series designs	NR	E:	OOO	X	OOO
With temporary treatment	NR	C:	OOO	~X	OOO
With continuous treatment	NR	E:	OOO	XOXO	XOXO
	NR	C:	OOO	O O	O O
Randomized experimental designs					
Posttest-only control-group design	R	E:		X	O
	R	C:		~X	O
Pretest-posttest control group design	R	E:	O	X	O
	R	C:	O	~X	O
Solomon 4-group design	R	E_1:	O	X	O
	R	E_2:		X	O
	R	C_1:	O	~X	O
	R	C_2:		~X	O
Randomized experimental design with matching	M R	E:		X	O
	M R	C:		~X	O
		Order		**Post 1**	**Post 2**
Within-subjects or crossover design	R	E_1	X	O ~X	O
	R	E_2	~X	O X	O

Note. Assign. = assignment of participants to groups (NR = nonrandom, R = random, M R = matched then randomly assigned). Grp. = group or condition (E: = experimental, C: = control or comparison). Pre = pretest (O = an observation or measurement; a blank means there was no pretest for that group). I.V. = active independent variable (X = intervention, ~X = control, comparison or other treatment). Post = posttest (O = a posttest observation or measure).

Time Series Designs

- Single-Group Time-Series Designs
  - One-group pretest-posttest design
  - Single-group time-series design
- Multiple-Group Time-Series Designs
  - With temporary treatment
  - With continuous treatment

Randomized Experimental Designs

- Controlling for No-treatment Effects (pp. 79-80)
- Posttest-Only Control Group Design (pp. 80-81)
- Pretest-Posttest Control Group Design (pp. 81-82)
- Solomon Four-Group Design (p. 83)
- Randomized Experimental Design with Matching (p. 83)
- Within-Subjects Randomized Experimental (or Crossover) Design


FINDING A SOLOMON
4 GROUP IN THE WILD

You are a researcher in science education who is interested in the role of diagrams in instruct

- Identify the IV(s)
- Identify the DV(s)
- Identify the design name and evaluate its strength

Pretest–posttest nonequivalent comparison group design
Moderate strength quasi-experimental: assigning treatments nonrandomly to groups that are probably similar

GML Chapter 6-7

Single-subject Designs

ABAB (Reversal Designs) | **Multiple Baselines** | **Alternative Treatments**

Establish baseline, give intervention, wait to level off, intervene again! AB -> AB

- Three baselines recorded simultaneously
- Researcher randomly intervenes on one while others are stable
- Compares two different treatments on single subject
- Alternate treatments to establish response pattern

Why Single Subjects?

Using very few participants increases the flexibility of the design and leads to completely different methods of data analysis. These single-subject designs use numerous repeated measures on each participant and the initiation and withdrawal of treatment.

Nonexperimental Approaches!!

There is no *active* IV and the researcher does not control the IV. The IV is *measured* instead.

Types of Nonexperimental Designs

Can you provide an example of each?

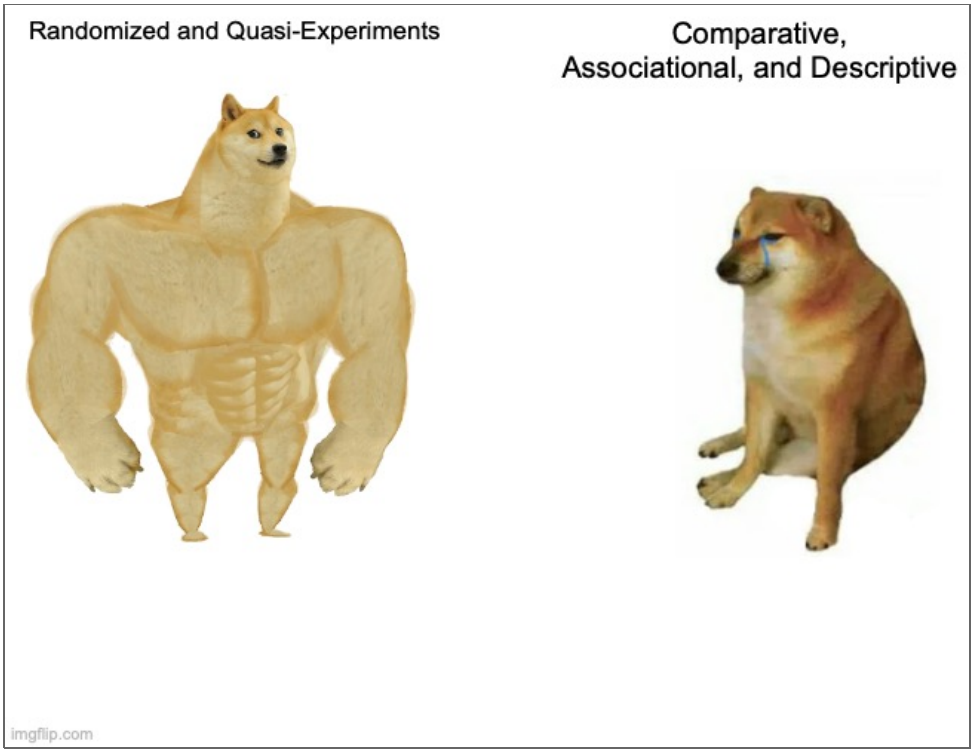
Descriptive | **Comparative** | **Association**

- Only considers 1 variable at a time
- Not interested in drawing inference
- Does not make comparisons or relationships

- Cannot randomly assign to groups
- Examines presumed effects of attribute IV (e.g., age, gender, ethnicity)
- Still has two or more levels composing the IV

- IV is continuous with 5 or more categories
- Everyone in single group
- Ex: Age and Self Concept; Hours watching TV and GPA

Summary


Randomized and Quasi-Experiments
Comparative,
Associational, and Descriptive
imgflip.com

Experiments vs. Surveys

Experiments | **Surveys**

- *Active* independent variables
- Tests *causal* relationships
- Isolates specific relationships between variables of interest
- Controls extraneous influence
- Better suited for theory testing
- Conclusions better reflect true, meaningful, and observed relationships within a physical, tangible world
- Non-experimental by nature
- Relies on attribute independent variables
- Examines the *presumed effect of IV on DV
- Suited to answer questions about preexisting attributes of persons or their ongoing environment that do not change
- Discovers how larger populations think and act without central component of control
- Sets the stage for later examining causality

What's Next?

The first of our two lessons on measurement will be very broad, focusing on measurement theory and definitions. The goal is for you to leave class with a basic understanding of the differences between conceptual and operational approaches, as well as the general steps in developing a measure to adequately assess a variable of interest.

Creating a Codebook

What is a codebook?

The codebook essentially has two functions:

- To provide a guide for the research team coding the data
- To document the data file's layout and code descriptions

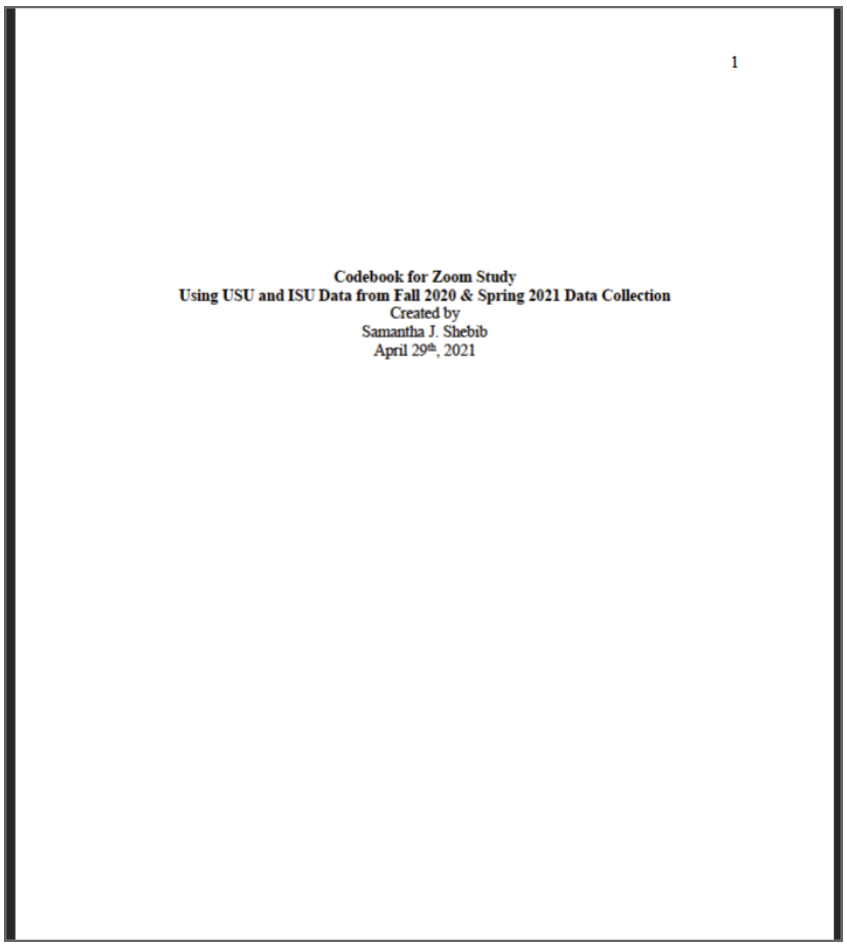
Basically, it helps you keep track of your data as it moves across various stages of the project.

What does it include?

- Survey objectives
- A description of the design and method
- A copy of the survey
- Steps for data cleaning and recording (so you can backtrack later)
- Conceptual definitions
- Operational definitions (i.e., the scales you used)
- Response formats (e.g., Likert, Thurstone, semantic differential)
- Descriptive info for measures (alpha or omega, means, SDs)
- Variable names and codes

Example: Instructor Background and Zoom Cameras

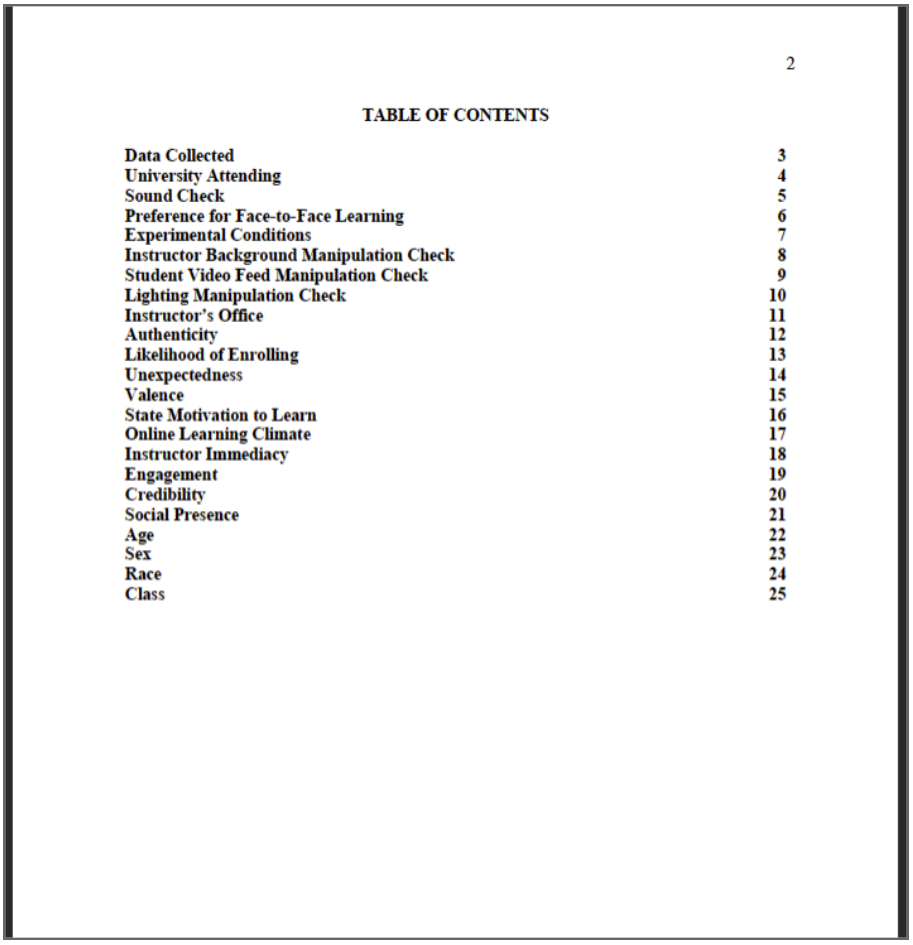
The Study



1

Codebook for Zoom Study
Using USU and ISU Data from Fall 2020 & Spring 2021 Data Collection
Created by
Samantha J. Shebib
April 29th, 2021

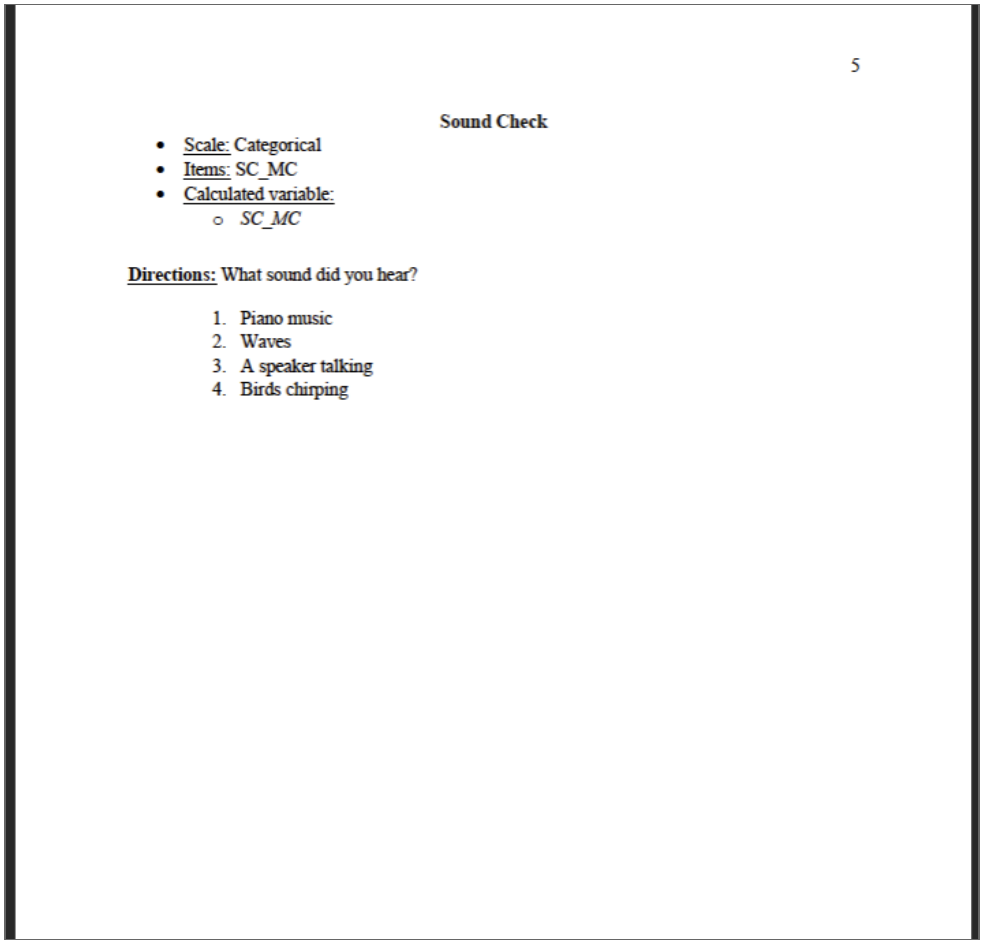
Title



2

TABLE OF CONTENTS

TOC



5

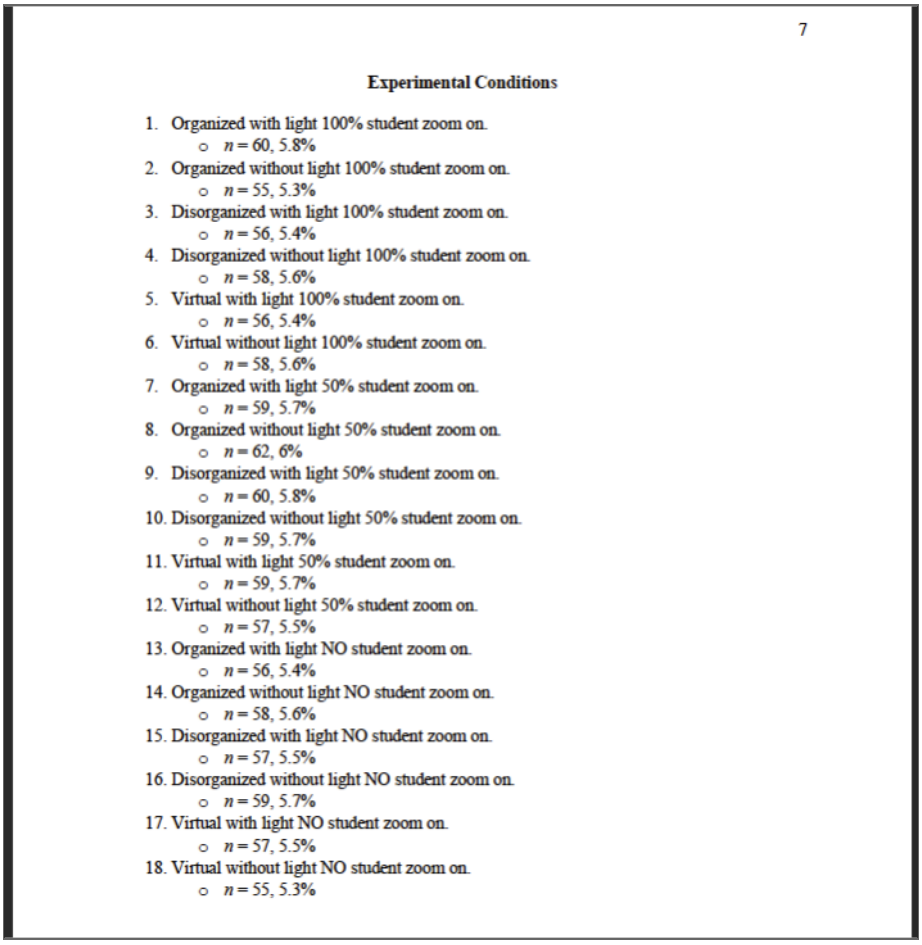
Sound Check

- Scale: Categorical
- Items: SC_MC
- Calculated variable:
  - *SC_MC*

Directions: What sound did you hear?

1. Piano music
2. Waves
3. A speaker talking
4. Birds chirping

Settings

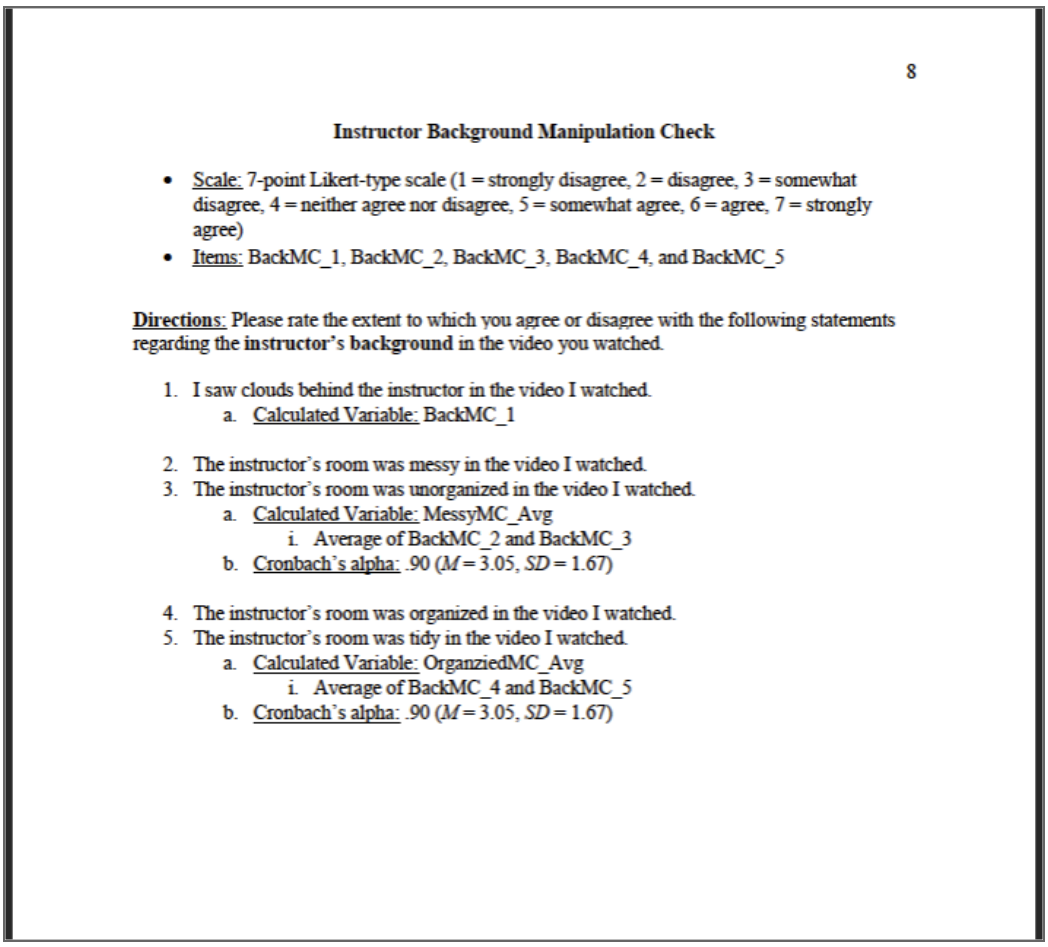


7

Experimental Conditions

1. Organized with light 100% student zoom on.
   - $n = 60$, 5.8%
2. Organized without light 100% student zoom on.
   - $n = 55$, 5.3%
3. Disorganized with light 100% student zoom on.
   - $n = 56$, 5.4%
4. Disorganized without light 100% student zoom on.
   - $n = 58$, 5.6%
5. Virtual with light 100% student zoom on.
   - $n = 56$, 5.4%
6. Virtual without light 100% student zoom on.
   - $n = 58$, 5.6%
7. Organized with light 50% student zoom on.
   - $n = 59$, 5.7%
8. Organized without light 50% student zoom on.
   - $n = 62$, 6%
9. Disorganized with light 50% student zoom on.
   - $n = 60$, 5.8%
10. Disorganized without light 50% student zoom on.
    - $n = 59$, 5.7%
11. Virtual with light 50% student zoom on.
    - $n = 59$, 5.7%
12. Virtual without light 50% student zoom on.
    - $n = 57$, 5.5%
13. Organized with light NO student zoom on.
    - $n = 56$, 5.4%
14. Organized without light NO student zoom on.
    - $n = 58$, 5.6%
15. Disorganized with light NO student zoom on.
    - $n = 57$, 5.5%
16. Disorganized without light NO student zoom on.
    - $n = 59$, 5.7%
17. Virtual with light NO student zoom on.
    - $n = 57$, 5.5%
18. Virtual without light NO student zoom on.
    - $n = 55$, 5.3%

Conditions



8

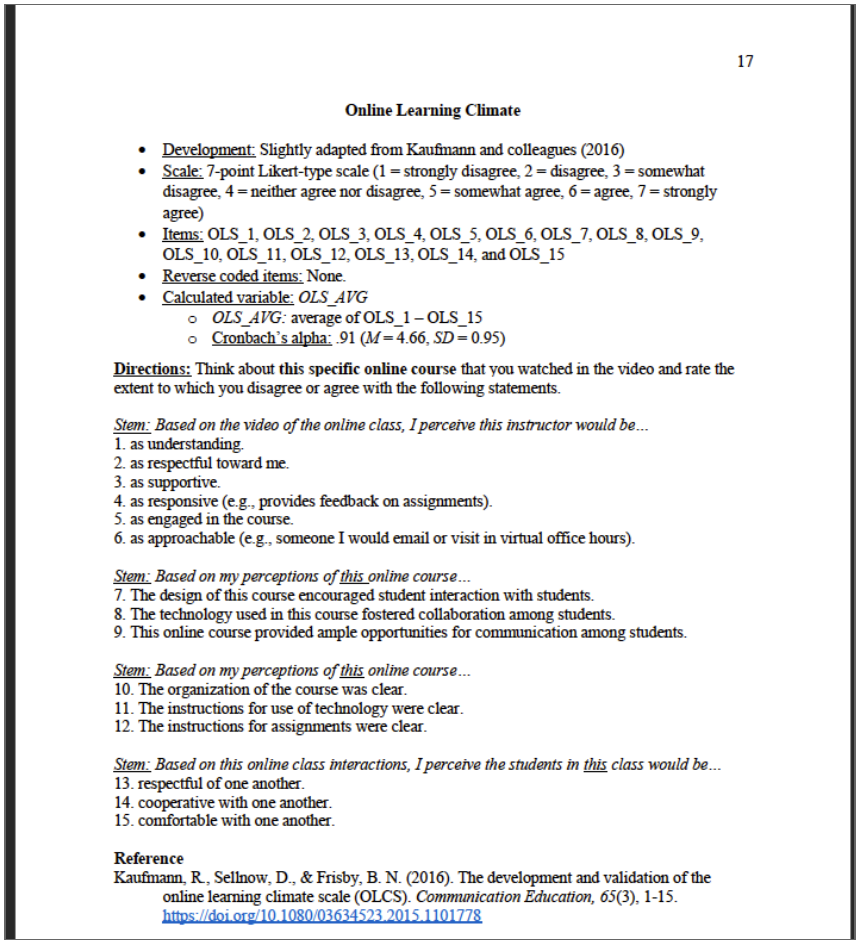
Instructor Background Manipulation Check

- Scale: 7-point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7 = strongly agree)
- Items: BackMC_1, BackMC_2, BackMC_3, BackMC_4, and BackMC_5

Directions: Please rate the extent to which you agree or disagree with the following statements regarding the **instructor's background** in the video you watched.

1. I saw clouds behind the instructor in the video I watched.
    a. Calculated Variable: BackMC_1
2. The instructor's room was messy in the video I watched.
3. The instructor's room was unorganized in the video I watched.
    a. Calculated Variable: MessyMC_Avg
        i. Average of BackMC_2 and BackMC_3
    b. Cronbach's alpha: .90 ($M = 3.05$, $SD = 1.67$)
4. The instructor's room was organized in the video I watched.
5. The instructor's room was tidy in the video I watched.
    a. Calculated Variable: OrganziedMC_Avg
        i. Average of BackMC_4 and BackMC_5
    b. Cronbach's alpha: .90 ($M = 3.05$, $SD = 1.67$)

Manipulation Check



17

Online Learning Climate

- Development: Slightly adapted from Kaufmann and colleagues (2016)
- Scale: 7-point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7 = strongly agree)
- Items: OLS_1, OLS_2, OLS_3, OLS_4, OLS_5, OLS_6, OLS_7, OLS_8, OLS_9, OLS_10, OLS_11, OLS_12, OLS_13, OLS_14, and OLS_15
- Reverse coded items: None.
- Calculated variable: *OLS_AVG*
  - *OLS_AVG:* average of OLS_1 – OLS_15
  - Cronbach's alpha: .91 ($M = 4.66$, $SD = 0.95$)

Directions: Think about **this specific online course** that you watched in the video and rate the extent to which you disagree or agree with the following statements.

Stem: Based on the video of the online class, I perceive this instructor would be…
1. as understanding.
2. as respectful toward me.
3. as supportive.
4. as responsive (e.g., provides feedback on assignments).
5. as engaged in the course.
6. as approachable (e.g., someone I would email or visit in virtual office hours).

Stem: Based on my perceptions of this online course…
7. The design of this course encouraged student interaction with students.
8. The technology used in this course fostered collaboration among students.
9. This online course provided ample opportunities for communication among students.

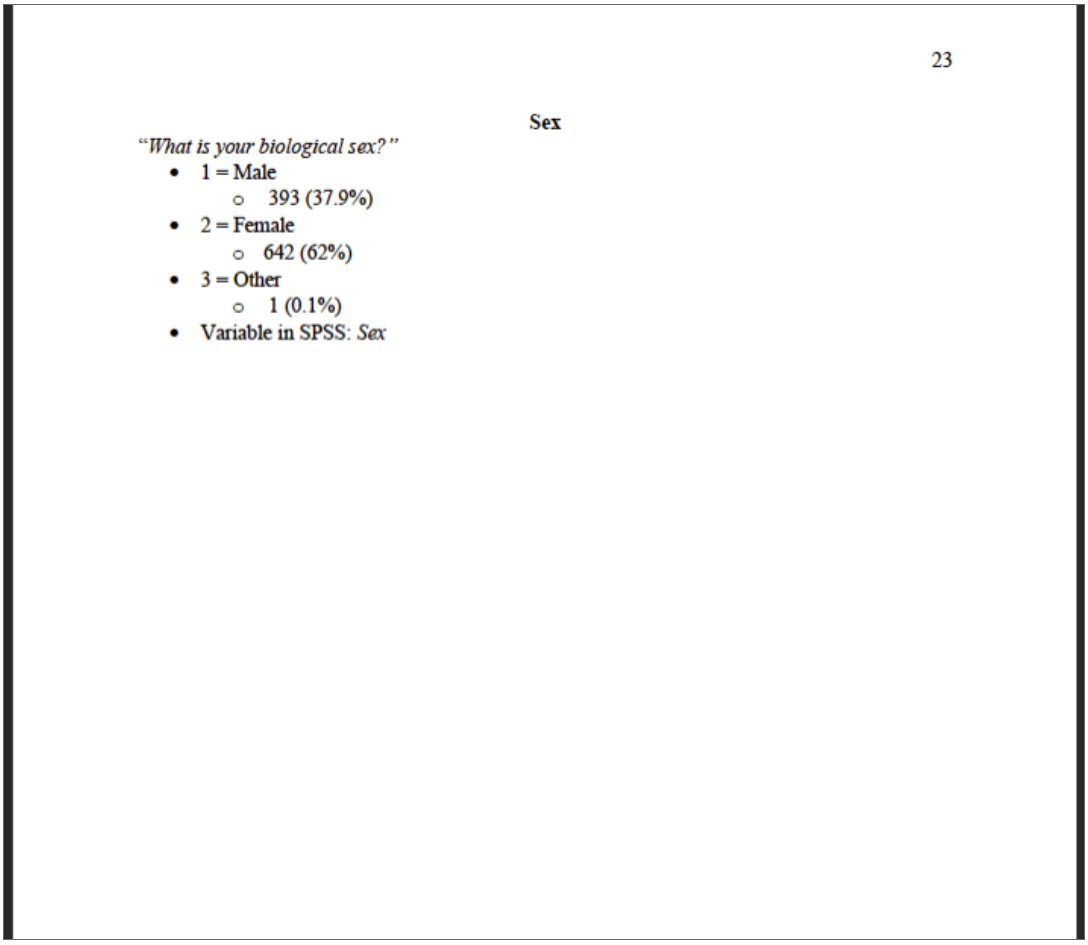
Stem: Based on my perceptions of this online course…
10. The organization of the course was clear.
11. The instructions for use of technology were clear.
12. The instructions for assignments were clear.

Stem: Based on this online class interactions, I perceive the students in this class would be…
13. respectful of one another.
14. cooperative with one another.
15. comfortable with one another.

Reference

Kaufmann, R., Sellnow, D., & Frisby, B. N. (2016). The development and validation of the online learning climate scale (OLCS). *Communication Education, 65*(3), 1-15. https://doi.org/10.1080/03634523.2015.1101778

DV


23
Sex
"What is your biological sex?"
1 = Male
393 (37.9%)
2 = Female
642 (62%)
3 = Other
1 (0.1%)
Variable in SPSS: Sex

Demos

The Worst Case Scenario...

The codebook helps you keep track of your steps.
If you (or a reviewer) has an issue with your data, you have a map of everything that can be done! This allows for easy explanation and/or correction.

Next Steps for your Codebook?

Right now, you are probably working on the IRB protocol. This involves knowing a few things:

- Some background literature
- The RQs or Hs
- The survey design
- Recruitment advertisements / messages
- The measures you want to use
- The sample you want to reach
- How many people you want to sample?

Divide and Conquer.

Frey Facts

Make your codebook however you want. Just keep good records.

Power Analyses

What is power?

Power is the probability of detecting an effect, given that the effect is really there. In other words, it is the *probability of rejecting the null hypothesis when it is in fact false*.

An example

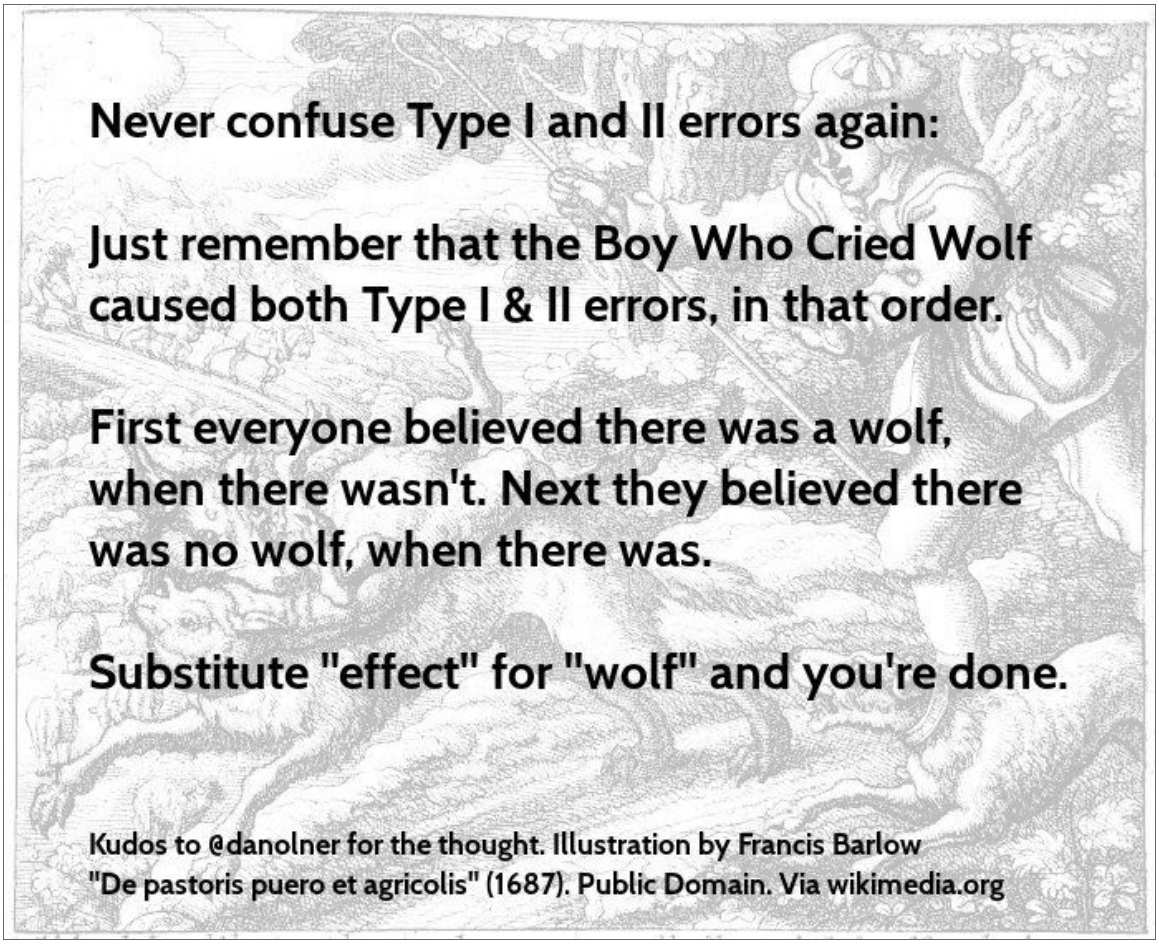
For example, let’s say that we have a simple study with drug A and a placebo group, and that t

Other Definitions

Effect Size: A numerical value representing the strength of the relationship between the IV and DV
Type I error: Occurs when the null hypothesis is true (in other words, there really is no effect), but you reject the null hypothesis
Type II error: A Type II error occurs when the alternative hypothesis is correct, but you fail to reject the null hypothesis (in other words, there really is an effect, but you failed to detect it)

Type I and Type II Error

Null hypothesis is ...	True	False
Rejected	Type I error False positive Probability = α	Correct decision True positive Probability = 1 - β
Not rejected	Correct decision True negative Probability = 1 - α	Type II error False negative Probability = β


Never confuse Type I and II errors again:
Just remember that the Boy Who Cried Wolf caused both Type I & II errors, in that order.
First everyone believed there was a wolf, when there wasn't. Next they believed there was no wolf, when there was.
Substitute "effect" for "wolf" and you're done.
Kudos to @danolner for the thought. Illustration by Francis Barlow "De pastoris puero et agricolis" (1687). Public Domain. Via wikimedia.org

Alpha | **Beta**

The probability of a Type I error (reject a true null).
For a test with a level of significance of 0.05 = 1/20, a true null hypothesis will be rejected one out of every 20 times.
We are willing to live with a 5% chance that we will conclude that there is a difference when there really isn't (we are 95% confident).
The probability of a Type II error (fail to reject a false null)
The probability that we would accept the null hypothesis even if the alternative hypothesis is actually true
If power is .80 or 80%, then beta is .2 or 20%

Putting it all together

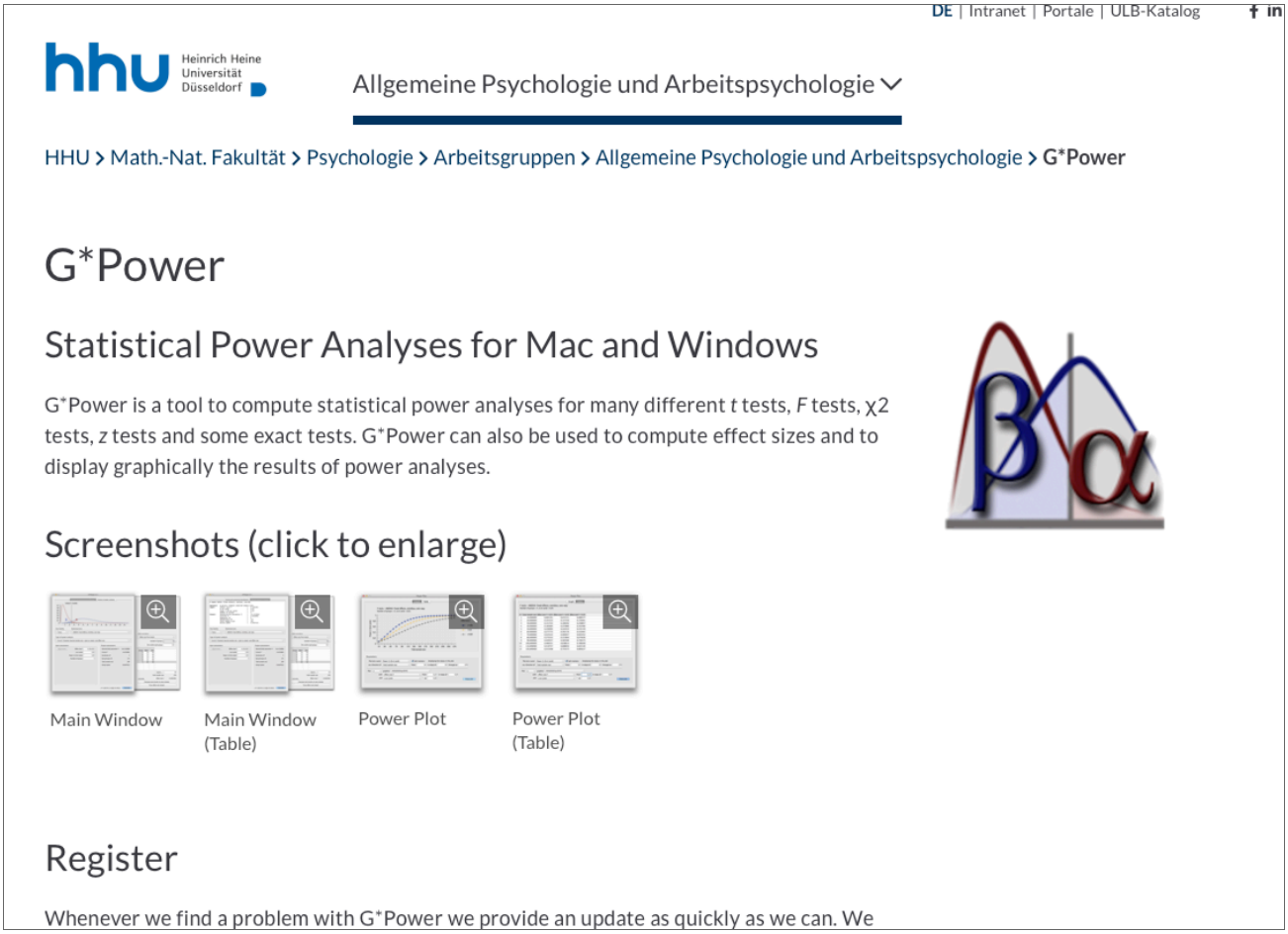
If we want to avoid false positives (Type I), then we raise our confidence level (alpha)
BUT, the more stringent we are at avoiding false positives, the more we increase the probability of a false negative

Why do it?

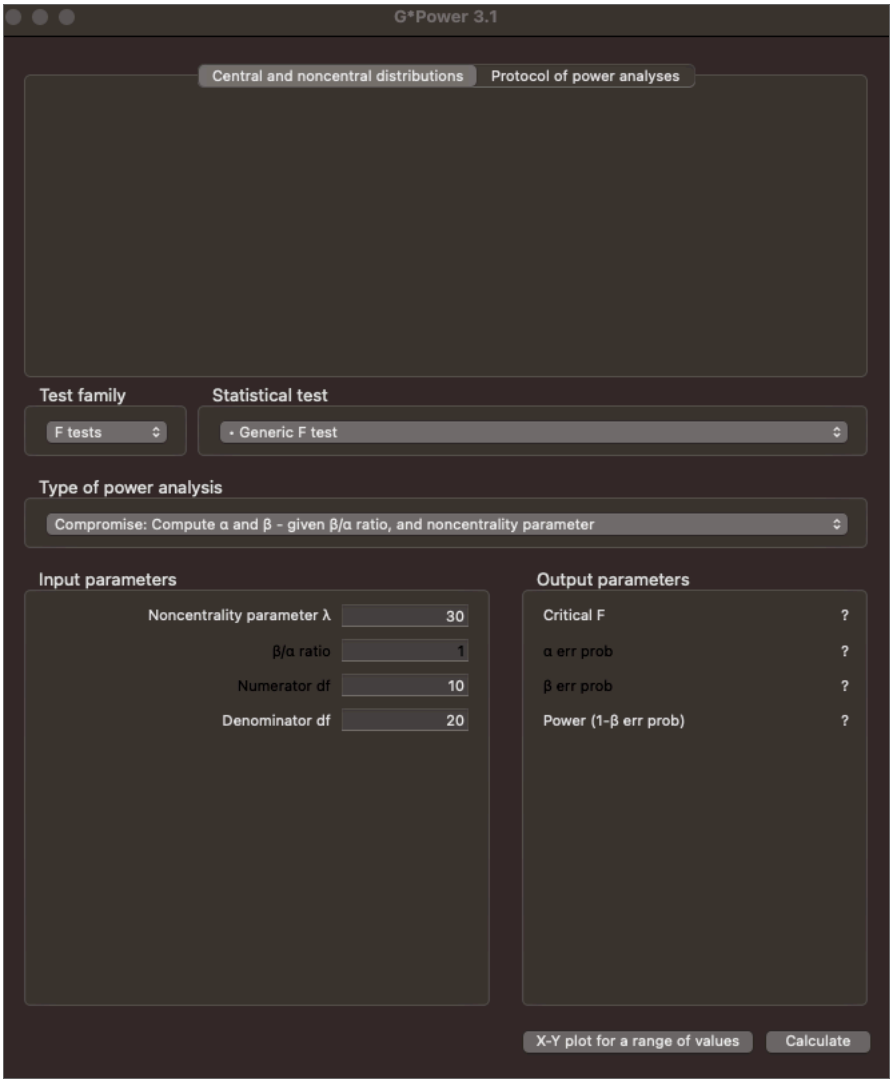
- To determine the appropriate *sample size* needed to detect a certain size effect
- To determine power given effect size and number of subjects
  - If you have 100 people available, you might need to know if it is worth doing the study
- It is good research!

Let's Try: G*Power

Download G*Power



- Test family:
- Statistical test
- Type of power analysis
- Input parameters:
  - Effect size
  - alpha (typically .05)
  - power (typically .80)
- Calculate!



tkfr222@uky.edu | @TKFrey | tkodyfrey.github.io

University of Kentucky