Statistics with jamovi

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Last Update: 2021-06-25

Contents

Welcome

This is the website for PSYC 290 and PSYC 790 at the University of Wisconsin-Stout, taught by Dana Wanzer. These resources are aimed at teaching you how to use jamovi and null hypothesis significance testing (NHST) to answer research questions.

Portions of this book may have been adapted from "Learning statistics with jamovi: A tutorial for psychology students and other beginners" by Danielle J. Navarro and David R. Foxcroft, version 0.70. Furthermore, the template and style of this book is from PsyTeachR.

Chapter 1

Introduction

This chapter will introduce you to the course (PSYC 290 or PSYC 790), the instructor (Dr. Dana Wanzer), and the textbook.

1.1 PSYC 290

Welcome to PSYC 290 - Interpreting Psychological Research! I'm excited to teach this course, because as a follow-up to PSYC 190 you'll be learning about how to analyze and interpret statistical results.

1.1.1 Learning objectives

By the end of the course, you can expect to

1. Understand the appropriate statistical procedure to apply in basic psychological research.
2. Understand the logic behind basic inferential statistics.
3. Interpret pertinent statistical information in psychology-related journal articles and other publications.
4. Conduct appropriate statistical tests using statistical software.
5. Interpret and evaluate the results of statistical tests.
6. Report the results of statistical analyses using APA style.

In particular, you're going to learn how to analyze data in a statistical program called jamovi, although occasionally we will practice interpreting output from SPSS and R so you can get some experience interpreting statistical output from other statistical software.

1.1.2 Weekly Schedule

This class is purely online and asynchronous in Spring 2020, meaning we will not meet as a class at any point during the semester. Each week will look pretty similar:

1. You will have assigned readings that may include book chapters, chapters from this online textbook, journal articles, or videos.
2. After completing the readings, you will complete a reading reflection to demonstrate you completed the readings, understand the material and its application, help develop the glossary for this textbook, and ask questions.
3. You will have a practice activity each week to help you understand and apply the material. You can complete these repeatedly until you receive full credit.
4. Optionally, you can attend student hours to work on homework, ask questions, and get extra practice examples to extend your understanding. While they are all optional, they are highly recommended and you will be required to attend at least two student hours throughout the semester.
5. Lastly, you will complete either a homework assignment or exam to test your understanding of the material. Homework assignments can be redone with an additional reflection.

1.1.3 Late assignments and re-doing homework

All assignments can be turned in late for absolutely no penalty; however, there are specific dates that are hard deadlines to help you stay on track in this course. Life happens, and sometimes you won't be able to complete an assignment for a week or two and that is completely understandable.

That being said, you should make every effort to stay on top of the coursework in this class. Dedicate hours to work on course activities so you do not fall behind! Please reach out to me if you start feeling overwhelmed or need help getting back on track. I am here to support you!

Furthermore, if you do not get the grade on the homework assignment that you want you can always re-do the homework assignment for up to full credit. There will be additional work you will need to complete to be able to re-do an assignment; more information on this will be available on Canvas.

1.1.4 Getting help in this class

Come to student hours regularly! The GA and myself are *always* available to help you. We will be scheduling regularly recurring student hours each week so you can come ask questions, get help on your homework, or just have a space to come together to work on your assignments in a dedicated online space.

We will also have an online Microsoft Teams team channel so that you can ask questions there. This way everyone can benefit from the answers to questions

students have!

If you have more personal questions, you can message me on Teams or email me at wanzerd@uwstout.edu.

1.2 Dana, your instructor

My name is Dana Wanzer (pronounced DAY-nuh JUAN-zur) and I started teaching at UW-Stout in Fall 2019. I teach statistics (BS and MS programs) and evaluation (MS program) in the psychology department. I *love* statistics! It is one way we can answer our research questions and test our hypotheses.

However, I know not everyone likes statistics. Some of you may not care much about them, and some of you may be scared about taking this course (especially in a pandemic and in an online asynchronous environment). Please know that **I am here for you and I want to make this class an enjoyable learning experience**. If there is anything I can do to help make this class more enjoyable and to help you learn, please reach out to me.

1.3 Navigating this website/book

This book was developed in R/Rstudio using bookdown and is hosted on a platform called GitHub. You can see the code for this book here.

There are some icons at the top of this book that you may find useful:

1. The first button of the toolbar toggles the visibility of the sidebar, which contains the table of contents. You can also hit the `S` key on your keyboard to toggle the sidebar.

2. The second button of the toolbar is the search button, which you can use to search the entire book. You can also hit the `F` (Find) key on your keyboard.

3. The third button is for font/theme settings, which you can use to change font size (smaller or bigger), font family (serif or sans serif), and theme (white, sepia, or night).
4. The fourth button provides information on the keyboard shortcuts.
5. On the right of the toolbar are icons to share on various social media platforms.

At some point when the textbook is more finalized, it will be turned into a PDF that can be downloaded and saved to your computer for use in the future. I will let you know when that happens!

1.3.1 Quiz questions

Throughout this textbook, there will be questions to help you test your knowledge. When you type in or select the correct answer, the dashed box will change color and become solid.

For example:

- What is 2+2?
- We attend the University of Wisconsin- Stout Madison Green Bay
- True or false: Dana thinks statistics is awesome. TRUE FALSE

1.3.2 Errors, mistakes, and suggestions

I am human, therefore I err. If you find an error in the textbook or something you think might be a mistake, please let me know ASAP so I can update this for everyone else. Let me know which section you find the error or mistake in and what the error or mistake is. For example, if there was an error here you could say, "There was an error in 1.2 that the first sentence should really be 'To err is human (Alexander Pope, 1711).'"

In addition, if you have ideas to help make this textbook even better, please let me know. I would love to make this a useful resource to you both during our course and in your future research. Help me in making that a reality!

Chapter 2

Statistics foundations

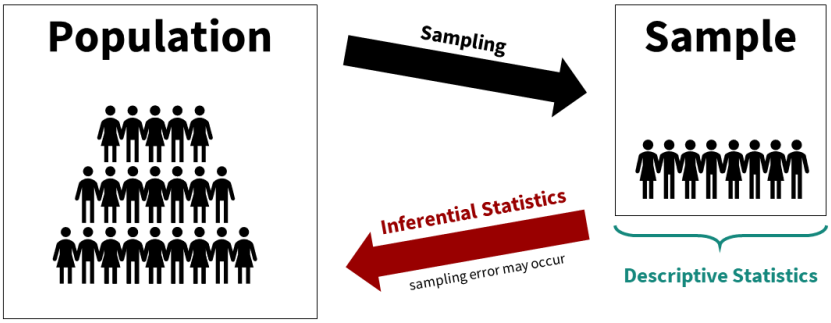
You have learned about both quantitative and qualitative methods. We will be focusing primarily on quantitative methods in this class and in this textbook. By quantitative methods, I mean methods that predominantly collect quantitative data that deals with numbers. We can then analyze that data using statistical procedures, which we will shorthand to "statistics." Understanding what we mean by statistics is the purpose of this chapter.

2.1 Descriptive vs inferential statistics

There are basically two different types of statistics:

1. **Descriptive statistics** are used to summarize, organize, and overall *describe* our sample data. Typically, we do so using measures of central tendency (e.g., mean, median, mode) and measures of dispersion (e.g., range, standard deviation, variance). We may also visualize the data using tables or graphs.
2. **Inferential statistics** are what we use when we collect data about a sample and see how well that sample *infers* things about the population from which the sample comes from. Typically, we do so with statistical tests like the t-test, ANOVA, correlation, chi-square, regression, and more.

We can visualize the relationship between the population, sample, descriptive statistics, and inferential statistics (see figure below). We are typically interested in a **population** of interest but may not be able to collect data from the entire population because of budget, time, access, or other constraints. We therefore **sample** from the population; ideally, we do so randomly, but there are other types of sampling methods available. We then use **descriptive statistics** to describe our sample data and **inferential statistics** to make generalizations about the population from which they were selected.



2.1.1 An example

This has been pretty abstract so far. Let's go through a fairly simple research study to walk through all of this.

Imagine we're conducting an experimental study examining whether watching Schitt's Creek–a very good show–versus watching video lessons on studying techniques–useful, but boring–improved test performance in UW-Stout students.

Our population of interest is therefore all UW-Stout students, roughly 9,500 students total. We cannot include them all in our study; it wouldn't be feasible for us to collect all that data and probably not possible to get the university to get on board with the study of the entire student body. Therefore, we smartly decide to only collect data from a sample of the student body.

Who might our sample be? Ideally, we'd gather a random sample of the 9,500 students. However, to do that we'd likely need to still get university approval and get a list of a portion of student emails for recruitment purposes (oversampling because our response rate is unlikely to be 100%). I just want to do this study to show what descriptive and inferential statistics are, so I just use students in my two sections of introduction to psychology classes (around 80 students total) as my population. This is definitely not a random sample, but a fine study for our illustrative purposes.

We conduct our study–let's assume we're fabulous researchers and it worked out perfectly. We randomly assign half our students to watch Schitt's Creek as part of their studying, and the other half watch video lessons on studying techniques. They have an exam a week later and we measure their accuracy on that exam. We then want to know: which group performed better on the exam?

First, let's describe the sample. We would likely visualize our results, perhaps as a histogram of all test scores, maybe separated by which group they were in. This would help us look at whether our data is normally distributed (more on this in a subsequent chapter on assumption checking). We would get the

descriptive statistics: probably the mean, maybe the median if our data is skewed, the standard deviation and variance, and the range. If we wrote up our results and didn't share a visualization, this information would give a good sense of our data to our readers.

But what we really want to know is: which group performed better on the test? For that, we need our mean, standard deviations, and sample sizes for both groups. We then plug the numbers into the equation for this particular inferential statistic (in this case, an independent t-test, but we'll learn about that later) or–even better–we perform the statistic in our statistical software (jamovi). It spits out our statistical value and our p-value and we can then infer what the results mean for our population and answers our research question.[1]

2.2 Measures of central tendency and dispersion

There are multiple **measures of central tendency** (these are *all* averages so you must be careful when you say that word to explain which type you mean!):

- **Mean**: the sum of all points divided by the total number of points; susceptible to outliers
- **Median**: the middlemost value; less susceptible to outliers and best used when the data is skewed
- **Mode**: most frequent score
  - **Multimodal** or **bimodal**: when two or more values are the most frequent score

There are other terms we use to describe data:

- **Frequency distribution**: overview of the times each value occurs in a dataset; often portrayed visually like with a histogram
- **Histogram**: a visual depiction of the frequency distribution using bars to depict a range of the distribution
- **Kurtosis**: the weight of the tails relative to a normal distribution. There are some fancy terms related to kurtosis that you may hear about, but honestly I don't hear them used very frequently by researchers.
  - **Leptokurtic**: light tails; values are more concentrated around the mean

[1] You might be wondering: well, what were the results? Which group performed better? As much as I love Schitt's Creek, most students don't know how to study well, and so the students who watched the video lessons on studying techniques far outperformed the students who watched Schitt's Creek.

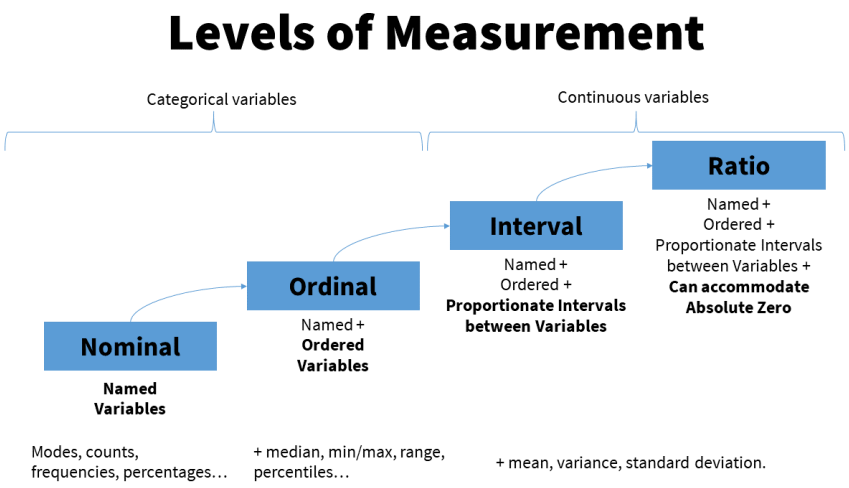
Interested in better techniques for studying? Check out The Learning Scientists. This articledoes a good job of summarizing the research on effective study practices.

  - **Platykurtic**: heavy tails; values are less concentrated around the mean

- **Normal distribution**: a special distribution in which the data are symmetrical on both sides of the mean; under a normal distribution, the mean is also equal to the median
- **Quartile**: when a dataset is divided into four equal parts, each part is a quartile (Q1, Q2, Q3, and Q4)
  - **Interquartile range**: the middle 50% (Q1 to Q3)
- **Range**: the difference between the maximum and minimum value (e.g., if the minimum score is 17 and the maximum is 49, then the range is 32)
- **Skew**: in a non-normal distribution, it is when one tail of the distribution is longer than another. Present in asymmetric distributions
  - **Negative skew**: when the tail points to the negative end of the spectrum; in other words, most of the values are on the right side of the distribution
  - **Positive skew**: when the tail points to the positive end of the spectrum; in other words, most of the values are on the left side of the distribution

2.3 Levels of measurement

This should be refresher material for you, but it is extremely important you are familiar with the four levels of measurement.



Categorical: variables that have *categories* to the levels, but cannot be analyzed with a mean because the levels are not proportionate. There are two types of categorical variables:

- **Nominal**: a categorical variable in which each level of the variable is named but there is no order to them (e.g., breeds of dogs)
  - **Binary**, **dummy-coded**, or **dichotomous**: a nominal variable with only two levels (general 0 or 1). This is a special type of nominal variable.
- **Ordinal**: a categorical variable in which each level of the variable is named and there is an order to them (e.g., ranks)

Continuous: variables with proportionate intervals between the levels meaning they can be analyzed with a mean, SD, variance. There are two types of continuous variables (although for the purpose of this course we will simply call them continuous variables):

- **Interval**: a continuous variable that has intervals that are directly proportionate (e.g., the distance between 2-3 is the same as the distance between 5-6)
- **Ratio**: a continuous variable like an internal variable but can accommodate an absolute zero, meaning a zero is actually possible (e.g., weight, temperature in Kelvin, reaction time)

2.3.1 Examples of levels of measurement

Confused still on the levels of measurement? Maybe this will help! Notice that studying can be measured at different levels. Depending on the nature of the question and response options, it might be nominal, ordinal, or continuous! Here's an example of data at the continuous, ordinal, and nominal level.

Name	Study_Continuous	Study_Ordinal	Study_Nominal
Name (Character)	*Hours studied per day*	*Likert scale of amount of studying*	*Whether or not they study every day*
Jesus	5.0	A great deal	Yes
Nicky	4.5	A great deal	Yes
Bradford	3.2	A moderate amount	Yes
Sylvia	1.7	A small amount	Yes
Martha	0.2	Rarely	Yes
Lillian	0.0	Never	No
Trayvon	0.0	Never	No

We can make any continuous variable into an ordinal and nominal variable and any ordinal variable into a nominal variable. But if we have a nominal variable

we cannot make it ordinal, nor can we make an ordinal variable continuous. In other words, continuous variables *contain more information*. Often, we want to avoid losing information and *always* keep the variable at the highest level of measurement. Continuous has more information than ordinal has more information than nominal.

Another way to put it: never do a median split and avoid "collapsing" categories when you can. You're losing information from your data by doing so.

2.4 Normal distribution

A very important distribution of data is known as the **normal distribution**. You may have also heard it called a bell-shaped curve. It has really important statistical properties which is why most of the inferential statistics we'll be learning in this class are *parametric statistics* that assume our data has a *normal distribution*.

Some of the important statistical properties of the normal distribution:

- Data are equally distributed on both sides of the mean.
- Skew and kurtosis are equal to 0, which is to say there is no skew or bad kurtosis.
- The mean is equal to the median, and both are the exact center of the distribution of data. In other words, if your mean and median are *not* the same, you know you have skewed data! In fact, if your median $<$ mean then you have positive skew and if your median $>$ mean then you have negative skew.
- We know the percentage of cases within 1, 2, 3, etc. standard deviations from the mean.

2.5 Key Terms

This chapter will cover some basic key terms you should recall from PSYC 190. These terms will come up repeatedly throughout the semester.

2.5.1 Study design terms

Some terms you should be familiar with:

- **Between-group/subject design**: different people are in each condition; participants are only exposed to a single condition
- **Correlational research**: a study in which causality cannot be claimed; correlation does not infer causation! It is, however, one of three necessary conditions to infer causality. It is a *necessary* but *insufficient alone* condition.

- **Cross-sectional research**: also called non-experimental research; the IV is not manipulated and there is no random assignment. Furthermore, data is only collected at one time point (as opposed to longitudinal research)
- **Experimental research**: the IV is manipulated and there is random assignment
- **Falsification**: A key way we separate science from pseudo-science is that we attempt to *falsify* our hypotheses as opposed to try *verify* our hypotheses. Null hypothesis significance testing (NHST) is about falsifying the null hypothesis; we can never truly verify our alternative hypothesis.
- **Hypothesis**: What we think the answer to our research question is (often our alternative hypothesis). The alternative and null hypotheses must be mutually exclusive (a result can't satisfy both) and exhaustive (all possible results are specified)
  - **Alternative hypothesis**: Often that the IV had **an** effect on the DV; can be specified as a two-tailed (an effect) or one-tailed (greater/less than) hypothesis
  - **Null hypothesis**: Often the *nill* hypothesis in that the IV had **no** effect on the DV
- **Qualitative methods**: Broadly, methods that focus on words and meaning (e.g., interviews)
- **Quantitative methods**: Broadly, methods that focus on numbers and statistics (e.g., Likert scales)
- **Quasi-experimental research**: the IV is manipulated but there is no random assignment
- **Randomization**: participants are randomly assigned to conditions
- **Repeated-measures design**: participants are repeatedly measured on the dependent variable, either across conditions or across time
- **Theory**: A description of a behavior that makes predictions about future behaviors
- **Variation**:
  - **Systematic**: researcher something systematically error into the study, especially into one condition over another. For example, by randomly assigning participants into one of two conditions, we are introducing systematic variability between participants. However, it could be unintentional systematic variation; for example, perhaps we have two researchers collecting data and one is mean and the other is nice, and so participants respond differently depending on which researcher collects data from them.
  - **Unsystematic**: random variation

- **Within-group/subject design**: the same person is in all conditions

2.5.2 Variables

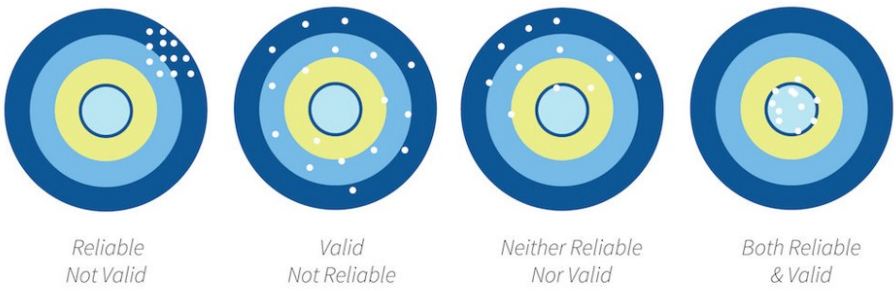
We tend to talk about two different types of variables in our studies:

1. **Independent variable** (IV; also known as the predictor variable): this is the variable that is thought to be the cause of some effect. In experimental research, it is the variable that is manipulated.
2. **Dependent variable** (DV; also known as the outcome variable): this is the variable that is thought to be affected by changes in the IV.

There are other types of variables we may be interested in:

- **Confounding variable**: a variable that affects or is related to both the independent and dependent variable
- **Covariate**: a variable that only affects or is only related to the dependent variable

2.5.3 Reliability and validity



- **Reliability**: the consistency of a measure by time (test-retest reliability), across items (internal consistency) or across different researchers (inter-rater reliability)
- **Validity**: the extent to which a test measures what it claims to measure
  - **Construct validity**: validity of inferences about the higher order constructs that represent sampling particulars. There are multiple types of construct validity; here are a few:
    - **Content validity**: experts using their judgment that something measures what it is supposed to measure
    - **Convergent validity**: correlations among two theoretically related constructs (or measurements) are strong and positive
    - **Divergent validity**: correlations among two theoretically not-related constructs (or measurements) are zero/null

    - **Criterion validity**: content on one test (predictor) correlates with performance on relevant criterion measures (outcome)
- **Statistical validity**: validity of inferences about the correlation between treatment and outcome
- **Internal validity**: validity about whether the observed relationship between A and B reflects a causal relationship between A and B
- **External validity**: validity of inferences about whether the cause-effect relationship holds over variation in persons, places, treatment variables, and measurement variables

2.5.4 Other terms

If other terms come up in the course of the semester that you believe should belong in this key term website, include it in your weekly reflection so I can update this page!

Chapter 3

Overview of jamovi

jamovi is a free and open statistical software that helps us run our descriptive and inferential statistics. Why are we using jamovi and not another program?

1. Did I mention it's free? You won't ever have to pay a dime to use the software in the future.
2. It's open source, meaning that the statistical community helps support and improve the program. As jamovi says, "jamovi is made by the scientific community, for the scientific community."
3. It's built on top of the R statistical language, meaning you can begin learning how to code (if you want). I do all of my statistical analyses using R in a different program called RStudio (actually this book was developed in RStudio and hosted on GitHub!). It's a very powerful tool which is also free and open source.
4. It's incredibly easy to learn and use. I have taught statistics using both SPSS and jamovi, and students (and I!) greatly prefer jamovi.
5. It promotes reproducibility. jamovi will save your data, analyses, options, and results all in one file so you can easily pick up where you left off. This will make your homework and future data analyses a breeze.

3.1 Getting started with jamovi

Throughout this course, you will be watching videos from the Introduction to jamovi LinkedIn Learning course by Barton Poulson, founder of datalab.cc. By the end of this course, you will receive a certificate indicating you watched all the videos that you can put on your LinkedIn profile.

For this chapter, you should first watch the first set of videos (Introduction