

**Western University**  
**Department of Psychology**  
PSYCHOL 9041

**Introduction to Data Management and Linear Modeling Using R**  
**Fall 2023**

**Lecture: See Student Centre for course times and locations.**

**Lab: See Student Centre for course times and locations.**

**Enrollment Restrictions**

Enrollment in this course is restricted to graduate students in the Department of Psychology, as well as any student that has obtained special permission to enroll in this course from the course instructor as well as the Graduate Chair (or equivalent) from the student's home program.

**Instructor and Teaching Assistant Information**

Instructor: Dr. John Sakaluk (“Sack-uh-luck”) (He/Him/His)

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Teaching Assistant	TBD
Email	TBD
Office	TBD
Office Hours	TBD

**Course Description**

The last decade has seen a rapid increase in the popularity of the statistical programming language R as a data analysis workhorse of the social sciences. This popularity is largely owing in R's status as both an open source, cross-platform, and all-inclusive alternative to other proprietary, operating-specific, and analysis-specific statistical software (e.g., SPSS, SAS, Mplus, CMA), as well as its tremendous capacity for data visualization and reproducible document creation.

With R, it is often the case that fitting one's desired statistical model is the quickest and most straightforward part of the data-analysis process; where useRs experience a sometimes challenging learning curve is the before and after steps. In this course, we will therefore focus on increasing your fluency with getting the data you need into R and appropriately wrangled, and to also calculate and extract the pieces of quantitative information you need from your datasets and place them into compelling formats for dissemination.

Most days will include a lecture and a live-coding session (including discussion and Q&A). There is also a lab each week, during which you will have time to apply coding techniques taught during the course. Throughout the course you will also be expected

to complete several self-guided tutorials (some of which include video content). See the Schedule of Dates and Activities for a complete list of topics.

### **Course Format**

The course will be taught synchronously--initially in person, with the flexibility to pivot to online via zoom should public health circumstances dictate a shift.

### **Course Learning Outcomes/Objectives**

Upon completion of this course, students should be able to:

1. Understand the value (to themselves and others) of creating and maintaining a “mindlessly reproducible” coding workflow for data analysis
2. Understand at a “birds-eye” level how R handles information (e.g., assignment to objects, object types, common operators), enabling them to write (and read) sensible code
3. Apply features of a mindless reproducible workflow to their analyses (e.g., projects, absolute file paths, coherent and documented R Markdown files or Scripts)
4. Apply common “tidyverse” functions for the purpose of data management (e.g., importing data, selecting cases and variables, creating or altering variables and their values, transforming and/or merging across data sets)
5. Apply the psych package for computation (and evaluation) of more complex psychometric scores
6. Calculate simple descriptive statistics (e.g., frequency, central tendency, dispersion, missingness)
7. Create dynamically populated tables with reproducible values of descriptive statistics and/or model output
8. Create (and understand) effective visualizations of of raw data, descriptive statistics, and/or inferential trends
9. Understand the major elements of the general linear model (e.g., observed vs. predicted scores, intercepts, slopes, variables, residuals) and how they can be combined to conduct a variety of commonly used analyses in psychological research (e.g., *t*-tests, analyses of variance, regression, moderation and mediation)
10. Apply linear models to data sets in R, and correctly interpret and/or extract diagnostic, model, and/or parameter estimate information
11. Dynamically report general linear model output (i.e., reproducibly in text, tables, and/or visualizations)
12. Appreciate how modifications to the general linear model enable more specialized forms of data analysis (e.g., categorical data analysis, analysis of dependent observations, multivariate modeling)
13. Apply and understand simple loops and user-written functions to expedite computationally- or coding-intensive tasks

### **Course Materials**

The course will require you to regularly consult several open-access resources to learn about how to do different things in R (e.g., basic data management, visualization, RMarkdown). Most of these have hard-copy versions that you can purchase, if interested (I own/regularly use many of these), but the open-access versions are entirely sufficient (and oftentimes more recently updated than the hardcopy versions).

## **Books**

1. [R for Data Science](#) (“R4DS”, Grolemund & Wickham)
  - Basics of data importation, management, and visualization
2. [R Graphics Cookbook](#) (“The Cookbook”, Chang)
  - “Recipes” for ggplot syntax for virtually any type of plot imaginable
3. [Fundamentals of Data Visualization](#) (Wilke)
  - Less of a “how-to?” and more of a “what and why?” resource for good data visualization practices
4. [Learning Statistics with R](#) (“LSR”, Navarro)
  - An excellent introductory grad-stats textbook with application in R
5. [Beyond Multiple Linear Regression” Applied Generalized Linear Models and Multilevel Models in R](#)
  - An in-development (but still great-looking) resource for modeling non-normal, categorical, and multilevel observations
6. [Big Book of R](#)
  - Not an independent book, but organized like a book with a Table of Contents to link to open source books (incl. Some mentioned here) for various tasks (from general-specific, basic-advanced) in R

## **Software**

Please have the following software downloaded and installed/accounts created before the start of the first day of class.

1. [R](#) (Download/Install)
  - *R* is the program that actually does the programming/analytic “work”
2. [RStudio](#) (Download/Install)
  - *R* Studio adds a graphic interface to *R* (including a script editor) that greatly improves *R*’s functionality and user-friendliness. I wouldn’t attempt to try to learn/use *R* without it!
3. [A LaTeX TeX distribution](#) (Download/install [different options for Mac and Windows])
  - LaTeX is a system for rendering text, math, and symbols (imagine: how painful it would be to specify complex equations having to go into Word’s “symbol” list one at a time...). This is necessary for R Markdown to be able to fully knit your documents.

4. [Slack](#) (Download/install)
  - Slack will be useful for everyone (including myself and the TA) to more expediently ask/answer questions, share resources, ask for help, etc., as a community of learners, than email/office hours (which should be reserved for more complex/personalized matters). Please join the channel here.

### ***Other Helpful Online Resources***

1. [RStudio Primers](#)
  - The RStudio team has already created several online tutorials called “Primers” to help ease your learning into particular types of tasks in *R*. We will use these throughout the semester.
2. [RStudio Cheat-Sheets](#)
  - The RStudio team has created “cheat-sheets” for key processes and tidyverse packages. These provide nice overviews of the key concepts, functions, and arguments needed to perform common tasks in *R*, and are a great place to start troubleshooting problems you come across.
3. [R for Psychological Science](#)
  - Created by Dr. Dani Navarro (of LSR fame), this is an incredible set of videos and tutorials for many of the skills you will be developing throughout the class
4. R Package documentation .pdfs and (when possible) vignettes (see the [documentation](#) and [vignette](#) for metafor:: as an example)
  - For most other packages, you will often need to do your own detective-work to identify the functions you need, the arguments they will demand, and how to navigate the output they will supply. Mainstream packages have a standard-looking documentation .pdf that will provide this information to you; other (often well-developed) packages will also have more user-friendly vignette (i.e., tutorial) papers demonstrating the core functionality of a package.
5. [StackOverflow](#) and [CrossValidated](#)
  - Community Q&A websites for programming (e.g., *R*) and statistics questions (those that are not programming-related), respectively. When you can’t solve your own problems, the answers are often already waiting for you in a post here, and if not, you can ask the community who are often very responsive/effective (but your mileage with friendliness/warmth may vary...).

## Methods of Evaluation

Assignment	Date of Evaluation (if known)	Weighting
Coding Capacity Building Assignments (x6)	Throughout Semester	36% (6% each)
R Language Fluency Test	Oct. 27	15%
Data Viz Assignment	Nov. 10	15%
Capstone Project	Dec. 8	34%
Total		100%

### Coding Capacity Building Assignments (x6)

These capacity building assignments are designed to incrementally increase your ability navigate the coding environment in R and add to your ability to manage, describe, and analyze data in R. These will typically be graded according to a rubric that assigns points on the basis of assignment reproducibility AND correctness.

You are permitted to submit *one* of the six Mini-Assignments up to two days late without explanation (life happens); it will be graded without penalty (however, you will not receive a grade/feedback at the normal pace, and we cannot guarantee it will be returned in advance of the next mini-assignment submission). Submissions more than two days late will not be graded without a formal/excused absence (i.e., with official documentation).

### R Language Fluency Test

This test will occur during class time, and contains roughly 30 questions designed to assess your ability to read, interpret, and anticipate the output of R code.

For the R Fluency Test, a formal/excused absence (i.e., with official documentation) is necessary should you miss the day of the test.

### Data Viz Assignment

This assignment will assess your ability to describe a “story” you wish to tell with data visualization and apply it in code. You will need to make 2-4 visualizations in 2x styles: 1) benefit for publication in a peer-reviewed journal; and 2) benefit for a more dynamic dissemination outlet (e.g., a science knowledge translation outlet, a blog, social media). You will (like the Coding Capacity Building Assignments) be graded on the basis of both reproducibility AND correctness, with the correctness points being affected by a “complexity modifier” based on the difficulty of the visualization techniques you have applied.

For the Data Viz. Assignment, late work (defined as beginning once the submission portal closes) will be penalized by a 5% deduction from your assigned grade per day of lateness, up to a maximum of 5 days, at which point you will be assigned a grade of 0. For example, if your submission was originally graded as 8.5/10, but you submitted it two days late, you would receive  $8.5 \times (1.00 - [.05 \times 2])$ , you would receive an adjusted grade of 7.65/10.

## Capstone Project

For the Capstone Project, you will be asked to create a new/full “mindlessly reproducible” analytic workflow for a data set and analysis(/analyses) of your choosing. You will be able to bring your own data set into the course (e.g., from your honours thesis of yore [as long as you have not analyzed it in R before], a data set from your advisor [used with permission], an open data set available online), and write a dynamic research paper, including a short introduction, full (and reproducible) methods and results sections, and a short discussion section. Like the Data Viz Assignment, you will be graded on the basis of both reproducibility AND correctness, with the correctness points being affected by a “complexity modifier” based on the difficulty of the analytic techniques you have applied.

For the Capstone Project, late work (defined as beginning once the submission portal closes) will be penalized by a 10% deduction from your assigned grade per day of lateness, up to a maximum of 5 days, at which point you will be assigned a grade of 0. The increased penalty is a result of the strain lateness will introduce for timely submission of final grades. For example, if your submission was originally graded as 36/40, but you submitted it three days late, you would receive  $36 \cdot (1.00 - [.15 \cdot 3])$ , you would receive an adjusted grade of 25.2/40.

## Course Timeline

Week	Date	Topics/Content Areas/ Learning Activities	Suggested Resources
1	Mon, Sept. 11	Intro to the Class, R and R-Studio: Reproducible Workflows, and How R Processes Information	<ul style="list-style-type: none"> <li>Gandrud (2015), Chapter 1: <i>Introducing Reproducible Research</i></li> <li>R4DS: <a href="#">1: Introduction</a>, <a href="#">4: Workflow basics</a>, <a href="#">6: Workflow scripts</a>, <a href="#">8: Workflow projects</a>, <a href="#">10: Tibbles</a>, and <a href="#">11: Data Import</a></li> <li>Navarro's R for Psychological Science: <a href="#">File System</a>, <a href="#">Workspaces</a>, <a href="#">Packages</a>, <a href="#">Getting Started</a>, and <a href="#">Scripts</a></li> <li>Navarro Video: <a href="#">Say Hello to Your Data</a></li> </ul>
2	Mon, Sept. 18	Data Management in R, I: Importing and Wrangling Data <b><u>Capacity Building Assignment #1 Due</u></b>	<ul style="list-style-type: none"> <li>R4DS <a href="#">5: Data transformation</a></li> <li>Navarro, <a href="#">Manipulating Data</a></li> <li>Navarro Videos: <a href="#">Filtering Data</a>, <a href="#">Data Arranging</a>, <a href="#">Variable Selection</a></li> <li><a href="#">dplyr cheatsheet</a></li> </ul>
3	Mon, Sept. 25	Data Management in R, II: Advanced Restructuring, and Composites <b><u>Capacity Building Assignment #2 Due</u></b>	<ul style="list-style-type: none"> <li>R4DS <a href="#">5: Data transformation</a>, <a href="#">12: Tidy Data</a></li> <li>Navarro Video: <a href="#">Mutate</a></li> <li></li> </ul>
4	Mon, Oct. 2	Describe Your Data: Statistics, Missingness, and Tables <b><u>Capacity Building Assignment #3 Due</u></b>	<ul style="list-style-type: none"> <li>Navarro: <a href="#">Describing data</a>, <a href="#">Visualizing data</a></li> </ul>

Week	Date	Topics/Content Areas/ Learning Activities	Suggested Resources
			<ul style="list-style-type: none"> <li>• R4DS: <a href="#">Data Transformation (see Grouped Summaries)</a></li> <li>• <a href="#">10 Guidelines for Better Tables</a></li> <li>• <a href="#">10 Guidelines with gt</a></li> </ul>
5	Mon, Oct. 9	<b><u>THANKSGIVING</u></b>	
6	Thurs, Oct. 16	Describe Your Data: Visualizations <b><u>Capacity Building Assignment #4 Due</u></b>	<ul style="list-style-type: none"> <li>• R4DS: <a href="#">Visualizing Data</a></li> <li>• Wilke: <a href="#">29: Telling a Story and Making a Point</a></li> <li>• <a href="#">From data to viz</a></li> <li>• <a href="#">R Graph Gallery</a></li> <li>• <a href="#">R Graphics Cookbook</a></li> <li>• <a href="#">ggplot2 cheatsheet</a></li> <li>• <a href="#">ggplot2 extension gallery</a></li> </ul>
7	Thurs, Oct. 23	Modeling I: GLM Fundamentals and Preparing Data for GLMs <b><u>Capacity Building Assignment #5 Due</u></b>	<ul style="list-style-type: none"> <li>• Cohen, Cohen, West, &amp; Aiken (2003; Chapter 8)</li> <li>• Fox &amp; Weisberg (2011)</li> <li>• MacCallum et al. (2002)</li> <li>• Simmons et al. (2011)</li> </ul>
8	Thurs, Oct. 30	<b><u>READING WEEK</u></b>	
9	Thurs., Nov. 6	<b><u>R “Fluency” Test</u></b>	
10	Thurs., Nov. 13	Model Fitting I: Overview of the General Linear Model	<ul style="list-style-type: none"> <li>• Judd et al. (2012)</li> <li>• Schoemann et al. (2017)</li> <li>• West et al. (1996)</li> <li>• Götz et al. (in press)</li> </ul>

Week	Date	Topics/Content Areas/ Learning Activities	Suggested Resources
11	Thurs., Nov. 20	Modeling II: Fitting GLMs in R  <b><u>Data Viz Assignment Due</u></b>	<ul style="list-style-type: none"> <li>• Dienes (2008)</li> <li>• Funder &amp; Ozer (2019)</li> <li>• Bakker et al. (2016)</li> <li>• Anerson et al. (2017)</li> <li>• Lakens (2014)</li> <li>• <a href="#">Simmons</a> (2014)</li> </ul>
12	Thurs., Nov. 27	Modeling III: Advanced Applications of the GLM	<ul style="list-style-type: none"> <li>• <a href="#">R4DS: Functions</a></li> <li>• <a href="#">Advanced R: Functions</a></li> <li>• <a href="#">R Studio Primer: Functions</a></li> </ul>
13	Thurs., Dec. 4	Advanced Programming: Loops and Simulations of GLM Principles + Capstone Workday <b><u>Capacity Building Assignment #6 Due</u></b> <b><u>Capstone Project Due</u></b>	

### Statement on Academic Offences

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/scholastic\\_discipline\\_grad.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf)

All required papers may be subject to submission for textual similarity review to the commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (<http://www.turnitin.com>).

### Health/Wellness Services

Students who are in emotional/mental distress should refer to Mental Health@Western <http://www.uwo.ca/uwocom/mentalhealth/> for a complete list of options about how to obtain help.

## **Accessible Education Western (AEW)**

Western is committed to achieving barrier-free accessibility for all its members, including graduate students. As part of this commitment, Western provides a variety of services devoted to promoting, advocating, and accommodating persons with disabilities in their respective graduate program.

Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW), a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction.