



Department of
Psychological and
Behavioural Science

2025/26
Full Course Outline



PB230

Intermediate Statistics and Research
Methods for Psychological and
Behavioural Science

General Information

Course Summary

This course aims to provide students with integrated core knowledge and skills in contemporary research and analysis methods in psychological and behavioural science. Specific core methodological tools for preregistering and collecting data will be presented in lectures, selected to reflect parallel theoretical issues raised in the other Year 2 courses.

This course presents conceptual and practical knowledge on the range of tools available to the psychological/behavioural scientist. In particular, this course will examine current controversies and new developments in research methods in psychology and behavioural science. The overall goal of the course is to learn to think critically about how psychological and behavioural science is conducted, how conclusions are drawn, and how data are appropriately analysed considering intermediate issues such as measurement error and clustering. We will cover both methodological and statistical issues that affect the validity of research in psychology, with an emphasis on psychological and behavioural sciences. We will also discuss the recent controversy in psychology about the replicability of scientific results and preregistration of both quantitative and qualitative research. The course also instructs students in the use of quantitative data collection methods, including surveys, experiments, assessment tools, and computerised tasks. It also covers principles and issues involved in the analysis of quantitative data, including the importance of transparency in data analysis and reporting.

Where statistics are concerned, this course presents students with knowledge of, and practical exposure to, statistical modelling. It covers linear and non-linear models, factor analysis, structural equation modelling, multilevel modelling, and intermediate issues in data cleaning and imputation. These topics build directly on from the introduction to the linear model students received in PB130. Throughout the course, an understanding of key concepts such as statistical power and effect sizes will be emphasised in line with current controversies regarding replicability and questionable research practice. Practical sessions will equip students with knowledge of how to conduct the taught statistical techniques using the R programming language.

Availability

This course is compulsory for students following the BSc in Psychological and Behavioural Science. It is not available to any other students.

Aims

By the end of the course you should:

- Be able to situate recent trends in open science in the context of psychological enquiry.
- Have practical experience of collecting and analysing psychological and/or behavioural data.
- Understand statistical methods needed to conduct intermediate data analyses.
- Understand intermediate methods of qualitative enquiry.

Learning Outcomes

- To be able to conduct power analyses and provide transparent data management and analysis plans for the preregistration of psychological research;
- Describe the steps involved in collecting, analysing, and summarising quantitative psychological data;
- Apply intermediate statistics to data in psychological and behavioural science;
- Design research projects for the replication of psychological effects in existing research.

Academic Staff



Dr Thomas Curran – Course Leader

Associate Professor

Email: t.curran@lse.ac.uk



Dr Sakshi Ghai

Assistant Professor

Email: s.ghai2@lse.ac.uk



Dr Ben Tappin

Assistant Professor

Email: b.tappin@lse.ac.uk



Dr Miriam Tresh

Assistant Professorial Lecturer

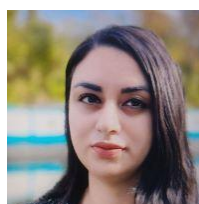
Email: m.tresh@lse.ac.uk



Dr Deema Awad

Assistant Professor

Email: d.awad@lse.ac.uk



Rija Tariq Qureshi

Graduate Teaching Assistant

Email: r.qureshi1@lse.ac.uk

Professional Services Staff



Anika Bloomfield

Undergraduate Programme Manager

Email: a.n.bloomfield@lse.ac.uk



Sean Rooney

Scientific Officer & Head of Laboratory Innovation

Email: s.rooney@lse.ac.uk



Salvatore Ridino

Undergraduate Programme Administrator

Email: s.ridino@lse.ac.uk

Office hours

Aside from your timetabled teaching time, the course teacher offers office hours. This is time set aside to meet with you to discuss any questions or concerns you may have. Please do not hesitate to get in touch if you feel you need study support or advice. You make office hour appointments via the Student Hub. There are many other sources of support for LSE students, and your Academic Mentor and teachers, among others, can help you find what you need.

Topic Summary

Week	Topic
AT1	Introduction: Psychology's crisis of confidence
AT2	Sounding the alarm: Replication crisis in psychology
AT3	Preregistering research: Background and a practical primer
AT4	Cleaning up your act: Data cleaning strategies and imputation
AT5	Reproducible data analysis: Creating transparent analysis plans in R
AT6	Reading Week – No Teaching
AT7	Intermediate issues in experimental design
AT8	Counterbalancing
AT9	Randomisation
AT10	Intermediate data visualisation: Dashboards in R
AT11	Intermediate statistical inference I: Limitations of NHST and alternatives
Winter Break	
WT1	Intermediate statistical inference II: An introduction to Bayesian probability
WT2	Intermediate Qualitative Methods I: Interview studies or 'the art of letting go'
WT3	Intermediate Qualitative Methods II: Preregistering qualitative research
WT4	The general linear model: A recap and things I didn't tell you
WT5	Structural equation modelling I: Path analysis
WT6	Reading Week – No Teaching
WT7	Structural equation modelling II: Factor analysis
WT8	Structural equation modelling III: Latent variable SEM
WT9	Multilevel modelling I: When the data are clustered
WT10	Multilevel modelling II: Latent growth curve analysis
WT11	Looking ahead to year three
Spring Break	

Linked Learning for BSc in Psychological and Behavioural Science



In Year 2 of the BSc in Psychological and Behavioural Science you'll continue experience linked learning.

- Some of the work in PB230 will directly relate back to PB130.
- In the lab sessions in PB230 you'll be investigating some of the phenomena discussed in the Year 2 half-unit courses.
- The last week of PB230 looks ahead to Year 3, specifically your Independent Research Project.
- In Year 3, you'll also be linking back to these Year 2 courses.

Teaching for PB230

Lectures

Lectures are an essential component of university life in the UK (and in most universities around the world). Lectures generally take the form of one member of staff delivering content to all the students on a particular course. Lectures may be given live in person, or they may take the form of pre-recorded videos in Moodle. If a lecture is live in person, then dialogue between lecturers and students is very much encouraged. Where lectures are pre-recorded, there will be an associated in-person question and answer session where you can and ask any questions that you might have.

Each academic will have their own approach to lectures, but the aim remains the same; to convey key entry points of knowledge for each topic and facilitate critical assessment of the material.

Lectures are not designed to be exhaustive and sometimes students will finish the lecture with more questions than answers. This is not something to worry about but to work on: lectures aim to open up the field, excite your curiosity and get you to read more, discuss and exchange doubts and ideas with teachers and peers.

Classes

Classes see groups of around 15 students working together with a member of staff. They are intended to provide students with a space for exploring the issues covered in the lectures further. Unlike lectures, academics act to facilitate the class with the expectation that students will lead the discussion, for example there may be presentations and discussions of key texts led by students. Some classes operate as a 'reading group' and forum for collective mutual support for critical reflection, integrating key ideas covered during lectures.

Classes are an integral part of courses and as such attendance is compulsory and will be recorded on LSE for You. Any student who is regularly absent will be automatically reported to their Academic Mentor, therefore if you expect to miss a class it is advisable to discuss the matter in advance with the class teacher.

R Workshops

Workshops are very similar to classes but rather than a time to review readings etc. they are an opportunity for you to put the techniques that you have learned, in the lectures, into practice. Workshops will often be larger in size and facilitated by several members of staff. In Your PB230 workshops will be for the whole cohort and will focus on developing your skills in R.

Workshops are an integral part of courses and as such attendance is compulsory and will be recorded on LSE for You. Any student who is regularly absent from a workshop will be automatically reported to their Academic Mentor. If you expect to miss a workshop it is advisable to discuss the matter in advance with the workshop leader.

Lab sessions

Lab sessions are where we will introduce you to the key experimental work connected to the five key domains of the psychology curriculum. Lab sessions are an integral part of courses and as such attendance is compulsory and will be recorded on LSE for You. Any student who is regularly absent from a lab sessions will be automatically reported to their Academic Mentor. If you expect to miss a session it is advisable to discuss the matter in advance with the course leader.

Reading Week

There is a 'Reading week' in week 6 of both Autumn and Winter term. During these weeks there will be no lectures, classes, workshops or lab sessions. Instead, you should review your progress thus far and consider plans for the remaining weeks. You could consider:

- Assess your progress in achieving the Learning Outcomes.
- Consider your learning about overlapping theories and phenomena from this and other courses that you take (especially PB200, PB201, PB202, PB204 and PB205).
- Reviewing any texts that you may have missed so far.
- Revisiting texts that you read earlier in the term but were not sure about.
- Reviewing your notes in preparation for the assessments.

You may want to meet up with other students to:

- Use peer assessment to measure your progress in achieving the Learning Outcomes.
- Consider your learning about overlapping theories and phenomena from this and other courses that people in your group take.
- Talk about your overall experience of the programme.
- Discuss and develop further ideas sparked by the course.

Moodle

Moodle is LSE's virtual learning environment. During this time of blended online and on-campus teaching Moodle is a vital platform as the central hub for all teaching and learning. You can access Moodle by visiting moodle.lse.ac.uk.

PB230 has a designated Moodle page containing the asynchronous lecture videos and activities (such as quizzes and forum posts), lectures slides, reading lists and additional resources, such as links, audio and videos files and podcasts.

You will be asked to submit your formative and summative assessments electronically through Moodle, we'll provide feedback and, for summative work provisional marks, via Moodle. Moodle is managed by your course leader so how it is used will vary from course to course.

Research Ethics

Throughout the course we will frequently refer to the research ethics. You should make sure that you have read the British Psychological Society's Code of Human Research Ethics.

Resources

There are a number of different types of resource for PB230. The main resource will be readings – either books, chapters in books or journal articles. Other resources will include videos, magazine articles, webpages, talks and podcasts. There are some resources which are relevant to the whole course, you'll find these listed below. There are then resources relevant to each topic which you'll find listed on the relevant page.

Within all of the resource lists we'll indicate which things are essential and which provide you further content. You are also encouraged to go more deeply into topics that particularly interest you.

- **Essential** - in this guide items marked with two stars (**) are essential, you must read, watch or listen to these before the lecture.
- **Further** - you are not generally expected to go through each of these readings. However, you should try to delve into topics by exploring these resources more widely. You should engage with these further resources, particularly if you plan to cover a topic seriously, for example for an essay.
- **Deep** - if you want to explore a topic even more deeply there are two ways that you can do this. Firstly, the lecturer and class teacher will include links to all resources that they discuss in the lecture. This may be on the particular slide or in a list at the end but may not show on the reading list. Secondly, you can investigate readings listed in the bibliographies of the essential readings.

You can access all resources via the PB230 Moodle page – there will be a link to the reading list (which in turn links to the library catalogue) and lists of other types of resources.

Course Wide Resources

Readings

- ** Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. London: Sage.
- ** Camerer, C. F., Dreber, A., Holzmeister, F., Ho, T. H., Huber, J., Johannesson, M., ... & Altmejd, A. (2018). Evaluating the replicability of social science experiments in Nature and Science between 2010 and 2015. *Nature Human Behaviour*, 2(9), 637-644.
- ** L. Haven, T., & Van Grootel, D. L. (2019). Preregistering qualitative research. *Accountability in Research*, 26(3), 229-244.
- ** Munafò, M. R., Nosek, B. A., Bishop, D. V., Button, K. S., Chambers, C. D., Du Sert, N. P., ... & Ioannidis, J. P. (2017). A manifesto for reproducible science. *Nature human behaviour*, 1(1), 1-9.
- ** Nosek, B. A., & Lakens, D. (2014). Registered reports: A method to increase the credibility of published results. *Social Psychology*, 45(3), 137-141.
- ** Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science*, 349(6251).
- American Psychological Association (2020) *Publication manual of the American Psychological Association: the official guide to APA style* Washington DC: APA (7th ed)
- Chambers, C. (2017). *The 7 deadly sins of psychology: A manifesto for reforming the culture of scientific practice*. Princeton, NJ: Princeton University Press.
- Keith, T.Z. (2019). *Multiple regression and beyond: An introduction to multiple regression and structural equation modelling* (3rd ed). London: Routledge.
- Tabachnick, B., & Fidell, L. (2019). *Using multivariate statistics*. Boston: Pearson Education (7th ed.)

Topics

AT1 – Introduction: Psychology's crisis of confidence

Dr Thomas Curran

In this first week, students will get an introduction to the course and the assessment. We will go over the course contents and aims, talk about the scientific process and scientific norms as they relate to the psychological and behavioural sciences, touch on the contemporary "crisis of confidence" in psychology and other high profile 'horrors', and introduce open science solutions as a precursor to subsequent weeks. This week there will also be a focus on the first assessment, which is a preregistration of replication of the students' choosing.

Before coming to this lecture, please complete the following three tasks:

1. Watch the TED talk by Naomi Oreskes, Why we should trust scientists (see below)
2. Listen to the podcast by BBC Radio 4, Analysis: The Replication Crisis, November 2018 (see below)
3. Read the magazine article: Engber, Daniel. 'Daryl Bem Proved ESP Is Real. Which Means Science Is Broken.' Slate Magazine (see below)

Overview of course

- Weekly overview of course content
- Course assessment
- Assessment one (preregistered replication)

Psychology as a robust science

- What do we mean by science?
- Merton's Norms

Is psychology broken?

- The year of horrors
- Trust in science
- Questionable research practices
- New directions in open science

Aims

- To introduce the course, its weekly content and its assessment;
- To take off where we left last year by looking at open science and contemporary issues with research methodology in the psychological and behavioural sciences;
- To equip students with a critical awareness of open science solutions to issues of trust in the psychological and behavioural sciences.

Learning Outcomes

After attending this lecture and completing the relevant reading you should be able to:

- Understand the critical components of the course and its assessment.
- Identify key axioms of science and scientific norms.
- Outline the critical issues currently afflicting the psychological and behavioural sciences.
- Discuss where psychology went wrong and how open science might present a solution.

Resources

Readings

** Benedikt, B., & Friesike, S. (2014). Open Science: One Term, Five Schools of Thought. In Bartling and Friesike (Eds.) *Opening Science: The Evolving Guide on How the Internet Is Changing Research, Collaboration and Scholarly Publishing*, pp. 17–47. Cham: Springer International Publishing.

** Gelman, A., & Loken, E. (2013). The garden of forking paths: Why multiple comparisons can be a problem, even when there is no "fishing expedition" or "p-hacking" and the research hypothesis was posited ahead of time. *Department of Statistics, Columbia University*.

Wagenmakers (2012). A year of horrors. <http://www.ejwagenmakers.com/2012/Wagenmakers2012Horrors.pdf>

Website

Ascvhwanden, C. (2015). Science Isn't Broken: It's just a hell of a lot harder than we give it credit for. Available here:

<https://fivethirtyeight.com/features/science-isnt-broken/#part1>

Talk

TED talk by Naomi Oreskes, Why we should trust scientists, May 2014

https://www.ted.com/talks/naomi_oreskes_why_we_should_trust_scientists

Podcast

BBC Radio 4, Analysis: The Replication Crisis, November 2018 <https://www.bbc.co.uk/sounds/play/m00013p9>

Magazine

Engber, Daniel. 'Daryl Bem Proved ESP Is Real. Which Means Science Is Broken.' Slate Magazine, 7 June 2017.

<https://slate.com/health-and-science/2017/06/daryl-bem-proved-esp-is-real-showed-science-is-broken.html>

AT2 – Sounding the alarm: Replication crisis in psychology

Dr Sakshi Ghai

In this lecture, students will build on what they have learned in AT1 and delve deeper into the "crisis of confidence" in psychological and behavioural science. Here our focus will be on replication. We will seek to understand why psychological studies often fail to replicate, we will examine the backlash and counter-backlash to replications, and we will take a look at the Open Science Collaboration and Many Labs movements, which are dedicated to improving scientific practice in the psychological and behavioural sciences through transparency and replication. We will finish by having students search the literature for replications that they may wish to preregister for their preregistered report assessment.

Before coming to the lecture, please do the following:

1. Listen to the following podcast by NPR Planet Money, The experiment experiment (see below)
2. Read the accessible piece about Many Labs 2 - 'Replication Failures in Psychology Not Due to Differences in Study Populations'.
3. Read the following New York Times piece by Jay van Bavel on why studies fail to replicate (see below)

Sounding the alarm

- Psychology in a crisis
- How reproducible are psychology findings?
- Open Science Collaboration

Why is this happening?

- Publication bias
- Researcher bias
- False positives (sampling error)
- Power
- Misconduct
- P-hacking

Replication

- Reducing false positives through replication
- Many Labs project
- Controversies
- Ego depletion example
- Finding replications for your assessment

Aims

- Discuss the controversy around psychology and the replicability of its results;
- To introduce students to replication movement in the psychological and behavioural sciences;
- To critically assess the replication movement and understand its benefits and limitations;
- To discuss the methods of study selection for the first assignment.

Learning outcomes

After attending this lecture and completing the relevant reading, you should be able to:

- Describe the contextual influences and limitations on the quality of research in the psychological and behavioural sciences.
- Outline the strengths, drawbacks, and empirical potential of the replication movement.
- Articulate how the nature of sampling error affects the false positive rate in psychology and how replication addresses this.

Homework preparation for class in AT4

Find a good candidate for a replication study that you might use to preregister for your assignment. There are no restrictions, but keep in mind that the study needs to be simple, feasible, and relatively straightforward (i.e., using a research design and analysis we introduced last year). So no longitudinal fMRI experiments on heroin addicts! One list of experiments that researchers like to see replicated can be found at the [PsychFileDrawer](#) website (but many of these experiments are relatively involved). Browsing issues of *Science*, *PNAS*, *Psychological Science*, and *Journal of Personality and Social Psychology* should provide ample source of inspiration. Another idea is to seek replication of a famous experiment (e.g., the one about cognitive dissonance). **Then, prepare a 3-minute presentation in which you explain what the candidate study is about and why you would want to see it replicated. You will present this case in class and there will be questions from your peers and teacher.**

Resources

Readings

- ** Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological science*, 22, 1359-1366.
- ** Open Science Collaboration (2015). Estimating the Reproducibility of Psychological Science. *Science*, 349.
- Simons, D. J. (2014). The value of direct replication. *Perspectives on Psychological Science*, 9, 76-80.
- Button, K. S., Ioannidis, J. P., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S., & Munafò, M. R. (2013). Power failure: why small sample size undermines the reliability of neuroscience. *Nature reviews neuroscience*, 14, 365-376.

Magazines

Owens, B (2018) Replication failures in psychology not due to differences in study populations *Nature*
<https://www.nature.com/articles/d41586-018-07474-y>

Van Bavel (2016). Why do so many studies fail to replicate?

<https://www.nytimes.com/2016/05/29/opinion/sunday/why-do-so-many-studies-fail-to-replicate.html>

Podcast

NPR Planet Money, The experiment experiment, January 2019

<https://www.npr.org/sections/money/2016/01/15/463237871/episode-677-theexperiment-experiment>

AT3 - Preregistering research: Background and a practical primer

Dr Sakshi Ghai

This week, students will be introduced to preregistration as a way of combatting the "crisis of confidence" in psychological and behavioural science. We will delve into the emerging preregistration movement to take a look at why preregistration might help us fix psychology and how we do it. Along the way we will look at exploratory and confirmatory hypothesis testing, common questions, arguments for and against the drive towards preregistration and the key components of registering your research.

Before this lecture and workshop, please read the following two articles:

1. Wagenmakers, E. J., Wetzels, R., Borsboom, D., van der Maas, H. L., & Kievit, R. A. (2012). An agenda for purely confirmatory research. *Perspectives on Psychological Science*, 7, 632-638 (see below).
2. Chambers, C. (2019). What's next for Registered Reports? *Nature*, 573, 187–89 (see below)

Why preregistration

- Exploratory vs confirmatory
- Common questions
- The rise of registered reports in the psychological and behavioural sciences

Preregistration

- The process
- Arguments for and against
- Types of preregistration
- Key components
- Power and sample size
- A step-by-step guide

Aim

- To learn about the preregistration movement and be able to preregister your own research.

Learning outcomes

After attending this lecture, participating in the associated workshop, and completing the relevant reading you should be able to:

- Understand preregistration initiatives that are currently reinventing the basic foundations of psychological and behavioural science;
- Describe the challenges and principles of preregistration;
- Describe the different types of preregistration;
- Understand how to conduct a power analysis for sample size;

Resources

Readings

- ** Wagenmakers, E. J., Wetzels, R., Borsboom, D., van der Maas, H. L., & Kievit, R. A. (2012). An agenda for purely confirmatory research. *Perspectives on Psychological Science*, 7, 632-638 (see below).
- ** Nosek, B. A., Ebersole, C. R., DeHaven, A. C., & Mellor, D. T. (2018). The preregistration revolution. *Proceedings of the National Academy of Sciences*, 115, 2600-2606.
- van 't Veer, A., & Giner-Sorolla, R. Pre-registration in social psychology – A discussion and suggested template *Journal of Experimental Social Psychology*, 67, 2-12.
- Lakens, D. (2019). The value of preregistration for psychological science: A conceptual analysis. *Japanese Psychological Review*, 62, 221-230.
- Nosek, B. A., & Lakens, D. (2014). Registered reports: A method to increase the credibility of published results. *Social Psychology*, 45, 137-141.

Magazine

Chambers, C. (2019). What's next for Registered Reports? *Nature*, 573, 187–89.
<https://doi.org/10.1038/d41586-019-02674-6>

Blogs

Bishop, D. (2013). Why we need pre-registration
<https://deevybee.blogspot.com/2013/07/why-we-need-pre-registration.html>

Chambers, C. (2013). Trust in science would be improved by study pre-registration.
<https://www.theguardian.com/science/blog/2013/jun/05/trust-in-science-study-pre-registration>.

AT4 – Cleaning up your act: Data cleaning strategies and imputation

Dr Thomas Curran

This week, we are going to move from transparent methods to transparent data analysis and we begin with data screening, cleaning, and imputation. Data is messy and data screening and cleaning are probably the most important parts of the data analysis process. Yet it is also the most overlooked of the analytic stages. This is understandable, researchers invest years to the planning and collection of data, and they are eager to analyse it. But, as we shall see, this haste is dangerous and can impede on the validity of our conclusions. If missing data or outliers are not appropriately dealt with prior to analysis, results can be seriously flawed. We'll go through the stages of data screening and imputation with a view to providing a practical and transparent set of steps that can be followed to minimize the influence of missing data and outliers in our analyses.

Data entry

- How to enter data correctly and transparently
- Coding missing data
- Adding identifiers
- Checking for validity

Missingness

- Amount and pattern of missing data
- Causes of missing data
- Missing value analysis

Imputation

- Common but bad approaches to imputating data
- Scale mean (regression) imputation
- Expectation maximisation
- Multiple imputation

Outliers

- Univariate outliers and solutions
- Multivariate outliers and solutions

Aim

- To introduce students to state of the art methods for data screening, cleaning, and imputation in the psychological and behavioural sciences.

Learning outcomes

After attending this lecture, participating in the associated workshop, and completing the relevant reading, you should be able to:

- Learn how to screen and clean data;
- Describe the patterns and nature of data missingness using missing value analysis (MVA);
- Select between a variety of common imputation techniques;
- Identify and remove outliers.

Workshop

During the workshop we will:

- Visualize missing data in R
- Perform missing value analysis in R
- Impute data using the R package mice
- Identify and remove outliers in R

Class

In the class we will present and discuss ideas for research we are planning to replicate and receive feedback from peers and tutor.

Resources

Readings

** Osborne, J. (2013). *Best Practices in Data Cleaning*. Chapters 1, 6, & 7.

** Tabachnick, B., & Fidell, L. (2019). *Using Multivariate Statistics*. Chapter 4.

Cole, J. C. (2008). How to deal with missing data: Conceptual overview and details for two modern methods. In Osborne, J. (Ed.) *Best Practices in quantitative methods*. New York: Sage.

Schafer, J., & Graham, J. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, 7, 147-177.

Baraldi, A. N., & Enders, C. K. (2010). An introduction to modern missing data analyses. *Journal of school psychology*, 48(1), 5-3

AT5 – Reproducible data analysis: Creating transparent analysis plans in R

Dr Sakshi Ghai

This week students will continue their journey into transparent data analysis by looking into reproducible data analysis plans. These are plans for data analysis that are written a-priori – before the data are collected – and can be preregistered alongside the research methods. Such an approach avoids issues of HARKing or P hacking that are a source of psychology's crisis of confidence. But for data analysis planning to have any relevance, materials need to be created FAIR (findable, accessible, interpretable, reusable). In other words, they must be adequately described, archived, and made openly available in a research compendium. R tools offer a powerful framework for making open, reproducible, and collaborative research compendiums. This week we will focus on project management in R, introduce students to best practice in data analysis planning, and give them with a step-by-step guide to creating open and reproducible research compendiums for their preregistered project.

Before coming to the lecture and workshop, please complete the following three tasks:

1. Watch the TED talk by Hans Rosling, The best stats you've ever seen (see below)
2. Read the web article: Somers, James. 'The Scientific Paper Is Obsolete: Here's What's Next.' The Atlantic (see below)

Open data

- Why open data is important
- Links to replicability
- Psychologists' perspectives
- Barriers
- Data protection

Data management

- FAIR data
- Data protection considerations
- Data simulation

The research compendium

- The basic structure of a research compendium
- Organising files
- Writing the analysis code in markdown

Doing it in R

- Simulating data in R
- Building a research compendium in R

Aim

- To introduce students to best practice in data and project management with the creation of open and transparent research compendiums

Learning objectives

After attending this lecture, participating in the workshop, and completing the relevant you should be able to:

- Understand the basics of good research data management and be able to produce clean datasets;
- Use R tools to document code and analyses that produce reproducible research compendium;
- Be able to create a research compendium that includes a data plan using R projects for your preregistered report.

Workshop

During the workshop we will go through the steps of preregistering a research report using the templates provided by aspredicted.org and van't Veer and Giner-Sorolla (2016). We will also demonstrate how to conduct power analyses in R. Students will have the opportunity to go away and write up their own preregistration for their replication and submit it to aspredicted.org for formative feedback.

Resources

Reading

** Houtkoop, B. L., Chambers, C., Macleod, M., Bishop, D. V., Nichols, T. E., & Wagenmakers, E. J. (2018). Data sharing in psychology: A survey on barriers and preconditions. *Advances in methods and practices in psychological science*, 1(1), 70-85.

** Marwick, B., Boettiger, C., & Mullen, L. (2018). Packaging data analytical work reproducibly using R (and friends). *The American Statistician*, 72, 80-88.

Peng, R. D. (2011). Reproducible research in computational science. *Science*, 334(6060), 1226-1227.

Website

Somers, J. (2015). The Scientific Paper is Obsolete: Here's what's next. Available here:

<https://www.theatlantic.com/science/archive/2018/04/the-scientific-paper-is-obsolete/556676/>

Talk

TED talk by Hans Rosling, The best stats you've ever seen, Jan 2007.

<https://www.youtube.com/watch?v=hVimVzgtD6w>

AT7 – Intermediate issues in experimental design

Dr Thomas Curran

In AT7 we are going to take an interlude into research methods and cover some intermediate issues of experimental design. As we saw last year, the primary goal of experiments is to identify causal relationships between things in the world. Experiments do this by a systematic process of measuring how things behave under different conditions. But not all experiments are created equally and there are different types of designs depending on the research question of interest. There are also many threats to validity that must be considered before we can ascertain cause and effect. Students will be introduced to different types of experimental design, how to apply them, and their strengths and weaknesses. This will set us up to look in more depth at applying the different types of experimental design in the lab.

Experiments

- What is an experiment?
- Why do one
- Famous examples

Validity

- Internal validity
- External validity
- Construct validity
- Statistical validity

Experimental designs

- Between-persons
- Randomisation
- Within-persons
- Counterbalancing

Aim

- To introduce students to intermediate issues in experimental design

Learning outcomes

After attending this lecture, participating in the associated class, and completing the relevant reading and coursework, you should be able to:

- Explain what an experiment is and recognise examples of studies that are experiments and studies that are not experiments;
- Explain what internal validity is and why experiments are considered to be high in internal validity;
- Explain what external validity is and evaluate studies in terms of their external validity;
- Recognise examples of confounding variables and explain how they affect the internal validity of a study.

Resources

Readings

** Bellman, S. (2017). Experimental Design. In Matthes, J. (Ed.) *The International Encyclopaedia of Communication Research Methods*, London: Wiley. Pp 1-20

** Crump, M. J. C., Price, P. C., Jhangiani, I-C, A. & Leighton, D. C. (2017). *Research methods for psychology*. Chapter 4.



AT8 – Counterbalancing

Dr Thomas Curran

During this week, we will move from learning about principles of experimental design to applying these in the lab, with a particular focus on counterbalancing. As we're looking at the practicalities of experimental design there is no lecture just a lab session.

This week, we are going to learn how to set up and conduct a within-person experiment – testing the same people across different conditions over time. As we saw in AT7, there are many confounds to validity in such designs. And the extent to which causality can be attributed to the independent variable is compromised unless these confounds are controlled for. One of the ways we mitigate threats to internal validity in within-person designs is by counterbalancing order.

Aim

- To introduce students to within-person experimental design with counterbalancing and randomisation.

Learning outcomes

After attending the lab and completing the relevant readings you should be able to:

- Understand why counterbalancing and randomisation is needed in within-person experiments.
- Design within-person experiments with counterbalancing and randomisation.
- Create within-person experiments with counterbalancing and randomisation in Gorilla.

Workshop

During the workshop we will create a research compendium in R

Lab Session

This lab session provides a practical introduction to counterbalancing.

Resources

Readings

- ** Corriero, E. F. (2018). Counterbalancing. In M. Allen (Ed.) *The SAGE Encyclopaedia of Communication Research Methods*, pp. 278-281. Thousand Oaks: Sage.
- ** Carpenter, G. W. (2018). Random Assignment. In M. Allen (Ed.) *The SAGE Encyclopaedia of Communication Research Methods*, pp. 1397-1399. Thousand Oaks: Sage.



AT9 – Randomisation

Dr Deema Awad

This week follows on from AT8, where we are looking at applying the principles of experimental design in the lab, with a particular focus on randomisation. As in AT8, because we're looking at the practicalities of experimental design, there is no lecture.

We will again be applying some of the principles of experimental design covered in the lecture in AT7, we are going to learn how to set up and conduct a between-persons experiment – testing different people across different conditions. We will do this by running an eye-tracking experiment and then look at how we can replicate this using Psychopy.

Aim

- To introduce students to between-person experimental design with counterbalancing and randomisation.

Learning outcomes

After attending the lab and completing the relevant readings you should be able to:

- Understand why counterbalancing and randomisation is needed in between-person experiments.
- Design between-person experiments with counterbalancing and randomisation.
- Create between-person, eye tracking experiments with counterbalancing and randomisation.

Lab Session

During the lab session, we will run an eye-tracking experiment on each other, and then examine how to replicate the experiment's basics using the Psychopy software package. This directly connects to what you've been learning in PB200.

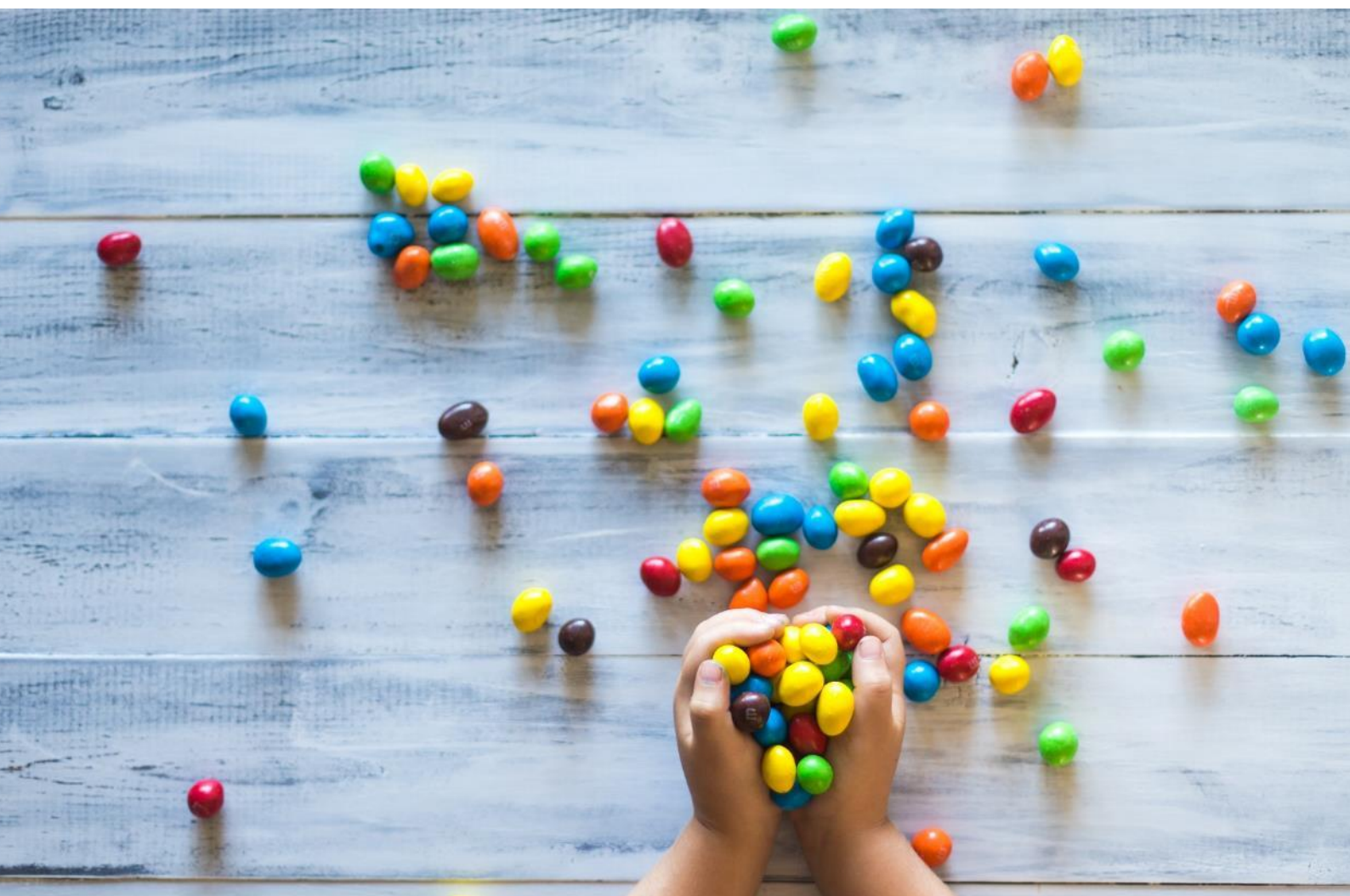
Resources

Readings

** Corriero, E. F. (2018). Counterbalancing. In M. Allen (Ed.) *The SAGE Encyclopaedia of Communication Research Methods*, pp. 278-281. Thousand Oaks: Sage.

** Carpenter, G. W. (2018). Random Assignment. In M. Allen (Ed.) *The SAGE Encyclopaedia of Communication Research Methods*, pp. 1397-1399. Thousand Oaks: Sage.

Peirce, J., Hirst, R., and Macaskill, M. (2022) *Building Experiments in PsychoPy* (2nd Ed.). London: Sage.



AT10 – Intermediate data visualisation: Dashboards in R

Dr Thomas Curran

This week, something a bit different. Instead of data modelling, we're going to look at intermediate ways to visualise data using dashboards in R. Dashboards are interactive tools that allow users to dynamically interact with data to reveal trends and relationships. They are used a lot in industry to document findings, and so we're going to teach you how to create them!

Aim

- Learn to create an interactive dashboard using R.

Learning outcomes

After attending this lecture and reading the appropriate references from the reading list, students should be able to:

- Create an interactive dashboard using the flexdashboard package in R.
- Toggle and format data for impact and engagement.
- Develop creative ways to communicate data analyses.

Lab Session

The lab will be an opportunity for students to build an R dashboard. We will learn how to include interactive elements and we will explore how to tweak your design elements using flexdashboard code. You will be given the opportunity to practice these concepts using various datasets in the context of four different scenarios.

Class

In the classes, we will discuss the preregistration project due in January; bring your questions!

Resources

Readings

** Warin, T. (2021). *Data Pipeline with R*. Chapter 11: Dashboards. Available here: <https://warin.ca/dpr/dashboards.html>.



AT11 – Intermediate statistical inference I: Limitations of NHST and alternatives

Dr Thomas Curran

Null-hypothesis significance testing (NHST) remains the most frequent method used in a range of disciplines, including psychological sciences. Despite this, numerous authors have criticised NHST and pointed to potential shortcomings. These include calculations of power and effect size. In this class, we consider some of the strengths and weaknesses of NHST. The purpose is not an iconoclastic destruction of the practice, but an evaluation of when it is suitable, some of the challenges it is faced with, and some suggestions for moving forward. In particular, this is useful to consider if you are designing an experiment, considering how to calculate power, and to ensure you are not led astray by standard NHST assumptions and practices when other methods might be more suited. This lecture will also serve as a point of departure for WT10, which considers Bayesian statistical inferences.

The Replication crisis in psychological sciences

- Where NHST may have contributed to the crisis
- The state of replication

Critique of NHST – some reflections

- Power calculations
- Effect sizes, weak p-values, and false positives
- The experimenter's perspective and interpretation (Kruschke's coin)

Suggestions for moving forward

- Pre-registration of studies
- Accessibility to raw data
- Bayesian methods

Aim

- To provide a balanced view of the strengths and pitfalls of NHST

Learning outcomes

After attending this lecture and reading the appropriate references from the reading list, students should be able to:

- Critically evaluate NHST as a viable research approach and method
- Describe possible shortcomings of NHST
- Point to methods that may supplement or assist NHST

Resources

Readings

- ** Kruschke, J. F. (2014) Doing Bayesian Data Analysis: A Tutorial with R and JAGS, and Stan, *Academic Press*. Chapter 11: Null Hypothesis Significance Testing
- ** Szucs, D. & Ioannidis, J. P. A. (2017) When Null Hypothesis Significance Testing is unsuitable for research: A reassessment, *Frontier in Human Neuroscience* 11, 1-21
- Kruschke, J. F. (2014) Doing Bayesian Data Analysis: A Tutorial with R and JAGS, and Stan *Academic Press*. Chapter 12: Bayesian approaches to testing a point ("null") hypothesis
- Dushoff, J., Kain, M. P. & Bolker, B. M. (2018) I can see clearly now: Reinterpreting statistical significance, *Methods in Ecology and Evolution* 10, 756-759



WT1 – Intermediate statistical inference II: An introduction to Bayesian probability

Dr Ben Tappin

Standard frequentist statistics has been the bread and butter for data evaluation for generations. As a result, most statistical textbooks teach students and researchers how to conduct t-tests, ANOVAS, and multiple linear regressions in order to evaluate the strength of the data in relation to the hypothesis (typically expressed via the p-value). These are tried and tested statistical methods that hold a fundamental place in scientific history and conduct. While frequentist statistics has been and continues to be immensely important, it is not the only statistical game in town.

In recent decades, Bayesian probability theory has become increasingly popular as a statistical method. Rather than seeing data as discrete frequencies that are to be tallied, Bayesian probability expresses the degree of belief in the veracity of a hypothesis given the available evidence and what is known prior to conducting the experiment (the latter, known as the prior, is a source of great statistical contention and we will discuss this in the lecture). Given this rise to prominence, it is essential. This lecture introduces you to this branch of statistics.

What is Bayesian probability?

- Thomas Bayes, Pierre-Simon Laplace and a remarkable theorem
- Applying Bayes' theorem to statistical inferences
- Replacing p-values and interpreting Bayesian statistics

Uses of Bayesian statistics

- Estimating the probability of a single event
- Measuring similarity instead of differences
- Harder to unintentionally p-hack your study

Challenges for Bayesian statisticians

- Where did that prior come from?

Aim

- To get insights into Bayesian statistics, its outcomes, and interpretations.

Learning outcomes

After attending this lecture and reading the appropriate references from the reading list, students should be able to:

- Understand the statistical outcomes of Bayesian tests
- Evaluate when researchers report their findings in this way
- Run Bayesian equivalents to t-tests and linear regressions in R

Lab Session

During the lab session we will be running a blank R challenge around Bayesian probability. We will:

- Discuss research designs in relation to the NHST debate
- Use a Bayesian t-test to analyse a data set
- Debate the merits and limitations of both statistical branches
- Deal with some messy data

Resources

Readings

** Kruschke, J. F. (2014) *Doing Bayesian Data Analysis: A Tutorial with R and JAGS*, and *Stan Academic Press*. Chapter 15: Overview of the generalized linear model,, Chapter 16: Metric predicted variable on one or two groups, Chapter 17: Metric predicted variable with one metric predictor

Kruschke, J. F. (2014) *Doing Bayesian Data Analysis: A Tutorial with R and JAGS*, and *Stan Academic Press*. Chapter 5: Bayes' Rule
McGrayne, S. B. (2011) *The theory that would not die: How Bayes' rule cracked the enigma code, hunted down Russian submarines & emerged triumphant from two centuries of controversy*, Yale University Press

Kruschke, J. & Lidell, T. M. (2018) The Bayesian new statistics: Hypothesis testing, estimation, meta-analysis, and power analysis from a Bayesian perspective, *Psychonomic Bulletin & Review* 25, 178-206.



WT2 – Intermediate Qualitative Methods I: Interview studies or ‘the art of letting go’

Dr Sakshi Ghai

This week we will turn our attention to qualitative methods, to explore how to design a qualitative study using the most common method available; the interview. We will first refresh our minds a little as to the nature of qualitative methods, before moving to consider what we need to think about (and what we need to plan for) when conducting interviews. Examples of good and bad interviews will be given, and we will discuss what could have been done better in the case of the ‘bad’ interview.

Remembering Qualitative Methods

- Brief refresher on key qualitative methods
- Moving from theory to practice

The Field, Access and Sampling

- How to access populations?
- What kind of interview should I conduct?
- How to choose your sample

Designing an Interview Study

- How to ask the ‘right’ questions
- How many questions are too many questions?
- What if my participant doesn’t say what I want them to say?

Aim

- To introduce students to the process of developing an interview-based study, including preparing, designing and conducting an interview

Learning outcomes

After attending this lecture and reading the appropriate references from the reading list, students should be able to:

- Explain the process of defining and conducting an interview-based study
- Develop an interview topic guide to answer a particular research question

Resources

Readings

** Braun, V., & Clarke, V. (2013). Successful qualitative research: A practical guide for beginners. Sage. Chp 4: Interactive Data Collection 1: Interviews

Adriansen, H. K. (2012). Timeline interviews: A tool for conducting life history research. *Qualitative studies*, 3(1), 40-55.

Bauman, Z., Beck, U., Beck-Gernsheim, E., Benhabib, S., Burgess, R. G., Chamberlain, M., ... & Devine, F. (2002). Qualitative interviewing: Asking, listening and interpreting. *Qualitative Research in Action*. 1st ed. London: SAGE Publications, 226-241.

Potter, J., & Hepburn, A. (2005). Qualitative interviews in psychology: Problems and possibilities. *Qualitative research in Psychology*, 2(4), 281-307.

Robinson, O. C. (2014). Sampling in interview-based qualitative research: A theoretical and practical guide. *Qualitative research in psychology*, 11(1), 25-41.



WT3 – Intermediate Qualitative Methods II: Preregistering qualitative research

Dr Sakshi Ghai

This week, students will return to preregistration as a way of combatting the "crisis of confidence" in psychological and behavioural science. But this time we are going to look at qualitative research. We will delve into the emerging preregistration movement for qualitative research and look at why it is necessary for narrative enquiry. We will also look at the controversies, the potential benefits, and the potential costs of implementing preregistration for qualitative research. The workshop will consist of a how-to session on preregistering qualitative research using the template provided by Haven and Van Grootel (2019).

Why preregistration

- Common questions
- The rise of registered reports in the psychological and behavioural sciences

Preregistering qualitative research

- The process
- Arguments for and against
- Types of preregistration
- Key components
- A step-by-step guide

Aim

- To learn about the preregistering qualitative research and be able to preregister your own qualitative research.

Learning outcomes

After attending this lecture, participating in the associated workshop, and completing the relevant reading you should be able to:

- Understand the nature and process of preregistering qualitative research;
- Described the pros and cons of qualitative research preregistration;
- Know how to preregister qualitative research.

Resources

Readings

** Haven, T., & Van Grootel, D. L. (2019). Preregistering qualitative research. *Accountability in Research*, 26(3), 229-244.

** Kern, F. G. & Gleditsch, K. S. (2017). Exploring Pre-registration and Pre-analysis Plans for Qualitative Inference.



WT4– The general linear model: A recap and things I didn't tell you 🐒

Dr Thomas Curran

Winter term sees us moving back to statistics and taking a recap of the linear model and the class of analyses that we covered last year: t-test, ANOVA, and regression. We'll go back over these univariate tests and recap their core principles and applications. Then, we're going to cover some auxiliary issues that I didn't tell you about last year but are nevertheless important to know. These are the four core assumptions of the linear model and how we diagnose for them in R.

Linear model recap

- A recap of the linear model and $y = ax + b$
- Comparing groups
- Testing relationships

Linear model assumptions

- Linearity
- Normal distribution stuff
- Homoscedasticity and homogeneity of variance
- Independence
- Perfect measurement

Where we go from here

- Univariate tests and their limitations
- The case for moving to multivariate statistics

Aims

- To recap the core principle and applications of the general linear model (GLM);
- To learn about the core assumptions of the linear model and how to diagnose them in R.

Learning Outcomes

After attending this lecture, participating in the workshop, and completing the relevant reading, you should be able to:

- Describe the core principles of the GLM and its class of univariate analyses;
- Explain the core assumptions of the linear model;
- Diagnose core assumptions of the linear model in R.

Workshop

During the workshop we will:

- Use the `car()` and `gvlma()` R functions to conduct model diagnostics for assumption testing.

Resources

Readings

- ** Carey, G. (2013). The general linear model: A gentle introduction. In G. Carey (Ed.) *Quantitative Methods in Neuroscience*, Chapter 9.
- ** Nimon, K. F. (2012). Statistical assumptions of substantive analyses across the general linear model: a mini-review. *Frontiers in psychology*, 3, 322.
- Meuleman, B., Loosveldt, G., & Emonds, V. (2013). Regression Analysis: Assumptions and Diagnostics. In H. Best and C. Wolf (Eds.) *The SAGE Handbook of Regression Analysis and Causal Inference*, pp. 83-110. London: Sage.

Website

Lindeløv, J. K. (2019). Common statistical tests are linear models (or: how to teach stats). Available here: <https://lindeloev.github.io/tests-as-linear/>



WT5 – Structural equation modelling I: Path analysis

Dr Thomas Curran

This week we are going to move from univariate tests to multivariate tests and introduce something called structural equation modelling. The underlying principles are the same: the general linear model. However, we now move to applying these principles in a multivariate framework (i.e., multiple outcome variables). The most basic structural equation model is the path model, which tests for relationships between multiple criterion and multiple outcome variables in some causal chain. This is sometimes called path analysis. We will see how path models build on the limitations of multiple regression and look at some of their practical applications to real world psychological phenomena. We will then apply this knowledge to real word data in the workshop.

Limitations of multiple regression

- Univariate analyses and the problem of single outcomes
- Complexity of psychological phenomena and causal chains
- Data-based vs model-based

Structural equation modelling

- What SEM is and why it overcomes limitations of multiple regression
- Types of SEM

Path analysis

- Most basic form of SEM
- A simple model example
- Wrights tracing rule
- Model identification
- Model fit

Aims

- Introduce students to the most basic structural equation model: the path model.

Learning outcomes

After attending this lecture, participating in the workshop, and completing the relevant reading, you should be able to:

- Describe the difference between univariate and multivariate analyses;
- Describe what path analysis is and the main limitations of multiple regression that it overcomes;
- Outline how path models are assessed and fit to the data.

Workshop

During the workshop we will use the lavaan package to conduct path analysis in R.

Resources

Readings

** Keith, T. Z. (2019). *Multiple regression and beyond: An introduction to multiple regression and structural equation modeling* (3rd ed). London: Routledge. Chapters 12, 13, and 14.

Beaumont, R. (2018). *An Introduction to Structural Equation Modelling (SEM)*. Chapter 65, pp. 1-7.



WT7 – Structural equation modelling II: Factor analysis

Dr Thomas Curran

Last week we introduced structural equation modelling as a multivariate tool of analysis using the linear model. We looked at the simplest of structural equation models – the path model. Here we introduced issues of parsimony and model fit and we saw how mediation models might be tested simultaneously (i.e. not using separate regressions). This week we build on this understanding and introduce factor analysis as a way of assessing the validity of measurement. Along the way, we will look at the difference between exploratory and confirmatory factor analysis. We will see how capturing variance with latent factors is preferable in psychology because latent factors are constructed in the absence of error. And we will also see how factor analysis is conducted in R.

The scourge of measurement error

- Error in measures and the problem of mean score variables for regression and path analysis
- Classic measurement theory
- Invalidity

Factor analysis

- Exploratory vs confirmatory
- Accounting for invalidity
- Latent variables

Confirmatory factor analysis

- The measurement model
- Anderson & Gerbing's 2-step approach to SEM

Aim

- To introduce students to latent variables and factor analysis in structural equation modelling.

Learning outcomes

After attending the lecture, participating in the associated workshop, and completing the relevant reading you should be able to:

- Describe the issues of measurement invalidity for estimates;
- Describe what exploratory and confirmatory factor analyses are;
- Outline how latent variables overcome issues of invalidity;
- Be able to apply exploratory and confirmatory factor analyses in R.

Workshop

During the workshop, we will:

- Use the psych () package to conduct an exploratory factor analysis
- Use the lavaan () package to conduct a confirmatory factor analysis

Resources

Readings

** Keith, T. Z. (2019). *Multiple regression and beyond: An introduction to multiple regression and structural equation modelling* (3rd ed). London: Routledge. Chapters 15 and 16.

** Field, A. (2012). *Discovering statistics using R*. London: Sage. Chapter 17.

Flora, D. B., & Flake, J. K. (2017). The purpose and practice of exploratory and confirmatory factor analysis in psychological research: Decisions for scale development and validation. *Canadian Journal of Behavioural Science*, 49, 78.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling (2nd Ed) in practice: A review and recommended two-step approach. *Psychological bulletin*, 103, 411.



WT8 – Structural equation modelling III: Latent variable SEM

Dr Thomas Curran

To this point, we have looked at path models and confirmatory factor analysis. One test for relationships and the other tests for the adequacy of measurement. However, neither of these models can test both relationships and measurement at the *same time*. This week we'll look at combining path analysis and confirmatory factor analysis in something called latent variable structural equation modelling. The advantage of this approach is that it can test relationships and causal models in the absence of error. It is indeed an elegant approach and it is one of the most common approaches to hypothesis testing in the psychological and behavioural sciences.

Before this lecture and workshop, please read the JEPS blog post: Structural Equation Modelling: What is it, what does it have in common with hippie music, and why does it eat cake to get rid of measurement error (see below)

Taking stock

- Function of path analysis
- Function of confirmatory factor analysis
- Problems of treating the separately

Pulling it all together: Latent variable SEM

- The three models you meet
- Combining the path model with the confirmatory factor model
- The importance of theory
- The basic steps of SEM
- Application in R
- How its written up

Where it gets complicated

- Estimation methods
- Missing data
- Modifications

Aim

- To introduce students to latent variable structural equation modelling and how to apply it in R.

Learning outcomes

After attending the lecture, participating in the workshop, and completing the relevant reading you should be able to:

- Describe what latent variable SEM is and how it builds on path models and confirmatory factor analysis.
- Describe the steps needed in latent variable SEM.
- Be able to apply latent variable SEM in R.

Workshop

During the workshop, we will use the lavaan () packaged to conduct latent variable structural equation modelling

Resources

Readings

- ** Keith, T. Z. (2019). *Multiple regression and beyond: An introduction to multiple regression and structural equation modeling* (3rd ed.). London: Routledge. Chapter 17.
- ** Loehlin, J. C. & Beaujean, A. A. (2017). *Latent Variable Models: An Introduction to Factor, Path, and Structural Equation Analysis* (5th Ed.) Routledge: London. Chapter 1.

Blog

- ** Edelsbrunner, P. & Thurn, C. (2015). Structural Equation Modelling: What is it, what does it have in common with hippie music, and why does it eat cake to get rid of measurement error *Jeps Bulletin* <https://blog.efpsa.org/2015/12/14/structural-equation-modeling-what-is-it-what-does-it-have-in-common-with-hippie-music-and-why-does-it-eat-cake-to-get-rid-of-measurement-error/#:~:text=The%20model%20combines%20aspects%20of,to%20factor%20analysis%20are%20modeled>



WT9 – Multilevel modelling I: When the data are clustered

Dr Thomas Curran

To this point, we have looked at various univariate and multivariate statistical models that are part of the general linear model. Each time we have run these analyses we have assumed that the data are sampled independently. This assumption, however, is almost always breached in real world settings. When doing research on children's academic achievement, for example, kids are clustered within schools, which are clustered within geographical regions. In repeated measures designs, time points are nested within days, which are nested within people. At each of these levels, there is within-cluster variance and between-cluster variance that must be accounted for in analyses but are not in the techniques we have covered to date. Multilevel models (also known as linear mixed models, hierarchical linear models, or mixed-effect models) have become increasingly popular in psychology for analysing clustered data. Helpfully for us, they are also underpinned by the linear model and so you are already familiar with the basic concepts! We will build on this knowledge to demonstrate how multilevel modelling accounts for data clustering and how to apply them to cross-sectional and repeated measures data using R.

Before this lecture and workshop, please read *Murder, muddled thinking and multilevel modelling* blog in the The Psychologist (see below)

Clustering

- Data structures
- Levels of analysis
- Clustering by group
- Clustering by person

Multilevel modelling

- What is multilevel modelling
- Is it needed?
- Simple 2-level group design
- Simple 2-level longitudinal design
- Centering
- Building the level 1 and level 2 models
- Fixed and random effects
- Within-person vs between-person effects
- Cross-level interactions

Analysis in R

- 2-level multilevel model with group design
- 2-level multilevel model with longitudinal design

Aims

- To introduce students to multilevel modelling and analysis of clustered data.
- To apply multilevel modelling to real data in R.

Learning outcomes

After attending this lecture, participating in the workshop, and completing the relevant reading you should be able to:

- Describe the how data can be clustered by group or time.
- Describe when multilevel modelling is appropriate.
- Describe the different forms of 2-level multilevel modelling.
- Know how to analyse repeated measures data with multilevel modelling.
- Know how to analyse group clustered data with multilevel modelling.

Workshop

During the workshop we will use the lmer and lme4 packages in R to conduct multilevel modelling.

Resources

Readings

** Peugh, J. L. (2010). A practical guide to multilevel modeling. *Journal of school psychology*, 48, 85-112.

** Hayes, A. F. (2006). A primer on multilevel modeling. *Human communication research*, 32, 385-410.

Nezlek, J. B. (2008). An introduction to multilevel modeling for social and personality psychology. *Social and Personality Psychology Compass*, 2, 842-860.

Field, A. (2012). *Discovering statistics using R*. London: Sage. Chapter 19.

Blog

Cartwright, M., Traviss, G., & Blance, A. (2012). Murder, muddled thinking and multilevel modelling *The Psychologist* BPS
<https://thepsychologist.bps.org.uk/volume-25/edition-9/murder-muddled-thinking-and-multilevel-modelling>

WT10 – Multilevel modelling II: Latent growth curve analysis

Dr Thomas Curran

Last week we looked at multilevel modelling and how to account for clustering in data. Here we touched on longitudinal analyses and how multilevel modelling can test for within-person effects of time-varying predictors. This week we are going to reinforce this understanding by applying multilevel modelling of longitudinal data in a latent variable SEM framework using something called latent growth curve analysis. The mechanics of multilevel modelling and latent growth curve analysis are essentially the same, but latent growth curve analysis has the advantage of modelling within-person trajectories as a latent factor. We can also use the flexibility granted by SEM to test more complex models in this framework (something that cannot be done in multilevel modelling).

Longitudinal data

- Modelling trajectories
- Within-person effects
- How multilevel modelling models within-person effects
- The latent variable framework

Advantages of latent variable framework

- Estimation
- Missing data
- Complex models
- Non-linear trajectories

Analysis in R

- Latent growth curve modelling in R

Aim

- To introduce students to latent growth curve modelling for longitudinal data

Learning outcomes

After attending this lecture, participating in the workshop, and completing the relevant reading and coursework you should be able to:

- Describe the similarities and differences between multilevel modelling and latent growth curve modelling.
- Describe the advantages of modelling within-person trajectories with latent variables.
- Understand the how to latent growth curve models in R.

Workshop

During the workshop we will use the lavaan package to conduct latent growth curve modelling in R.

Resources

Readings

- ** Byrne, B. M., & Crombie, G. (2003). Modeling and testing change: An introduction to the latent growth curve model. *Understanding Statistics*, 2(3), 177-203.
- ** Duncan, T. E., & Duncan, S. C. (2009). The ABC's of LGM: An introductory guide to latent variable growth curve modeling. *Social and personality psychology compass*, 3, 979-991.
- Keith, T. Z. (2019). *Multiple regression and beyond: An introduction to multiple regression and structural equation modeling* (3rd ed). London: Routledge. Chapter 21.
- Tu, Y. K., D'Aiuto, F., Baelum, V., & Gilthorpe, M. S. (2009). An introduction to latent growth curve modelling for longitudinal continuous data in dental research. *European Journal of Oral Sciences*, 117, 343-350.
- McNeish, D., & Matta, T. (2018). Differentiating between mixed-effects and latent-curve approaches to growth modeling. *Behavior Research Methods*, 50, 1398-1414.



WT11– Looking ahead to year three

Dr Thomas Curran

To finish our journey into intermediate research methods and statistics we are going to look ahead to year three and the research project. We will cover what you should expect in terms of the dissertation and things to consider ahead of the final year. This will include a detailed overview of the dissertation process, the selection of topic, the selection of supervisor, and the likely means of collecting data from the lab and field. There will also be an opportunity in this session to ask questions about the final year – as well as about the secondary data analysis assignment.

The final year

- What to expect
- Things to think about

The dissertation

- Selecting a topic
- Selecting a supervisor
- Ethical considerations
- Planning

Q and A

- Questions about the third year
- Feedback on the course

Aim

- To make students aware of what to expect in the third years, particularly as regards the dissertation project

Learning outcomes

After attending this lecture students should be able to:

- Understand what is to come in the third year
- Start thinking about topics and supervisors for their final year projects

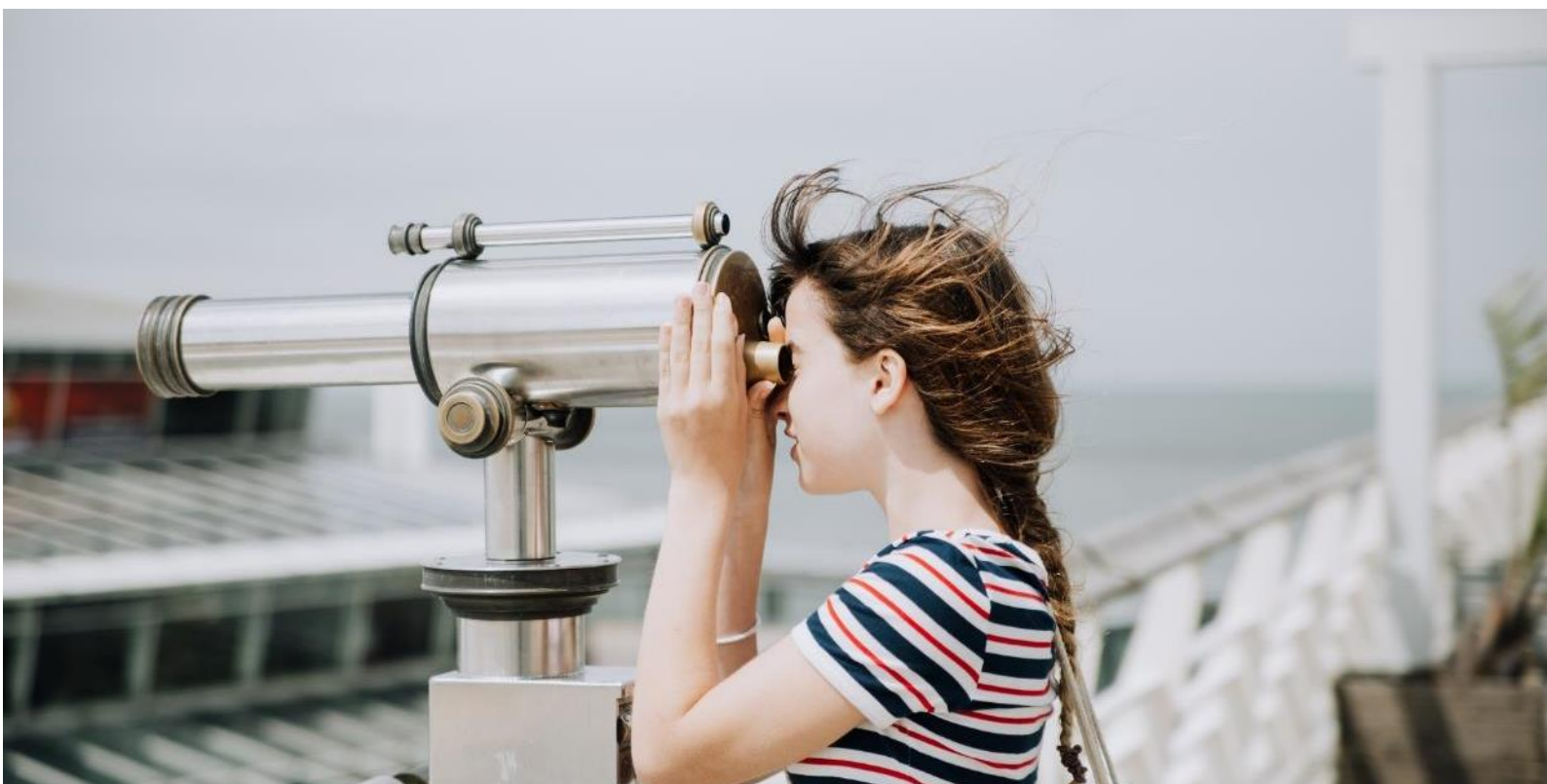
Resources

Readings

** Holliman, A. J., & Jones, T. (2018). Identifying a Topic for a Psychology Dissertation: A Process Map for Students. *Psychology Teaching Review*, 24, 82-90.

Magazine

** Dittmann, M. (2005). Starting the dissertation: Experts offer tips on picking a topic, conducting a lit review and narrowing your focus in gradPSYCH, American Psychological Association. <https://www.apa.org/gradpsych/2005/01/starting>



Assessment and Feedback

When assessing you, our aim is to encourage and support you to develop a sophisticated knowledge of the subject, the capacity for independent and critical judgment, and the ability to express your ideas with clarity. During this course you will undertake formative assessments and summative assessments.

Formative Assessments

Formative assessments, which do not count towards the final grade, are designed to help cement your learning and prepare you for summative assessments. For PB230 the formative assessments will consist of:

1. Practice preregistration (uploaded to aspredicted.org and submitted as a PDF)
2. Statistics worksheet covering the material in WT1
3. Statistics worksheet covering the material in WT2, WT3 & WT4
4. Statistics worksheet covering the material in WT5 & WT7

Summative Assessments

Summative assessments do count towards the final grade. In this course there are four elements to the summative assessment:

1. Research Compendium (50%). This will take the form of a preregistered report of a chosen replication, organised as a compendium and submitted as a zip file. It should contain the following sections:
 - Description and justification for replication
 - Preregistered methods
 - Preregistered data analysis plan
 - Example write up of results using simulated data
2. Secondary Data Analysis (50%). You will need to complete three tasks.

Deadlines and Feedback

All the deadlines for submissions and when to expect the relevant feedback will be published in due course on Moodle.

If things go wrong

If you are not able to meet an assessment deadline, then you should seek an extension or potentially a deferral. The rules around this vary so please check the assessment brief or contact the Professional Services Team (see page 2).

If you do defer a piece of summative assessment, or fail the course overall, then you will be able to take the deferred (or retake failed) assessments during the summer with a new deadline during the Resit and Deferral Assessment Period (RDAP). We will contact you closer to the time if this impacts you.

Please remember that you are also always able to submit Exceptional Circumstances, for more information visit

lse.ac.uk/exceptionalcircumstances.

Assessment Criteria for PB230

The Department of Psychological and Behavioural Science is committed to transparency and clarity in our assessment criteria and we have provided you with some guidance of what we will be looking for in assessed work below.

Quite deliberately, we will apply the same general criteria for both summative and formative assessments because the formative work is meant to help you prepare for summative work. All work in the Department of Psychological and Behavioural Science is assessed using three criteria of Content, Presentation and Critical Judgement, however what we're looking for in each type of work will vary slightly.

For more information on our assessment strategy and criteria take a look at [Assessment Criteria for undergraduate courses](#), available in the Assessment & Feedback section of Moodle.

Applying Assessment Criteria to your work

These assessment criteria are intended as broad guides for what we will be hoping to find in your work but please remember that at university level assessment is more of an art than an exact science so these notes are for general guidance only. It is worth remembering that assessment is **not** carried out according to a checklist of separate contents, but in a more integrated way that assesses the piece as a whole and allows for deficits in one aspect of the piece to be compensated for by particular merits in another aspect. The type of questions posed will require some novel thinking and/or synthesis across areas of the discipline. With such questions there may be some core of important material but there are usually a number of acceptable ways of framing that material and of introducing other relevant arguments.

Moreover, since there will always be constraints on what you can produce exams are time-limited, essays have a word-count, presentations have a time limit, **you** must decide which theories and findings are critical to **your** argument. An important skill to develop is determining which content to omit, and appropriate omissions will depend on the argument that you wish to present. As a result, there are no "model answers" against which your written work is assessed – there are many different ways of successfully approaching any one question, and answers employing widely differing arguments may be equally successful. All references to appropriateness, relevance, etc., of use of material in these assessment criteria should be understood as appropriateness, relevance, etc., of use of material relative to the argument that you present, and not relative to a model answer.

Assessment Feedback

You will receive feedback in a number of different ways and it is important to remember that feedback is not limited to marks! You should actively seek feedback from teachers and from other students. This could involve a range of approaches such as:

- Asking for an answer to a simple question (e.g., 'I think concept X means p, q, r ... am I on the right lines?')
- Asking for a view of the way you have handled a presentation of a topic or argument during a class
- Engaging in a more general dialogue with one or more teachers

To gain a picture of your progress on the course, it will be useful for you to try to integrate the information you gain from all forms of feedback. Meeting with your Academic Mentor can help you in this.

It is your responsibility to be sure that you understand the feedback you receive on your assessments, and to use it to understand your own strengths and weaknesses. Think about the comments you are given rather than focussing only on the mark. Try to understand your feedback comments in the light of the assessment criteria, perhaps even to understand the criteria better. For more advice on how to make the best use of your feedback read [Using Feedback](#), available in the Assessment & Feedback section of Moodle.

Final Mark

Your final mark will be made available on LSE for You in line with the School-Wide results release process. You can find out more details about this online at lse.ac.uk/results.

Please remember that all results are provisional until they are released via LSE for You.

