Engaging students in research methods and statistics: A “how to” guide to making this possible.

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Engagement in a statistics and methods course

- Why do they hate statistics so much?
  - Brief review of some of the previous research into statistics teaching
- What can we do to engage students more in stats and RM?
  - Outline of the first four weeks of the RHUL psychology stats/RM course
40% of new psychology students do not realise that statistics is part of the psychology curriculum (Ruggeri et al., 2008)

Statistics is perceived as the hardest aspect of a psychology degree (Barry, 2012)

Students do not see the real word relevance of statistics, and tend to concentrate on passing assessment, rather than understanding the course content (Onwuegabuzie et al., 2013)
Problem 2: “Statistics makes me feel very anxious”

- Statistics is the most anxiety provoking part of the degree, with up to 80% reporting SA (Onwuegbuzie & Wilson, 2003)

- Higher levels of SA predict:
  - Lower marks (Macher et al., 2012)
  - Procrastination (Onwuegbuzie, 2004)

- Statistics anxiety is multifaceted, including mathematical ability
  - Statistics Anxiety Rating Scale
  - Adapted for UK (Hanna et al., 2008)
Dear News Media,

When reporting poll results, please keep in mind the following suggestions:

1. If two poll numbers differ by less than the margin of error, it’s not a news story.
2. Scientific facts are not determined by public opinion polls.
3. A poll taken of your viewers/internet users is not a scientific poll.
4. What if all polls included the option “Don’t care”?

Signed,
-Someone who took a basic statistics course.

Developing an engaging statistics and research methods course: The first four weeks...
Overall module and teaching structure (PS1010)

Year-long first year course (25% of first year content)
- Integrated statistics and methodology course
- Assessment of PS1010: Weekly MCQ quizzes, critical thinking assignment, three lab reports and unseen, open book exam

<table>
<thead>
<tr>
<th>Weekly teaching structure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lecture:</strong></td>
</tr>
<tr>
<td>Covers statistics and</td>
</tr>
<tr>
<td>methods content</td>
</tr>
<tr>
<td>1 hour with lecturer</td>
</tr>
</tbody>
</table>

**Lecture:**
Covers statistics and methods content
1 hour with lecturer

**Workshop:**
Structured practice of lecture content
1 hour with lab tutor

**Lab class:**
Interactive research practice (PBL)
2 hours with lab tutor
**Week 1**: Emphasis on the relevance of stats/RM

- Lecture content emphasises the relevance to:
  - The rest of their psychology degree
  - Transferable skills and their future career

- Lab class content aims to foster:
  - Critical thinking skills
  - Confidence in critical thinking and speaking in classes
  - First work on a simple research paper
Slides from lecture 1: Making stats/RM relevant

Psychology and research

Why do you need to learn research methods?!

Does chocolate make you intelligent?

Design a study to test this

What did you find in your study?

What questions did your study raise?

- Research is vital to all areas of psychology
- To understand research is to understand psychology
Slides from lecture 1: Making stats/RM relevant

Psychology and research

- Cognition
- Developmental psychology
- Individual differences
- Neuropsychology
- Social psychology
- Clinical psychology

Core areas in psychology: BPS curriculum
How do we do research?

1. Devise a research question
   - What do you want to find out?
2. Design a study to test the question
   - How will you find it out?
3. Choose the stimuli, questionnaires, etc.
   - What materials will you use?
4. Apply for ethical approval
   - Is your design ethical?
5. Run the study and collect the data
   - Data collection time
6. Analyse the data and see what you found out
   - What did your research find out?
7. Write your study up as a research report
   - Tell others about your research
Research skills after graduation

What skills do employers want from graduate applicants?

- **Transferable skills learned through research skills**

  - **Communication skills**
    - Written communication: Learned through project reports
    - Spoken communication: Group and class discussion in labs

  - **Problem solving skills**
    - Most of the research process is about problem solving! What is the research question? How can we test this? What do results mean?

  - **Evaluative skills**
    - Thinking critically about the work of others
    - Thinking critically about your own work

  - **Numeracy skills**
    - Ability to analyse, interpret and understand statistics
    - Ability to present numbers in a simple and clear manner

  - **IT skills**
    - Use of standard packages: Word, PowerPoint, Excel, internet, etc.
    - Use of specialist packages: Statistics, image manipulation, etc.

  - **Teamwork/Independence**
    - Teamwork: Projects and lab exercises will be conducted in groups
    - Independence: Written work, exam revision shows independence
Conspiracy theories

What conspiracy theories do you know about?

Might any actually be true?
Critical thinking = Creative thinking

- Try to look at things from as many different perspectives as possible
- Consider alternative explanations

A psychotherapist has a patient who is afraid of the colour pink. Why?
Thinking about research...

- Does TBI cause offending/illegal behaviour?
- Does offending/illegal behaviour cause TBI?

**Table 2: Causes of TBI**

<table>
<thead>
<tr>
<th>Source of injury</th>
<th>Number of participants</th>
<th>% of total sample</th>
<th>% of head injury sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joyriding</td>
<td>9</td>
<td>4.8</td>
<td>7.44</td>
</tr>
<tr>
<td>Falls on drugs</td>
<td>12</td>
<td>6.4</td>
<td>9.92</td>
</tr>
<tr>
<td>Falls sober</td>
<td>3</td>
<td>1.6</td>
<td>2.48</td>
</tr>
<tr>
<td>Sports injuries</td>
<td>3</td>
<td>1.6</td>
<td>2.48</td>
</tr>
<tr>
<td>Fights</td>
<td>70</td>
<td>37.2</td>
<td>57.85</td>
</tr>
<tr>
<td>Other crimes</td>
<td>3</td>
<td>1.6</td>
<td>2.48</td>
</tr>
<tr>
<td>Other (non-crime related)</td>
<td>21</td>
<td>11.2</td>
<td>17.36</td>
</tr>
<tr>
<td>Total</td>
<td>121</td>
<td>65.05%</td>
<td>100%</td>
</tr>
</tbody>
</table>

82.64% of head injuries resulted from crime related activities

- What else would you like to know about this study?
- What else might influence this relationship?
Week 2: How to read a psychology research paper

- Lecture content covers:
  - The structure of a typical psychological research paper
  - What should be contained within each paper
  - Questions to ask of all research paper (critical thinking)
  - How to find psychological research (Web of Knowledge)

- Lab class content gives detailed support for reading and understanding research papers
Psychological papers: the hourglass

- Introduction: the broader research question
- Introduction: narrow down to relevant research
- Introduction: justify your study and predictions
- Methods: clear enough for replication
- Results: appropriate, transparent and clear
- Discussion: describe/explain findings
- Discussion: implications and critique
- Discussion: place findings in wider context
Reading research papers

When reading a paper, answer these questions...

1. What is the most important previous work?
2. What is the main hypothesis?
3. Why is this research important?
4. Did the researchers use appropriate measurements and procedures?
5. What were the variables in the study?
6. What was the key finding of the research?
7. Do the findings justify the authors’ conclusions?
8. Are there weaknesses, and do they make you believe/trust the findings less?
Understanding the results

Table 1
Descriptive statistics (mean and S.D.) for males and females on the Gf tests

<table>
<thead>
<tr>
<th>Tests</th>
<th>Males</th>
<th>Females</th>
<th>d</th>
<th>IQ</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Culture-Fair Test</td>
<td>24.13</td>
<td>3.57</td>
<td>23.75</td>
<td>3.7</td>
<td>0.10</td>
</tr>
<tr>
<td>PMA-R</td>
<td>18.62</td>
<td>4.76</td>
<td>19.55</td>
<td>4.8</td>
<td>-0.19</td>
</tr>
<tr>
<td>APM</td>
<td>23.9</td>
<td>4.8</td>
<td>22.4</td>
<td>5.3</td>
<td>0.283</td>
</tr>
</tbody>
</table>

Significant differences are flagged with a *

- Are there sex differences in each IQ test?
- For each variable, think about two things:
  - Is there a significant difference?
  - Do males or females score significantly higher?
Week 3: Basics of research methodology

- Lecture content covers:
  - Main types of design used in psychological research
  - Primary design considerations for each type of design
  - Links to statistical analyses and the rest of the course

- Lab class content gives students various research design exercises to complete in groups. Lab tutors facilitate group work and discuss key issues for each exercise with the whole class.
Core designs in psychology

**Devising a research question.**
What will you research? How will you do it? Why is it needed?

- **Frequency**
  - Is group membership non-random?
  - Is occurrence of inpatient treatment different for people diagnosed with depression and anxiety?

- **Differences**
  - Is there a significant difference in memory after having coffee vs. having a placebo drink?

- **Relationships**
  - Is there a relationship between IQ and the personality traits extraversion and neuroticism?

Research questions for lab reports to be announced later...

Lab report 1
Lab report 2
Lab report 3
Key points to consider in research design

Devising a research question:
What will you research? How will you do it? Why is it needed?

Frequency
Is group membership non-random?
- One or two variables can be analysed
- Must be categorical
- Can have any number of categories, but usually less than 5

Differences
Is there a difference between conditions?
- Dependent variable:
  - What you measure
  - Must be continuous
- Independent variable:
  - What you manipulate
  - Must be categorical

Relationships
Is there a relationship between two variables?
- Variables are naturally occurring – no experimental manipulations
- Variables must be continuous scores
Devising a research question.
What will you research? How will you do it? Why is it needed?

Frequency
Is group membership non-random?
- Chi squared analysis

Differences
Is there a difference between conditions?
- t tests:
  - Independent t test
  - Repeated t test
  - ANOVA

Relationships
Is there a relationship between two variables?
- Correlation
- Regression

Lectures 7
Lab report 1

Lectures 11, 12 & 14
Lab report 2

Lectures 16 & 17
Lab report 3
Designing studies...

In your groups, design three studies examining the same issue.

- The relationship between caffeine consumption and performance at university
- Design three studies:
  - Categorical design
  - Experimental
  - Correlational

Remember to think about:
- What “scores” do you need for a design?
- For experimental designs:
  - Experimental or quasi experimental?
  - Independent or repeated design?
Confounding variables...

- We want to run a study looking at second language acquisition. To do this we invent a new language and ask participants to learn 20 “nonsense” and 20 “real” words. Later we give them a memory test to see how well they learned them.
- Here are some possible confounds...

<table>
<thead>
<tr>
<th>Sex (male/female)</th>
<th>Number of languages spoken</th>
<th>Existence of bilingual family members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of residence (geographical location)</td>
<td>Age</td>
<td>IQ</td>
</tr>
<tr>
<td>Level of education</td>
<td>Number of siblings</td>
<td>Amount of caffeine consumed</td>
</tr>
</tbody>
</table>

Group task: Discuss each of the possible confounds. Do you think that the confound might really influence the findings? Rank order them from 1 “most likely to influence the findings” to 9 “least likely to influence the findings”.

Week 4: Basics of statistical analysis

- Lecture content covers:
  - Difference between descriptive and inferential statistics
  - Hypothesis testing and Type I Errors
  - What does “statistical significance” really mean?
  - Importance of variability for all statistics

- Lab class content includes a “Maths Test”, specifically designed for the needs of psychological research
Slides from lecture 4: Basics of statistical analysis

Using statistics in your research...

1. Design your study
2. Collect the data
3. Calculate the descriptive statistics
4. Calculate the appropriate inferential statistic
5. Calculation gives you a "calculated value"

How do you know if your calculated value is "big enough" to be significant?

Lab class exercises
Next week...
Various lectures...
### Errors in hypothesis testing

<table>
<thead>
<tr>
<th>Truth in the real world (population)</th>
<th>Result of your statistical analysis (sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accept $H_0$ (No effect)</td>
<td>Accept $H_0$ (No effect)</td>
</tr>
<tr>
<td>Accept $H_1$ (Find effect)</td>
<td>Accept $H_1$ (Find effect)</td>
</tr>
</tbody>
</table>

- **Correct decision**
- **Type I error**
- **Type II error**

**Making a Type I Error is the most dangerous outcome from a study!**

Why might this be???
$p$ values and significance

- Inferential statistical analyses give you a $p$ value
  - $p$ = probability of making a Type I error

- $p = 0.05$ means 5% chance of Type I error
  - $p * 100 = \%$ chance committing a Type I error

- The bigger the effect in your data, the smaller the chance of making a Type I error (wrongly saying you found something!)

- If 5% is the risk you are willing to take, you want $p \leq 0.05$

<table>
<thead>
<tr>
<th>Not significant $p$ values</th>
<th>Significant $p$ values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than .050 ($p &gt; .050$)</td>
<td>Less than or equal to .050 ($p \leq .050$)</td>
</tr>
<tr>
<td>$p = .060$ is NOT SIGNIFICANT 😞</td>
<td>$p = .040$ IS SIGNIFICANT 😊</td>
</tr>
</tbody>
</table>
Don’t forget the descriptive statistics!

3. Results

There was a significant biological sex difference in psychological masculinity scores ($t(83) = 5.6, p < .001$) with higher scores for males ($M = 5.0, SD = .6$) than females ($M = 4.3, SD = .6$). There was also a significant biological sex difference in psychological femininity scores ($t(83) = 1.7, p = .050$) with higher scores for females ($M = 4.8, SD = .5$) than males ($M = 4.6, SD = .5$). These analyses confirm the expected biological sex differences in psychological gender identity with males tending to be more psychologically masculine and females tending to be more psychologically feminine. One-sample $t$-tests found that all six versions of the chimeric faces test showed a significant left visual field bias, indicating right hemisphere dominance for processing facial emotion (see Table 1).

When you talk about inferential statistics, use the descriptive statistics to explain the direction of the effects.

For tests of significant differences ($t$ test, ANOVA):
- Which group has significantly *higher* scores?

For tests of significant relationships (correlations):
- Is the relationship *positive* or *negative*?
Why care about dispersion?

Experiment one

Experiment two
The cake, variance and significance

Experimental variance

Random variance

Likely to be significant

Not likely to be significant
slides from lab 4: maths for psychology

This table summarises the data collected in a study researching children's abilities to accurately recognise the emotional valence (positive or negative) in a voice. Data were collected for boys and girls separately and across four different age groups. For each group, the table gives the number of children tested in that group and the mean (average) percentage correct for emotional voice processing.

<table>
<thead>
<tr>
<th>Age</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Mean</td>
<td>Number</td>
</tr>
<tr>
<td>5 years old</td>
<td>24</td>
<td>64%</td>
</tr>
<tr>
<td>7 years old</td>
<td>28</td>
<td>68%</td>
</tr>
<tr>
<td>9 years old</td>
<td>19</td>
<td>80%</td>
</tr>
<tr>
<td>11 years old</td>
<td>22</td>
<td>89%</td>
</tr>
</tbody>
</table>

1. How many different groups of children were tested in this study?
2. How many children in total were tested in this study?
3. How many boys were tested in this study?
4. What was the difference in sample size between boys and girls?
5. Which group: What does each of the following symbols mean?

<table>
<thead>
<tr>
<th>Operation</th>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than</td>
<td>&lt;</td>
<td>a. Less than</td>
</tr>
<tr>
<td>Greater than</td>
<td>&gt;</td>
<td>b. Greater than</td>
</tr>
<tr>
<td>Less than or equal to</td>
<td>\leq</td>
<td>c. Less than or equal to</td>
</tr>
<tr>
<td>Greater than or equal to</td>
<td>\geq</td>
<td>d. Greater than or equal to</td>
</tr>
<tr>
<td>Minus</td>
<td>-</td>
<td>c. Minus</td>
</tr>
<tr>
<td>Plus or minus</td>
<td>\pm</td>
<td>d. Minus negative</td>
</tr>
<tr>
<td>Solve</td>
<td>\Sigma</td>
<td>a. Solve</td>
</tr>
<tr>
<td>Average</td>
<td>\Sigma</td>
<td>b. Average</td>
</tr>
<tr>
<td>Mean</td>
<td>X</td>
<td>a. Mean</td>
</tr>
<tr>
<td>Mode</td>
<td>X</td>
<td>b. Mode</td>
</tr>
</tbody>
</table>

Round off the following numbers to one decimal place:
6. 3.91
7. 2.79
8. 1.116
9. 2.321
10. 4.565

For each of the following numbers, are they < .050?
6. .051
7. .049
8. .001
9. .500
10. .005

Solve the following:
1. $3^2 + 3 =$
2. $7 + \sqrt{16} =$
3. $5^2 + (-10) =$
4. $(8 \times 2) - 6 =$
5. $\sqrt{11 - 2} =$

No calculators allowed and they must not discuss answers!
Interpreting tables: Answers

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th></th>
<th>Girls</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Mean</td>
<td>Number</td>
<td>Mean</td>
</tr>
<tr>
<td>5 years old</td>
<td>24</td>
<td>64%</td>
<td>18</td>
<td>71%</td>
</tr>
<tr>
<td>7 years old</td>
<td>28</td>
<td>68%</td>
<td>15</td>
<td>76%</td>
</tr>
<tr>
<td>9 years old</td>
<td>19</td>
<td>80%</td>
<td>26</td>
<td>83%</td>
</tr>
<tr>
<td>11 years old</td>
<td>22</td>
<td>89%</td>
<td>21</td>
<td>90%</td>
</tr>
</tbody>
</table>

8 groups: 2 (sex) x 4 (age)

1. How many different groups of children were tested in this study?
173

2. How many children in total were tested in this study?
93

3. How many boys were tested in this study?
13 more boys

4. What was the difference in sample size between boys and girls?

7 year old boys, N = 28

5. Which group contained the most children, and how many were included?
Interpreting tables: Why?

- Tables are a very easy way to present data
- Tables make interpretation far easier
- Tables are used in most published journal articles
- In psychology you need to:
  - Create tables to represent your own data
  - Interpret tables in articles
Allow students to identify “strengths” and “areas for improvement”. Most are reassured at how easy the test was!

Is mathematical ability associated with performance on a stats/ RM course?

Factor analysis on maths scores:
1. Procedural mathematics
2. Interpretation of mathematics
3. Semantics and meaning of maths
## Correlations between mathematical ability & performance

<table>
<thead>
<tr>
<th></th>
<th>Multiple choice quizzes</th>
<th>Critical thinking essay</th>
<th>Lab report 1 ($\chi^2$)</th>
<th>Lab report 2 (t)</th>
<th>Lab report 3 (r)</th>
<th>Exam</th>
<th>Course total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Procedural maths</strong></td>
<td><strong>.098</strong>*</td>
<td>.079</td>
<td>.063</td>
<td>.040</td>
<td>.089</td>
<td><strong>.133</strong>**</td>
<td><strong>.137</strong>**</td>
</tr>
<tr>
<td><strong>Interpretation of maths</strong></td>
<td><strong>.097</strong>*</td>
<td><strong>.123</strong>*</td>
<td><strong>.111</strong>*</td>
<td>.060</td>
<td>.012</td>
<td><strong>.158</strong>**</td>
<td><strong>.153</strong>**</td>
</tr>
<tr>
<td><strong>Semantics &amp; meaning</strong></td>
<td>.006</td>
<td>.018</td>
<td>-.041</td>
<td>.010</td>
<td>.024</td>
<td>.076</td>
<td>.048</td>
</tr>
</tbody>
</table>
The problems, and (hopefully) some of the solutions

Engagement with statistics

“Statistics is irrelevant for psychology”

Relevance to employability and generic skills

Relevance to the rest of the degree

Aids understanding of all psychology

Engage students in research (make them excited!)

Enhance their understanding of the relevance

Various skills, including critical thinking

Alleviate anxiety about research papers

Clear overview of methodology

Alleviate anxiety about maths and statistics

Training in how to read papers

Make it clear what maths is needed and why

Help them understand their strengths and weaknesses
To get resources or find out more...

- “Maths Test” resources
- “Creating Independent Researchers”
  - **Free** one-day workshop at RHUL: curriculum design, assessment, etc. Sponsored by [Oxford University Press](www.oup.com)

Contact me for more info!!!

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[Visit my Twitter](https://twitter.com/VBourne_stats)
Thank you for listening!
Any questions?