Due Date: 24th Nov

Deliverables
Hand in via MMS, by 9.00pm on 24th November:
• a single zip file containing your work (which will include code, video or links to video, PDF etc.)
Marking
See the standard mark descriptors in the School Student Handbook:
http://info.cs.st-andrews.ac.uk/student-handbook/learning-teaching/feedback.html#Mark_Descriptors
Lateness
The standard penalty for late submission applies (Scheme B: 1 mark per 8 hour period, or part thereof):
http://info.cs.st-andrews.ac.uk/student-handbook/learning-teaching/assessment.html#lateness-penalties
Good Academic Practice
The University policy on Good Academic Practice applies:
https://www.st-andrews.ac.uk/students/rules/academicpractice/

Aims and Objectives:

1. To understand Analysis of Variance, how to determine, apply and interpret a F-Distribution value from an ANOVA.
2. To understand how to design an experiment for comparing two menu styles, along with the factors influencing each, and the threats to validity
3. To implement and test the two menu styles using your design

Resources

- ANOVA Excel spreadsheet (this is the basis for starting but needs to be extended) from lectures
- Video demonstrating linear menus, basic pie menus, and marking menus
- PhD thesis describing evaluation of marking menus

Learning Outcomes

By the end of this practical you should have familiarity with: ANOVA, factors influencing choice of menu styles and how to design experiments for them

Question 1

Complete a one-way ANOVA on the following error rate data which has been generated from three different "between-subjects experiments" on two keyboards A and B, two mouse devices C and D and three multi-touch systems E, F and G.

Report on the following:

- **Sums** of SS_{total} and SS_{error} and SS_{effect}
- **Degrees of Freedom** df_{effect} and df_{error}
- **F-Distribution value** (reported correctly) and how you interpret this!
- For each of the three ANOVAs can you reject the null hypothesis and why?
- At what significance level can you reject each null hypothesis, and what does this mean?
- Give the **precise wording** for how you would separately report the outcome of each of the three experiments from slide set 4 ie. "Reporting".
- What can you say about the error rates for A versus B, C versus D and the 3 multi-touch systems E, F and G?

Keyboard A	Keyboard B
1	3
2	4
3	5
4	6
5	7

Mouse C	Mouse D
2	8
4	10
6	12
8	14
10	16

MT E	MT F	MT G
28	30	51
28	44	70
34	36	58
36	39	60
46	30	67
38	46	62
41	44	55

Suggestion: employ and extend the spreadsheet given in week 4!

Question 2

Watch the included video, which demonstrates a comparison of three types of menu: linear menus, pie menus, and marking menus. Additionally, you may wish to look at the experimental design and evaluation in the included thesis for additional information.

To answer this question, briefly describe **four** factors to consider when deciding on whether to implement a linear menu or a pie menu, including how this factor would influence your decision.

Next, describe in less than **300 words** an experiment to empirically compare the two menu styles using a **between-subjects** design. Ensure you describe your hypothesis, independent and dependent variables, your setup, participants, apparatus, material and study procedure. Note any possible skill transfer effects, asymmetrical skill transfer, balancing and counterbalancing.

Finally, describe two possible threats to the experimental validity of what you propose.

Question 3

In a programming language of your choice, implement an application that allows you to empirically compare these two menus as stated in your experimental design. You will need to:

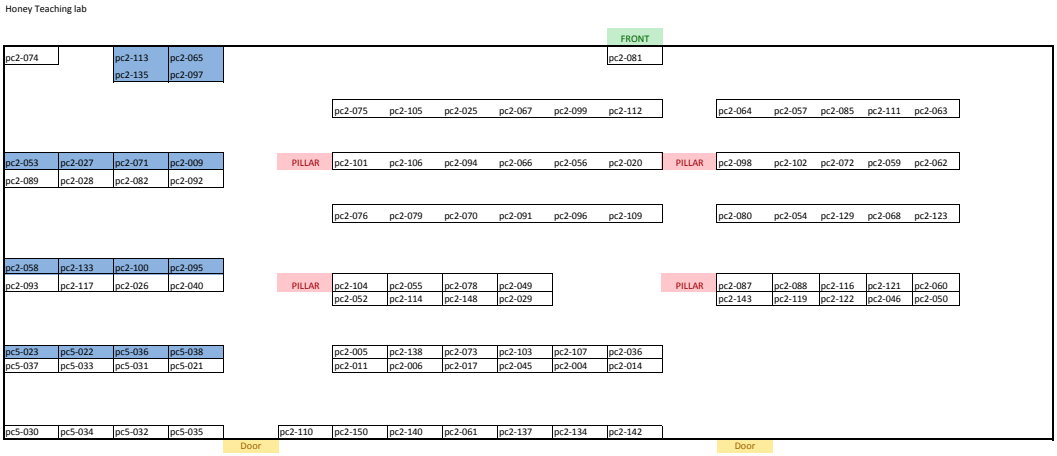
- Implement a basic pie menu and linear menu within the application
- Instrument your application to collect data for measuring your dependent variables.
- Implement test conditions as described in your Question 2 design.
- Run the experiment with at least 6 participants (3 per condition) from your tutorial group or elsewhere.
- Include **a short video** which shows your test application with both linear menu and pie menu use illustrated (you can place the video in a public venue eg. YouTube as long as the URL isn't public)
- Analyse the participant data and present your results in a short (1 page) report.

You are free to use any libraries you find for assisting in implementing the pie menu, or you may also implement this from scratch, but make use of libraries clear in your report.

For additional credit, you may want to consider the following extensions:

- As well as, or instead of, a between-subjects comparison, conduct a study that uses a **within-subjects** comparison, and use the appropriate statistical methods to test your hypothesis. What additional threats does this pose to internal validity, and how can you minimise these threats?
- In addition to a basic pie menu, implement a **marking menu** as shown in the video. If you have time, consider performing an empirical comparison between your marking menu and your pie menu.

If you need to edit the video you collect then Flashback 5 Pro is installed on 3 clients in H110. The computers are highlighted in magenta on the attached map. The free version, Flashback 5 Express, supports screen capture but not video editing to the clients in h105.http://enchroma.com/test/instructions/ you can of course use any video editing software you wish (if required).



Aaron Quigley and Daniel Rough, October 2016