Introduction to Computing for Psychology Students

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Contents

1 Course Goal:

Improve your ability to use your computer as a tool for academic activities.

This leads to the following learning objectives

2 Learning Objectives:

- Learn how to install software.
- Learn how to work from the command line.
- Learn the rudiments of programming sufficient to allow further progress through self study.
- Learn about the use of libraries to enable programming psychological experiments.
- Learn how to use version control

- Learn how to write papers that blend code and analyses to generate reproducible research reports. This includes learning
  - how to use citation databases
  - generate graphics of analyses
  - conduct statistical analyses
  - generate multiple output formats from a single source file.

3 Course Mechanics

To meet the learning objectives you will need to **do** more than you listen or observe. You will also need to break old habits. That means in the beginning it will be harder to do simple things. It also means that in the future things that used to be impossible for you to do will now be possible (but they may still not be easy). Combining computer skills with with your psychology content knowledge makes you more attractive to employers and on a graduate school application.

Thus, this course will require you to use the Linux operating system (the XUbuntu flavor) and tools available within that space. Later on, after this course, if you wish to return to the world of OSX and Windows10 you will know what you are looking for, and you will have the skills necessary to make it available.

4 Outline

4.1 Session 1 Installing Linux

4.1.1 Instructions for testing the Live CD and installing to USB

1. Learn how to boot your computer from a USB.
   - Mac OSX - start the computer with option key held down
   - Windows - may require going into the bios and enable booting usb (usually some key combo of F2 or F10 during the boot process - look for a very briefly flashed screen); followed by rebooting with a different F Key. Another option is to tell Windows to boot from recovery mode. Find the "advanced" menu of the Windows Start Up menu (look in the "recovery" section of the start-up). Select from "another device". Some devices, like Surfaces, have other key combinations.
   - Other systems: chrome books; ipads; probably won't work.
   - Sometimes it takes a while to figure out which of the options is the Xubuntu option. If one doesn't work, just note what it was and next time try a different one.
2. Run an XUbuntu Live CD If problems starting the use without installing option, restart, select install, and then quit from the first screen. That will usually drop you into what you need.

3. Explore the Live USB

   (a) Connect to the wifi.

      i. Click up/down arrow in upper right corner of screen.

      ii. Select the correct options (to be demonstrated).

         - Authentication: PEAP
         - Click box no certificate required
         - Use your full watiam address (including the stuff after @ sign usually).

   (b) Verify working by opening Firefox Web Browser

      i. Click little icon upper left.

      ii. From dropdown menu select *Web Browser*.

      iii. Go to `https://uwaterloo.ca`

   (c) Explore some of the other programs available in the dropdown menu and under the different headings.

      i. Which program is like Word for Windows?

      ii. How do you take a screenshot?

      iii. What is the standard email program on this version of Linux?

   (d) Installing programs There is a "gui" installer, but we are going to use the package management system from the command line.

      i. Open the terminal emulator

      ii. type `sudo apt update` What does *sudo* mean?

      iii. Do **NOT** upgrade your old packages at this point.

      iv. type `sudo apt install emacs` ; accept the defaults

      v. Leave the terminal open but drag over to the menu in the upper left corner and inspect the *Development* folder. You should emacs in there. Do **not** click it. We are going to launch from the command line.

      vi. Back in terminal type: `emacs &`. What does the ampersand do? It lets things run in the background without freezing the terminal. If you don't know what I mean, then start without the ampersand, and then try to type another command in the terminal. Remember: if you don't know what will happen? Try it (after maybe backing up important files).

      vii. Go to the emacs help menu and under the drop down options pick emacs psychotherapist. Remember it is here when you need some counselling in the first few sessions of this course.

4. Syllabus review (short break).

5. Problems with the live "CD". Nothing is permanent. All your upgrades and installations vanish everytime you turn it off and you would have to do it all over again everytime you restart. So, I want you to install Xubuntu so that any

changes you make will be persistent, but since I don't want to require you to alter your personnel machine, will will install it to a usb and you will then run your computer from this new, second, usb where the changes you make will persist.

6. Install Linux XUbuntu to a second USB This will be the major goal of the rest of our session. Follow the prompts on the screen. Work together. Ask questions.

   Where you need to be careful

   When you are picking where to install the system you need to make sure to pick the new USB location. It will probably be /dev/sd<something or other>. If you pick the wrong device you will install it in place of your current operating system. Try running, from a terminal, =ls /dev/sd* = without the usb in place. Then plug in the USB and note the new appearance of the another `/dev/sd<something>`.

   When you pick where to install the *bootloader* make sure you also pick the USB or you may have trouble booting into your old system the way you are used too.

7. When you think you are done, shut things down. Remove the live USB/CD, but leave the other one in place. Follow the steps you need to to boot your computer from a USB. If you are able to launch Ubuntu (and it might take a few tries to find the right menu entry) then you will see linux start. Enjoy the feeling of immense power.

8. Boot your computer from the *new* USB and install **emacs** *from the command line* again.

   (a) The command line - open up a "terminal". Your terminal will be running a "shell."

   (b) Package Managers

      i. The ubuntu package manager Basic commands:

         - apt update
         - apt install
         - apt search
         - apt remove

9. This time you might want to update those old programs.

4.1.2 Troubleshooting

I don't have a USB port? Do you have an sdcard port? Yes? You can use that. If you have neither you will need a different computer. It can be a cheap (as in the price of textbook cheap) and old one.

I only have one USB port. Can you work with a neighbor to repeat the installation instructions on a second USB that you can use on your machine? If not, you may need something like this. `https://images-na.ssl-images-amazon.com/images/I/81j1TYALbYL._SL1500_.jpg`

Can I just install Linux on my computer? You certainly can, and you can even keep you "old" operating system and use one or the other as you choose. But this seemed more than I could require of all students, but I encourage you to do it if you are willing. First, **back up everything** because trying this and getting it wrong could cause you to lose all your saved information.

I already use Linux. Good for you. Help a classmate.

What is Linux? Check wikipedia.

Why use Xubuntu? Is it different from Ubuntu (Debian, Arch, Fedora, OpenSuse...)? Linux is a kernel that powers the system. All the rest are different choices people make of the tools they want to wrap around that "engine." XUbuntu is a reasonably light-weight linux distribution that runs well on slow machines, and yet has enough of a user base to make it reasonably easy to find help on line.

4.1.3 Homework

1. Send me a screenshot of emacs open and running on your laptop. Hints: look for xfce4-screenshooter to take the screenshot. Log on to *Learn* while running linux. Of course that will require you to connect to the internet, and that will require you repeating those steps to configure the connection.

2. Look at the available software applications and download one (1). Don't go crazy on this. You are running your whole computer from a small usb, it will already be slow, and you will already be limited for space. Just find one program (look for "software" in the upper left corner icon drop down menu) that strikes you as cool or interesting and install it, play with it, and write a one-paragraph description of it using this format:

   ```
   * Package Name
     My Package
   ** Short Description
      A package for something.
   ** Review
      I liked it because ... and so on.
   ```

   Save it with yourlastname-firstname$_{\text{pkgname.org}}$ as the file name. Upload it to the dropbox on learn. And save it, because you will need it again soon.

   Use the program "mousepad" for the above.

4.2 Session 2 Command Line Basics and EMACS Introduction

4.2.1 Command Line

1. What is it?

2. Why use it? One opinion.

(a) The Manual

3. Find your terminal? Why is it called the terminal?

   (a) Operating Systems

      - Windows
        - CMD
        - Power Shell
        - WSL If you use this I recommend you install the Ubuntu version. That is the one that I know the most about from the options. Note that this will give you access to command line tools, but not to graphical tools.
        - **Recommended** If you have windows 10 you can run linux as a virtual machine.
      - OSX
        - Applications/Utilities/Terminal
        - Why don't you have to install a virtual machine to get linux commands on OSX?
      - Linux
        - probably xterm

4. Terminal Games

   (a) `ls -la /home/<username>`

      - What does all this output mean?
      - What changes when you leave out the `-la`?
      - What does the hyphen do?

   (b) Find the location of your Desktop folder.

   (c) Change to that directory. `cd`

   (d) Find out where you are? `pwd`

   (e) Find out how much free space you have on your computer disk. `df -h`

   (f) How do you get help for most of these commands? Usually `command --help` or (`-h`)

   (g) How do you find the manual? `man ls`

   (h) Navigating

      i. Paths: absolute and relative.
      ii. What do those "dots" mean?
      iii. What do those slashes mean?
      iv. Tab is your friend.
      v. Try the up arrow too.

   (i) File ownership

i. Make a text file from the command line. `touch /home/yourname/Documents/testText.txt`

ii. Who owns it?

(j) Make a directory `mkdir /home/britt/Documents/myFirstDir/`
Spaces are the enemy. Never use them, but if you have to, escape (`\`) them.

(k) Want more practice? Try the tutorials here.

4.2.2 Exercises Emacs

1. Emacs

   (a) What are Control and Meta used for? What keys are they? May depend on your keyboard and operating system. Don't like what they are? Remap them.

   (b) Tutorial `Ctrl-h t` (aka `C-h t`)

   (c) Find the Psychotherapist - you may need it.

   (d) Play a game - try `M-x tetris`

   (e) Init files and packages. Emacs has it's own package system that allows you to greatly expand its functionality. Most of those customization are set up in your `~/.emacs.d/init.el` file. Create it if it doesn't exist.
   You can learn more by reading the info file.
   A minimal init.el to get started

   ```
   (require package)
   (package-initialize)
   (add-to-list 'package-archives '("melpa" . "http://melpa.org/packages")
   ```

   (f) Program your editor

      i. Turn off the tool bar?

      ii. How? `C-h-f` will allow you to search for functions. Try the keyword menu and tab and see if you come across a likely contender (`menu-bar-showhide-tool-bar-menu-customize-disable`).

      iii. Navigate to the scratch buffer. Put that function in parantheses. Move to the end. Type `C-x C-e`. Did your tool bar go away?

      iv. Point is that you can heavily customize your editor. Don't worry too much about it for now.

   (g) Orgmode

      i. What is it? About the best thing ever.

      ii. Make an outline. Keep a calendar. Add code to your documents. Make links. Include images.

      iii. Practice now: Where is the help, remember? `C-h i` Note bene: may need to get `sudo apt install emacs25-common-non-dfsg` for all the documentation.

A. Learn to use the short cuts to open, save, and so on. That is one of the powers of the command line and similar style tools. Enhance your productivity and control.
B. Create an outline.
C. Create a link
D. Insert an image
E. Export as a web page.
F. What would you need to export a pdf? Try installing `texlive-latex-recommended`. If that doesn't fix the problem go with `texlive-full`. This is big.

4.3 Session 3 Version Control Github and Beginning With Python

4.3.1 Version Control

1. Git **Not** the same as Github, though that is one of the more common *social* uses of git for sharing and collaborating on code.
2. Social Coding and Data Sharing A brief discussion of what is going on here.
   (a) OSF.io
      i. Sign up
      ii. Find my projects
3. Installation of Git `sudo apt install git`
4. Github and Gitlab and Bitbucket and ...
   (a) Github is the big one with a large external presence.
      i. Sign-up
   (b) The university provides you with a gitlab presence at `https://git.uwaterloo.ca`
5. Git
   (a) Open a terminal
   (b) Move (`cd` or `dir`) into your Desktop
   (c) type `git init myrepo`
   (d) Should see message from the terminal prompt that it has been created.
   (e) Feel free to delete (e.g. `rm -rf ./myrepo`)
6. Making and Cloning a Course Repo
   (a) I create an empty repository on github
   (b) I create a repository on my laptop.
   (c) I add some small file.

(d) I set the upstream (origin) as the github site, and then I push.

(e) Now if I use a different computer I can push and pull (to be discussed) from this github site and keep everything synced together.

7. Demo the Course Git Site I am keeping back-ups of my notes for this course on github. You can get everything I create by cloning this repository.

   (a) Go to Course Repo on Github

   (b) Use that url to clone a copy to your laptop (or to fork a version to your github account). Occassionally `pull` in any changes or updates.

   (c) You will probably find it easier to skip the fork step for any repository that you are just going to use, but not change.

8. Magit

   (a) Emacs provides you with an interface for this called magit.

   (b) To use it you will have to create an init file (and delete ~/.emacs) Let's you discover the hidden directories.

   (c) You will have to enable emacs package repositories (everyone in linux land has a package manager).

   (d) You will need to install the magit package.

   (e) Then it is `C-c m` or `M-x magit`

9. Forks and Clones and Pull Requests HOMEWORK

   (a) Diagram the logic on the board.

   (b) Get everyone to create a fork of the course repository

   (c) Get everyone to create a local clone on their laptop

   (d) Set a second upstream pointing to me.

   (e) Pull from my repo to laptop.

   (f) Update and accept the changes.

   (g) Push this to your fork.

   (h) Add a new file to your laptop version.

   (i) Push this to your fork.

   (j) From github generate a pull request for me. This is one of this weeks homeworks.

4.3.2 Beginning Python

1. Python

   (a) Test for Python in a terminal.

      - open a terminal

- type `python --version` then `enter`
- If you see an answer you have python. Type `python`. Note the cursor has changed.
- type `2 + 2 enter`
- Do you see 4?
- type `quit()` to exit.
- Why do you need to have the parentheses after the word quit?

(b) If you only have version 2 try the command again with `python3 --version`.

(c) If you don't have python3, get it (may want the python3-dev version; often the hyphen -dev packages will work better for you as a bleeding edge user).

2. Coding - General Coding - providing instructions to a computer. The computer only does what you tell it.

3. Writing Code Code files are just plain text. You can open and write them in anything, though some tools can make the writing substantially easier. Usually extensions identify a language (e.g. .py for python and .R for R).

4. Testing Code

   (a) Interactive We already did a little of this, but let's try again.

   ```
   def myadd(a,b):
       return(a+b)

   print(myadd(3,4))
   ```

   ```
   7
   ```

   For interactive session it is like you are interacting with a user. You type your lines one or a few at a time, get an answer, and then decide what to do next.

   (b) Script You write a separate file that you read in, or import and use. Here is the file.

   def add2(a,b): return(a+b)

   def addMany(aa): ans = 0 for a in aa: ans = ans + a return(ans)

   ```
   from code.testScript import *

   print(add2(3,4))

   print(addMany([1,2,3,4,5,6]))
   ```

   ```
   7
   21
   ```

Try creating this file and then typing these commands in your terminal. For various weird reasons if you want the test script to be in a subdirectory of where you are working you will need a file `__init__.py` to trick python into treating it as a package. See the documentation and this stackOverflow answer.

5. Confirming You Can Write and Run a Python File HOMEWORK

   (a) Create a file `lastname.py`
   (b) Write the myadd function I demonstrated, but give it a different name.
   (c) Save.
   (d) Open up a terminal.
   (e) Start a python session.
   (f) Import your file with you function.
   (g) Use your function.
   (h) Take a screenshot of your terminal session showing the above session.
   (i) Submit that for your homework *along

4.4 Session 4 Python

4.4.1 Types

Integers 1, 2, . . .

Doubles/Floats 10.3, pi

Booleans True , False NB: some languages, e.g. R, use TRUE.

Lists and Tuples

Tuples (1,2), ('a',10.34,False) Have a fixed number of slots, can be different types. Define with parentheses

Lists [1,2,3,4] Have a potentially infinite number of slots, but must all be same type. Define with square brackets.

Dictionaries {'firstName' : 'Britt', 'lastName' : 'Anderson'}

Comments Not really code, but allows you to put stuff in your programs for other users and yourself to read. In python the lines start with a hash "#"

4.4.2 Constants and Variables

A conceptual difference more than a implementation difference

```
NOHRSDAY = 24

x = NOHRSDAY

x

24
```

1. Coding styles Makes your code easier to read by people using the same language.

   Try to follow good programming style, and if avaialable, langugage guides.

   Python Style Guide

4.4.3 Assignment and Equality

= is different from ==

```
a = 2
print(a == 3)
```

```
False
```

4.4.4 Loops

Think of recipes: "stir egg whites until peaked" or "simmer for 30 minutes". That is the intuition for a

1. For Python refers to things called "iterables." To iterate is another way of saying something you can keep doing the same thing over and over to. Imagine a bowl of ice cream. It is "eatable". You take one spoon, and keep taking spoonfuls until the bowl is empty.

   (a) Indexing You can get the location of an element in a list by referring to its *index*. Indexes start at 0 for many computer languages, but not all (e.g. R and Matlab). There are various shorthands for getting ranges of elements or the last element.

   ```
   nameDict = {'firstName' : 'Britt', 'lastName' : 'Anderson'}
   mylist = list(range(1,10))

   print(nameDict['firstName'])

   print(mylist)

   print(mylist[0])

   print(mylist[-1])

   print(mylist[0:4])
   ```

```
Britt
[1, 2, 3, 4, 5, 6, 7, 8, 9]
1
9
[1, 2, 3, 4]
```

```
for ml in mylist:
    print(ml)
```

```
for i,ml in enumerate(mylist):
    print("The {0}th element was {1}".format(i,ml))
```

```
1
2
3
4
5
6
7
8
9
The 0th element was 1
The 1th element was 2
The 2th element was 3
The 3th element was 4
The 4th element was 5
The 5th element was 6
The 6th element was 7
The 7th element was 8
The 8th element was 9
```

(b) For Class Exercise

i. Create a list of at least 8 individual characters.

ii. Make sure they are **not** in alphabetical order

iii. Print the letters one at a time.

iv. Print the letters sorted alphabetically one at a time, but *do not* overwrite your original list.

v. Print the letters from both lists with a format command that says which position the letter is in.

```
myList = list("brittAnderson")
for l in myList:
    print(l)
print("end of list 1\n")
```

```
for l in sorted(myList):
    print(l)
print("end of list 2\n")


for i,l in enumerate(zip(myList,sorted(myList))):
    print("The {0}th letter of myList is: {1}, but is {2} in the sorted
print("Thus ends the lesson")
```

```
b
r
i
t
t
A
n
d
e
r
s
o
n
end of list 1

A
b
d
e
i
n
n
o
r
r
s
t
t
end of list 2

The 0th letter of myList is: b, but is A in the sorted list.
The 1th letter of myList is: r, but is b in the sorted list.
The 2th letter of myList is: i, but is d in the sorted list.
The 3th letter of myList is: t, but is e in the sorted list.
The 4th letter of myList is: t, but is i in the sorted list.
The 5th letter of myList is: A, but is n in the sorted list.
```

```
The 6th letter of myList is: n, but is n in the sorted list.
The 7th letter of myList is: d, but is o in the sorted list.
The 8th letter of myList is: e, but is r in the sorted list.
The 9th letter of myList is: r, but is r in the sorted list.
The 10th letter of myList is: s, but is s in the sorted list.
The 11th letter of myList is: o, but is t in the sorted list.
The 12th letter of myList is: n, but is t in the sorted list.
Thus ends the lesson
```

2. While These are like for loops in that they do stuff over and over, but unlike for loops they do things indefinitely, until that is, you tell them to stop. How do you do that? You use a predicate that they test for each time through the loop. That means you need to specify a *predicate.*

   (a) Conditionals This is where you test whether something is or is not `True`. Note that Python, but not all computer languages, treats 0 as the same as False, and all non-zero values as True.

   ```
   if (2 == 3):
       print("Wha.....?\n\n")
   elif (3 == 2):
       print("Now that is odd")
   else:
       print("2 does not equal 3.")
   ```

   (b) While NB: note the use of colon (:) at the end of the `for` and `while` lines.

   ```
   i = 0
   while (i<=10):
       print("brittAnderson"[i])
       i = i+1
   ```

   ```
   b
   r
   i
   t
   t
   A
   n
   d
   e
   r
   s
   ```

4.4.5 Functions

You have seen an example of this before. Think of a function as a machine that grinds meat. You pour in a cow. You get out hamburger. Input. Output. Note that arguments

are "local". They are not referring to variables outside, in the program globally, but only make sense locally in the function. You drop values into those slots, and they you can use those names in your function, because until you use it, your function doesn't know what it will be getting.

```
def myadd(x,y):
   return(x+y)

myadd(2,3)

5
```

1. Class Exercise with Functions HOMEWORK You will be required to turn this in, but you can get started now.
   (a) Look up how to get user input from python on the command line.
   (b) Write a script that I will run on the command line thus: `python functionHW.py`
   (c) Your script should ask me to enter a word.
   (d) It will then print out the word.
   (e) Print out the sorted version one character at a time.
   (f) Ask me if I want to do it again (y/n). If 'y', repeat, and continue repeating until I answer 'n'.

4.4.6 Libraries CLASSDISCUSSION

Lots of people use python. If you can think that someone ought to have done ... they probably have. Use libraries whenever you can, because ... discussion points.

1. What are some popular libraries? CLASSACTIVITY:HOMEWORK Here are 20 recommended ones.

   Of particular note for us are:

   (a) Numpy
   (b) Scipy
   (c) Matplotlib
   (d) Pillow
   (e) Sympy

   Divide class into small groups. Assign a library. Have them present to us what it is good for, and maybe a short demo.

   Homework: Submit a short .py script to the class github repo that demonstrates the importation of your library and some basic use.

4.4.7 Programs

Nothing else really, but the more prolonged and complicated concatenation of the above.

4.4.8 Debugging and Basic Working Methods

The most basic is just to `print` statements into your code so that you can see what happening and whether your variables are actually what you think they should be.

4.4.9 IDEs

What does IDE stand for?

What are common IDEs for python and how do you get them. What are they good for.

Two popular ones are:

1. Spyder
2. pyCharm

This is what you need to use for this course: emacs.

1. Open up a blank file with a name that ends in .py
2. Type in some lines (e.g. a = 2, b = 3, print(a+b))
3. Type C-c C-c on the first line.
4. Read the error message
5. Fix it.
6. Keep C-c C-c'ing on each line and look at what is happening in your console.
7. When your cursor is on a python word, like `print`, look in the mode line.
8. Try M-x linum-mode
9. To see some fancier stuff install the `elpy` package for emacs.
   (a) M-x package-list-packages
   (b) C-s elpy
   (c) type "i"
   (d) type "x"
10. An easier way to get and maintain your emacs package is "use-package". See some instructions here.
11. When you try `(elpy-enable)` you will get error messages. Why? You don't have all the dependencies.
12. Uninstall elpy (go to that list and hit 'd' on the elpy package).
13. Follow instructions here to see what python packages you need and install them.

14. What no pip? Welcome to the world of using your computer (and dependency hell).

    ```
    sudo apt install python-pip
    pip install jedi rope flake8 autopep8 yapf black
    ```

15. Then reinstall elpy. Whoooo - wipes brow.

16. No! Needs to be for python3. Repeat all the above for python3 and then customize your emacs python shell command like this

    ```
    M-x customize-variable python-shell-interpreter
    ```

17. Check out the elpy documentation. Lots of cool features to make your programming easier.

Why do you have to do all this? Because Mama a'int spoon feeding you anymore boys and girls.

4.4.10 Pip to Install Libraries and Virtual Environments

1. Pip pip is the python install package program. There have been many ways to install python packages over the years and you will find a lot of tracks on the internet. There is a new system coming called wheel, but for now stick with pip (ubuntu also has many of these packages, but I find it better to try and not to mix package managers. Use your choice; mine is pip.

2. Virtual Environments You have system installations of things (like python and its libraries). Now you need to install something new for development purposes. You don't want different version of the same program clashing. The solution is to install your development version of libraries in a "virtual" environment. That is you trick your machine into thinking that a different directory is the root of everything, and thus it can install locally without disturbing your other system files. There are various subtle variations of this arrangement that may be important for different scenarios and use cases. There is also more than one virtual environment tool out there. We will be using and testing the built-in one.

   (a) **TODO** VENV

      i. Link to the python description page

      ii. Creating a venv and downloading Psychopy (to be used later in the course).

         A. First create a directory where you will store/keep your psychopy installation. Maybe something like: `mkdir /home/britt/research/psychopy/`

         B. change to that directory

         C. make sure you have installed the venv module. For our XUbuntu version that is `sudo apt install python3-venv`

D. `python3 -m venv /home/britt/research/psychopy`
Note this is just the name of my directory. Yours will be named differently.

E. Then you "activate" this virtual environment for the correct installation. `source /home/britt/research/psychopy/bin/activate`

F. Note the change in the prompt from your terminal

G. Now try to install psychopy with `pip install psychopy`

H. This will pull in a lot of files. Be patient.

I. We will need (according to the psychopy download page wxPython [a library for making gui's]).

J. Install pygame (inside the virtualenv with pip)

K. Then edit the file <venv>/lib/python/site-packages/psychopy/demos/coder/stimuli/face$_{jpg.py}$ to add ",winType = 'pygame')" to the function that creates the window.

L. The run python <path>/face$_{jpg.py}$ NB: I am having trouble getting pyglet windows to work, but pygame seems fine. (pip uninstall pyglet; then pip install pyglet==1.3)

M. For an exercise, have them get cheese and change out the picture to use their own face? Maybe use gimp or inkscape to select the face and make rest transparent? **TODO**

4.5 Session 5 R

4.5.1 R

1. Test for R from a terminal.
   - open terminal
   - type `r` then `enter`
   - type `2 + 2 enter`
   - Do you see 4?
   - type `quit()` to exit.
2. Test for R in Emacs
   - `M-x R`

4.5.2 R Coding Basics - compare

4.5.3 Types

R has many of the same types, but also makes much greater use of lists where there are names and elements (rather like a python dictionary). Many built-in statistical functions will return S3 or S4 objects. The point isn't to know what they are, as to know that there are special types in R that have special handling in R.

```
a = 1
typeof(a)
```

Figure 1: Use the function `typeof` in R to determine the datatype of a variable.

```
double
```

```
tpl = c(1,2)
lst = list("firstName" = 'Britt', "lastName" = 'Anderson')
df = data.frame('fn' = c("bob","jane","griffin"),"gndr" = c('m','f','o'))
df
```

Figure 2: Lists, Tuples, Data.Frames and Data.Tables

You can think of `data.frames` as sort of like spread sheets. But they are much handier. For example:

4.5.4 Data Selection in R CLASSACTIVITY

1. Open up Emacs.
2. Type `M-x R`
3. You should see an R environment appear.
4. Try it with `2+2` followed by <enter>.
5. Now type `cars`.
6. Is `cars` a data.frame?

   ```
   is.data.frame(cars)
   ```

7. How many cars are there that can go faster than 10, but not more than 20?

   ```
   length(cars$dist[cars$speed > 10 & cars$speed < 20])
   ```

8. Can you do that easily in Excel?
9. Questions for you to explore:
   (a) Sort (or `order`) cars by the `dist` variable.
   (b) Find the mean and standard deviation of the speed of the cars.
   (c) Are there other datasets?

   ```
   library(help="datasets")
   ```

   (d) Open any of the datasets that catches your eye.
   (e) What are the column names?
   (f) How many rows?
   (g) What is the *comment* designator for R?
   (h) What is the ending extension of an R script?

4.5.5 Assignment and Equality

= is different from ==

```
a = 2
print(a == 3)
```

```
[1] FALSE
```

While some things are the same, not all the language features are identical. You can use your knowledge of one language to help you make guesses in the other, but you cannot count on the notation and syntax being identical.

4.5.6 Loops

This is a good example of where things are slightly different

1. For

   ```
   ml = seq(1:10)

   for  (m in ml) {
       print(ml)
   }
   ```

   ```
   [1]  1  2  3  4  5  6  7  8  9 10
   [1]  1  2  3  4  5  6  7  8  9 10
   [1]  1  2  3  4  5  6  7  8  9 10
   [1]  1  2  3  4  5  6  7  8  9 10
   [1]  1  2  3  4  5  6  7  8  9 10
   [1]  1  2  3  4  5  6  7  8  9 10
   [1]  1  2  3  4  5  6  7  8  9 10
   [1]  1  2  3  4  5  6  7  8  9 10
   [1]  1  2  3  4  5  6  7  8  9 10
   [1]  1  2  3  4  5  6  7  8  9 10
   ```

   (a) Exercise: Change the above so that it prints on the individual number each time it goes through the loop.

   (b) For Class Exercise We will repeat the same exercise we did in Python, but using R this time.

      i. Create a list of at least 8 individual characters.

      ii. Make sure they are **not** in alphabetical order

      iii. Print the letters one at a time.

      iv. Print the letters sorted alphabetically one at a time, but *do not* overwrite your original list.

v. Print the letters from both lists with a format command that says which position the letter is in. String formatting is less nice in R. Check out `paste` and `sprintf`. For *help* try `?<commandname>`.

```
myName = "brittAnderson"
myList = unlist(strsplit(b,""))

for (l in myList){
  print(l)
}



for (l in myList[order(myList)]){
  print(l)
}

i = 1
for (n in order(myList)){
  t  <- sprintf("The %.0fth letter of myList is: %s, but is %s in the so
  print(t)
  i = i+1
  }


Error in strsplit(b, "") : object 'b' not found

Error in myList : object 'myList' not found

Error in myList : object 'myList' not found

Error in order(myList) : object 'myList' not found
```

2. While

   (a) Conditionals

```
if (2 == 3) {
    print("Wha.....?\n\n")
} else if (3 == 2) {
  print("Now that is odd")
} else {
  print("2 does not equal 3.")
}
```

   (b) While (again)

```
i = 0
while (i<=10) {
```

```
  print(unlist(strsplit("brittAnderson",""))[i])
  i = i+1
}


character(0)
[1] "b"
[1] "r"
[1] "i"
[1] "t"
[1] "t"
[1] "A"
[1] "n"
[1] "d"
[1] "e"
[1] "r"
```

4.5.7 Functions

```
myadd  <- function(x,y) {
  return(x+y)
  }

myadd(2,3)

[1] 5
```

1. Class Exercise with Functions HOMEWORK You will be required to turn this in, but you can get started now.
   (a) Look up how to get user input from python on the command line.
   (b) Write a script that I will run on the command line thus: `python functionHW.py`
   (c) Your script should ask me to enter a word.
   (d) It will then print out the word.
   (e) Print out the sorted version one character at a time.
   (f) Ask me if I want to do it again (y/n). If 'y', repeat, and continue repeating until I answer 'n'.

4.5.8 Libraries for R:classdiscussion:

```
install.packages("data.table")
install.packages("ggplot2")
library(data.table)
library(ggplot2)
```

Figure 3: Package Installation Commands in R. Note the use of quotes differs.

1. What are some popular libraries? CLASSACTIVITY:HOMEWORK Here are 20 recommended ones.

   Of particular note for us are:

   (a) knitr
   (b) ggplot2
   (c) data.table
   (d) magrittr
   (e) devtools/githubinstall

   Divide class into small groups. Assign a library. Have them present to us what it is good for, and maybe a short demo.

   Homework: Submit a short .R script to the class github repo that demonstrates the importation of your library and some basic use.

4.5.9 Programs

Nothing else really, but the more prolonged and complicated concatenation of the above.

4.5.10 Debugging and Basic Working Methods

The most basic is just to `print` statements into your code so that you can see what happening and whether your variables are actually what you think they should be.

4.5.11 IDEs

1. Vanilla Emacs

   (a) Open up a blank file with a name that ends in .R
   (b) Type in some lines (e.g. a = 2, b = 3, print(a+b))
   (c) Type C-c C-c on the first line.
   (d) Read the error message
   (e) Fix it.
   (f) Keep C-c C-c'ing on each line and look at what is happening in your console.
   (g) An easier way to get and maintain your emacs package is "use-package". See some instructions here.

2. Babel Mode

   (a) Open a file with the name <something>.org
   (b) Type in some text

(c) Open a source block

```
#+begin_src R
a = 2
b = 3
print(a+b)
#+end_src
```

(d) Type `C-c C-e h h`. That is four different key presses.

(e) You just generated a web page. View it in your browser.

(f) Now combine it with python by adding another source block below that uses the python language.

(g) For help google emacs orgmode babel

3. Install RStudio CLASSACTIVITY

Basic Steps:

(a) Update your repository

(b) Install R base

(c) Use wget to install the **.deb** package for our version of Ubuntu from the RStudio downloads page.

(d) run `sudo dpkg -i <PACKAGENAME>`

(e) try launching `rstudio`

Why use RStudio instead of Emacs (or anything else)?

One reason is the fact that it is becoming quite common so it mostly works out of the box.

A downside is that out-of-the-box performance comes with a loss of flexibility and adapatability on your part and a bias to the authors' choices of preferred packages. You also return to the "gui" click an icon usage. These are two habits you are trying to break.

4.6 Session 6 Data Handling

4.6.1 Data handling in R

1. Getting your data into R CLASSDISCUSSION

(a) First get some data. If you do not have your own data from a prior project you can get some from here (what follows use the HSQ dataset): `https://openpsychometrics.org/_rawdata/`

i. You have just downloaded a zip file. Now what?

ii. Unzip it.

- First option (command line): navigate to your download directory and then use command `unzip`

- Second option (emacs): navigate to your download directory (`C-x d`) and then put cursor on file and type `Z`.

(b) What is **csv**? How does it differ from Excel (xlsx)? Which is better? What about SPSS, SAS ...

(c) R uses a `read` command with many variants. There are extra libraries for other formats. Here we focus on csv. I downloaded the *HSQ* dataset.

```
d <- read.csv("./HSQ/HSQ/data.csv")
```

(d) Reading is different from `load`. How? Check the help.

(e) Note the assignment to a variable for the reading?

(f) What are the optional arguments to `read.csv` and why would you use them.

(g) Explore the data?

i. Use `ls()` to see the list of names of variables in your "workspace."

ii. Use `names(d)` (the *d* is the name of your variable of interest) to see the column names?

iii. How would you find out the number of rows?

iv. Display the first and third rows.

v. Do the same but limit to the age and gender columns.

vi. How many participants of each gender? I am using data.frame format here.

```
with(d,tapply(age,gender,length))
```

```
    5
  581
  477
    8
```

vii. Why do we have four rows?

viii. Always inspect your data

```
unique(d$gender)
```

```
2
1
3
0
```

ix. What do these mean? Inspect the codebook file. 3 is other and 0 not mentioned. Probably means no entry.

x. Limit your data to only self-declared men and women. Make a new data frame with just these rows. It should be 1058.

```
dmf <- d[d$gender %in% c(1,2),]
print(nrow(dmf))
```

Figure 4: Selecting the Men and Women. Explain this Line. What does `ls()` show now?

```
1058
```

2. Class Exercise to Work with the Data Come up with some exercises for class exploration

4.6.2 Data handling in Python

1. Pandas This is becoming the defacto R equivalent for Python. There are definitely libraries for reading and writing plain csv files, but they are becoming used less and less.

   (a) Getting Your Data Into Python You have to import pandas to use it.

   ```
   import pandas as pd
   dpd = pd.read_csv("./HSQ/HSQ/data.csv")
   dpd.columns.values
   ```

   (b) Repeat the same inquiries as above, but with Pandas.

   ```
   len(dpd['Q1'])
   ```

   ```
   dpdmg = dpd.copy()
   dpdmg = dpdmg[dpdmg['gender'].isin([1,2])]
   len(dpdmg['Q1'])
   ```

   What happens if you just select with `in`? You keep the same number of rows, because you replace the ineligible data with NaNs (not a number).

   (c) Functional Styles versus Object Orientation Python is an object oriented language. Pandas creates a data.frame object (intended to mimic R), but it is not the same thing, and while most of the commands are achievable in either, they are not the same. The **dot** shows you we are accessing either an attribute or a method of an object.

4.7 Session 7 Plotting in Python and R

4.7.1 General

Comment. While it is possible to do almost anything that you can do in one language in the other, some sorts of plots may be easier to produce in one than the other. In general, you are better using the language you know best, even if the library that you need is a bit complex. On the other hand, don't be a mono-programmer. If there is a great library that does exactly what you want in a new language, or one you know less well, consider learning enough to use it. Have a "get the job done" attitude rather than focusing on mastery. Too much changes too fast in this world for you to get too settled on any one language or approach.

4.7.2 R

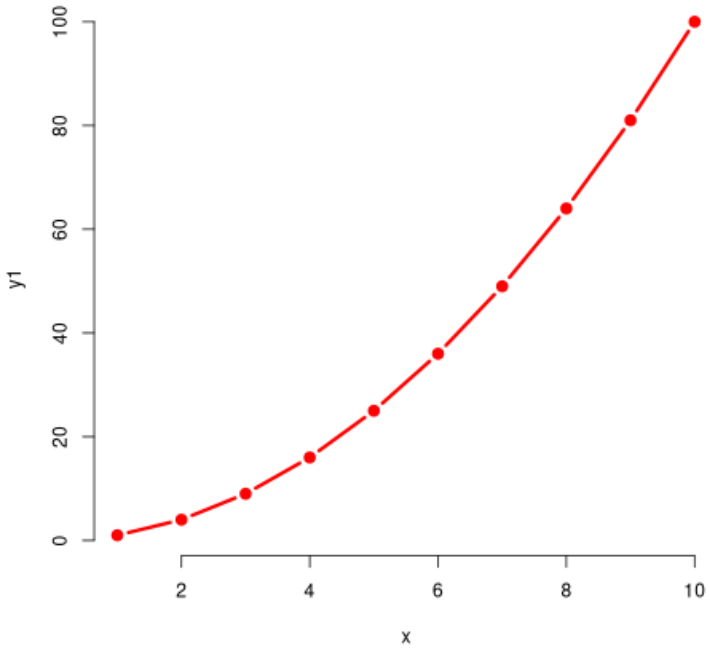
Base plot and ggplot are the two most common R libraries for plotting with ggplot seeming to have much of the current momentum. They have two different models behind them, one may fit your thinking better than the other. Use the one that seems to make most sense to you. But for today you will have to use them all.

1. Create some variables that you will use.

```
x <- 1:10
y1 <- x^2
y2  <- 2*y1
y3  <- rnorm(10)
```

2. Base Plot The two main commands you will use are `plot` and `lines`. Be careful. There is a command `line` (no 's'). That is not what you will want here.

```
plot(x,y1)
```



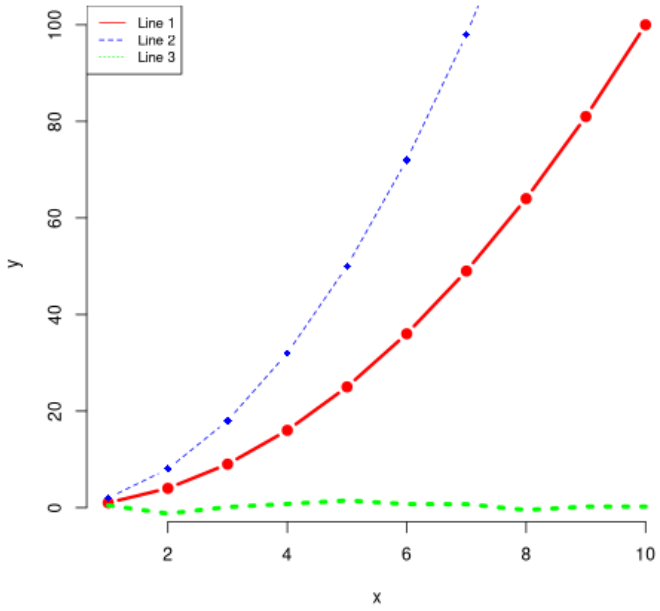
(a) Changing the look of base plot You have multiple *hidden* arguments you can use to change the look of the plot such as the symbols, whether it plots lines or dots, the color, the font size. Always remember to try the help command. Here is just one example.

```
plot(x,y1,type = 'b', frame = F, pch = 19, col = "red" , ylabel = "y", l
```

How would you include this plot in another document?

```
plot(x,y1,type = 'b', frame = F, pch = 19, col = "red" , ylab = "y", lty
lines(x,y2, pch = 18, col = "blue", type = "b" , lty = 2, lwd = 1)
lines(x,y3, pch = 17, col = "green" , type = "l", lty=3, lwd = 4)
legend("topleft", legend = c("Line 1", "Line 2", "Line 3"), col = c("red
       lty = 1:3, cex = 0.8)
```

Figure 5: Our base plot with additional data series added.

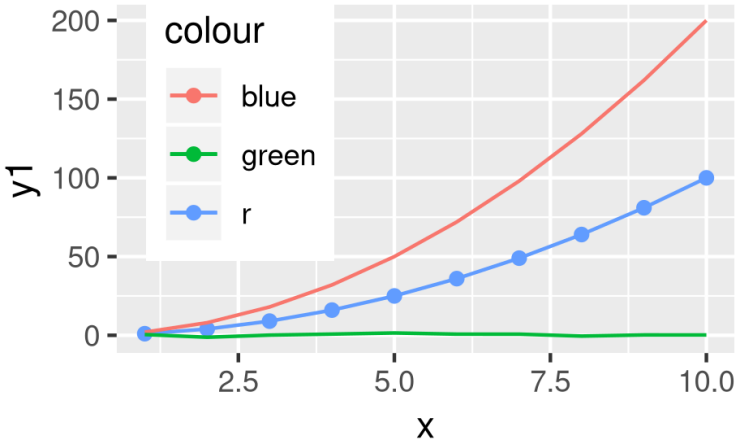


Who wants to try and recreate this in Excel or SPSS?

3. Ggplot `ggplot` uses a model where you build things up bit by bit all in one line, and you can keep adding to the same object. For instance.

   Note that people tend to say "ggplot", but they always mean =ggplot2". Note the number "2".

```
        library(ggplot2)
p  <- ggplot(data = data.frame("x" = x, "y1" = y1, "y2" = y2, "y3" = y3), ae
p <- p + geom_point() + geom_line() + theme(legend.position = c(0.2,0.65)) +
ggsave("ggplot1.png", width = 8, height = 5, units = "cm")
```



4. Scatter Plots and Box Plots

   (a) Using the R data set `mtcars` create in both base plot and ggplot a scatterplot of **mpg** and **wt**. What would you expect this to show even before you plot it. Always good to know what you are looking for as a clue to test if something went wrong.

   (b) Using the R data set `ToothGrowth` generate boxplots for `len` and `dose`. If you are feeling creative overlay the data points on top of the box plot.

5. Lattice Lattice Plot Overview

4.7.3 Interaction Plots

What is an interaction plot and when would you like to use one?

I am including this specifically because it was mentioned that is something that is hard to produce in SPSS, and the stats courses thought it could be useful.

1. Getting the data Download the data from `http://personality-project.org/r/datasets/heating.txt`

   Okay. It is a text file. Read that into pandas in Python.

2. Pandas Read in Text

```
import pandas as pd
url = "http://personality-project.org/r/datasets/heating.txt"
d = pd.read_csv(url, sep = "\t")
d.columns
```

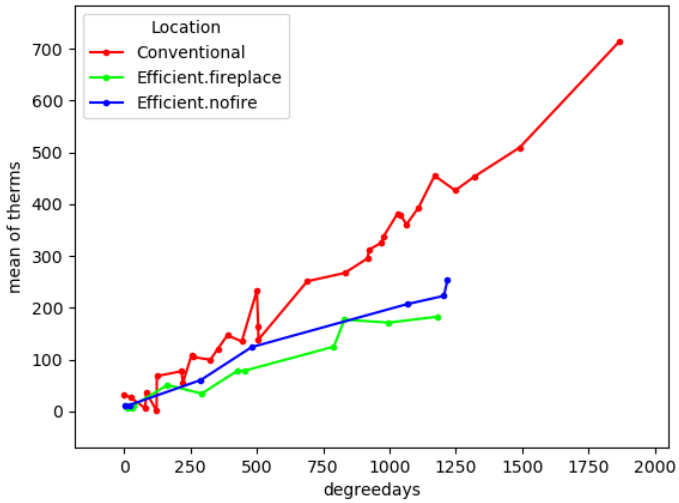
   Did the last line to check if the data imported correctly.

   We want to get plots of degree days versus therms, but we want to do it separately for each type of house to see if there is an *interaction*. That is, is the relationship

between degree days and therms different for the different types of houses. Types of houses *interacts* with `degreedays` when we want to predict `therms`.

We will also use some additional python modules to help us make this easier, specifically `scipy`, `matplotlib`, and `statsmodels`. These can be installed via `pip` (which we used at the beginning of the course).

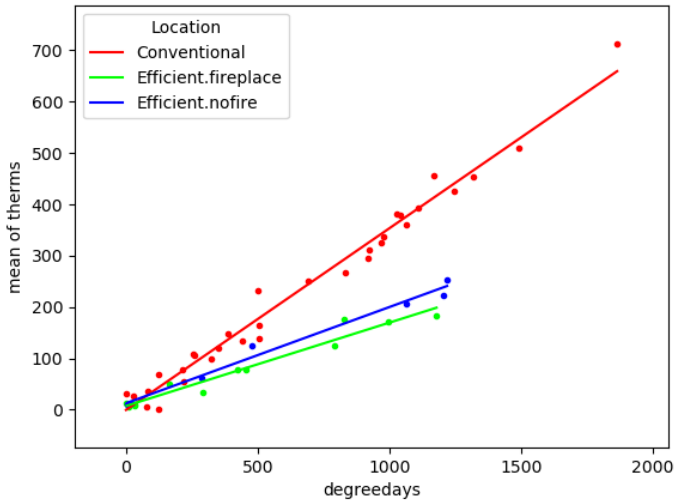
```
from statsmodels.graphics.factorplots import interaction_plot
from matplotlib import pyplot as plt
fig = interaction_plot(d['degreedays'],d['Location'],d['therms'])
plt.savefig("py-inter-plt.png")
"py-inter-plt.png"
```



Of course this gives us a "connect" the dots sort of look to our data, because that is what we are doing. Plotting the raw data points. We would prefer to fit a line, a *best* line to our data. We want to pick the line that runs through the data points and is as close as possible. The techniques for doing this, and the theory, come from your stats courses, but we can use those tools here without explanation just to get some practice with the libraries and functions that will later come in handy.

```
from statsmodels.formula.api import ols
ols_d = ols(formula = "therms ~ degreedays * Location",data = d)
myfits = ols_d.fit()
plt.clf()
f = plt.figure()
a = f.gca()
interaction_plot(d['degreedays'],d['Location'],myfits.fittedvalues,plottype=
```

```
a.legend = None
interaction_plot(d['degreedays'],d['Location'],d['therms'],plottype='scatter
plt.savefig("py-inter-fit-plt.png")
"py-inter-fit-plt.png"
```



4.8 Session 8 Programming Experiments

4.8.1 Experimental Programming in Python

The components of a typical experimental program in psychology involve some combination of showing something on a computer and getting a response from the participant. This typically means you will need some way of talking to the graphics part of the computer (to place text or images on the monitor), and some way of listening to the computer to record keyboard, button box, or mouse presses. *Listening* for eye movements or EEG is an extension of this basic approach.

It is possible (and sometimes more direct) to use python library that more directly address these goals, such as pyopengl for graphics or pygame for getting joystick input, but in general never reinvent the wheel if you don't have to. As computer are common tools of psychological research there have been some excellent libraries that serve as one-stop shops for our needs. The one we will use in this course is psychopy.

1. Psychopy Library

   (a) For future reference you should note that psychopy is building in increasing support for performing online studies. These extension often rely on another language, javascript. We will **not** be using these extension here, but if you master the basics you will be able to extend your use on your onw.

(b) Resources for Psychopy.

i. The authors of the Psychopy library have written an entire textbook on using python for psychology experiments that includes the online extensions. That is a good resource to pursue things after this course.

ii. On the psychopy website is an introduction to using the coder component of psychopy.

iii. Searching online with `psychopy tutorial` will get you a variety of hits. Note that you want to emphasize the `coder` version. Maybe the `builder` will meet your needs, but better to start with the `coder` version and use the `builder` for efficiency. In many cases it will be harder to build a complex experiment in the `builder` than by directly using the `coder` version.

(a) Psychopy Exercise This demo still needs testing

i. Open up a terminal.

ii. Begin a python session

iii. `from psychopy import visual,core`

iv. Create a window `mywin = visual.Window(size = (640,480))`

v. Test it `mywin.flip()`

vi. Why is it called *flip*?

vii. Add a red rectangle. `myrect = visual.Rect(mywin, linewidth = 0, fillcolor = "red", size = [.2,.2],pos=[0,0],units="norm")`

viii. Draw it `myrect.draw()`

ix. Show it `mywin.flip()`

x. Clean up and shut down in an orderly way `core.quit()`

(b) Extensions To work on these examples you will want to consult the psychopy API to see what functions do what, and what the arguments are that you need to supply.

i. Change the color of the square.

ii. Move the Square.

iii. Add some text

iv. Keep the window open for a certain amount of time, and then close it when that time has elapsed.

v. Run any of the demo programs you can find in the `.../psychopy/demo/coder/stimuli/` directory.

vi. Change something in the demo you are running and see what the effect is. Note you may want to save the original file with a new name and hack on the one with a new name. That way it will be easier to go back to the original if you break something.

2. Homework (can start in class)

(a) Provide me with a name of the basic variety or example of the experiment you intend to code (with at least one reference using that task).

(b) Provide a written (not code) outline of what you will need to do to implement the task.

(c) Provide links to any existing versions of the task that you hope to be able to adapt for your usage.

4.9 Session 9 Report Writing

IAMHERE

4.9.1 Writing a simple report

4.9.2 Mixing Code and Text for reproducibility

4.9.3 Start the experimental coding here and continue this week, because the next session will be for running the experiments.

4.10 Session 10 Coding the Experiment

These last three sessions are generally open with the idea that students will

1. Code up an experiment in Psychopy (e.g. stroop or reaction time or simple associative memory task).
2. They will collect data on their classmates
3. They will write up a report on their experience that includes the source code and simple data analyses.
4. They will include some references to pertinent literature.
5. They will do this using a reproducible mechanism providing both the raw file and the processed file (pdf preferred, html acceptable.

4.11 Session 11 Collecting the Data

Data collection.

4.12 Session 12 Presentations

Presentation. Should be able to produce an html 5 slide show of some of the motivation/method/data with graphics.

Can also work on final report and technical questions. The final report will have a later due date.