The R Programming Language

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What is R?

- R is a programming language that was invented in 1993
- Evolved to a very powerful set of capabilities
- Used for
    - Data handling and storage
    - Data analytics and statistical analyses
    - Calculations on arrays and matrices
    - Powerful graphing capabilities

Pros

- Free!
- Massive amount of online help and tutorials
- Large community of users
- Very flexible and powerful
- Looks very good on your resume

Cons

- Steep learning curve
- Use outside of academia is declining in favor of Python

Where can I get R?

- R is free and open source!
- r-project.org (http://r-project.org)
- R is available for Windows, Mac, and Linux platforms
- From r-project.org, you can access different CRAN servers across the world (Comprehensive R Archive Network)
- This only gets you the R interpreter, which is FUGLY!

Use R Studio to make life easier

- rstudio.com (http://rstudio.com)
- Organizes things into different panes

Walk through a simple analysis

- 2x2 ANOVA
- IVs
    - Attractiveness of defendant in a trial (attractive and unattractive)
    - Smiling (smiling v. not smiling)
- DV: Perceived guilt of defendant
- Hypothesis: Attractive persons who smile are perceived as being less guilty than unattractive persons or persons who do not smile.

Workflow

- Get data
- Import data into R
- Get descriptive stats
- Run ANOVA
- Look at results

Get data

- Most researchers use spreadsheets to initially organize data
- Data are entered into a spreadsheet and coded per level of each IV
- Example ...
- After data are entered, export spreadsheet as a CSV file (comma separated values)
- Example ...

In [1]:
```
# R code to import CSV file into an R data frame using the read.csv() function
# Data Frame:  A matrix with names above each column

my_anova_data = read.csv("./2waydata.csv")
my_anova_data
```

A data.frame: 32 × 3

FACTOR_A	FACTOR_S	GUILT
<fct>	<fct>	<int>
A	S	10
A	S	15
A	S	21
A	S	19
A	S	23
A	S	12
A	S	10
A	S	9
A	N	23
A	N	21
A	N	19
A	N	34
A	N	8
A	N	23
A	N	25
A	N	22
U	S	34
U	S	33
U	S	39
U	S	29
U	S	42
U	S	37
U	S	33
U	S	39
U	N	76
U	N	67
U	N	59
U	N	78
U	N	90
U	N	63
U	N	78
U	N	77

In [2]:
```
# To take a quick look at the STRUCTURE of the data in the data frame we can use t
he str() function

str(my_anova_data)
```

```
'data.frame':   32 obs. of  3 variables:
 $ FACTOR_A: Factor w/ 2 levels "A","U": 1 1 1 1 1 1 1 1 1 1 ...
 $ FACTOR_S: Factor w/ 2 levels "N","S": 2 2 2 2 2 2 2 2 1 1 ...
 $ GUILT   : int  10 15 21 19 23 12 10 9 23 21 ...
```

In [3]:
```
# Calculate the cell means of each of the two independent variables Attractiveness
(FACTOR_A) and
# Smiling (FACTOR_S)

require("dplyr")
group_by(my_anova_data, FACTOR_A, FACTOR_S) %>%
  summarise(
    count = n(),
    mean = mean(GUILT, na.rm = TRUE),
    sd = sd(GUILT, na.rm = TRUE)
  )
```

```
Loading required package: dplyr

Attaching package: ‘dplyr’

The following objects are masked from ‘package:stats’:

    filter, lag

The following objects are masked from ‘package:base’:

    intersect, setdiff, setequal, union
```

A grouped_df: 4 × 5

FACTOR_A	FACTOR_S	count	mean	sd
<fct>	<fct>	<int>	<dbl>	<dbl>
A	N	8	21.875	7.180082
A	S	8	14.875	5.488625
U	N	8	73.500	9.957051
U	S	8	35.750	4.234214

In [4]:
```
# Calculate the MARGINAL cell means of each of the two independent variables Attra
ctiveness (FACTOR_A) and
# Smiling (FACTOR_S)

library("plyr") # Use the plyr package
factor_a_means<-ddply(my_anova_data, .(FACTOR_A), summarize, mean=mean(GUILT))
print(factor_a_means)
factor_s_means<-ddply(my_anova_data, .(FACTOR_S), summarize, mean=mean(GUILT))
print(factor_s_means)
```

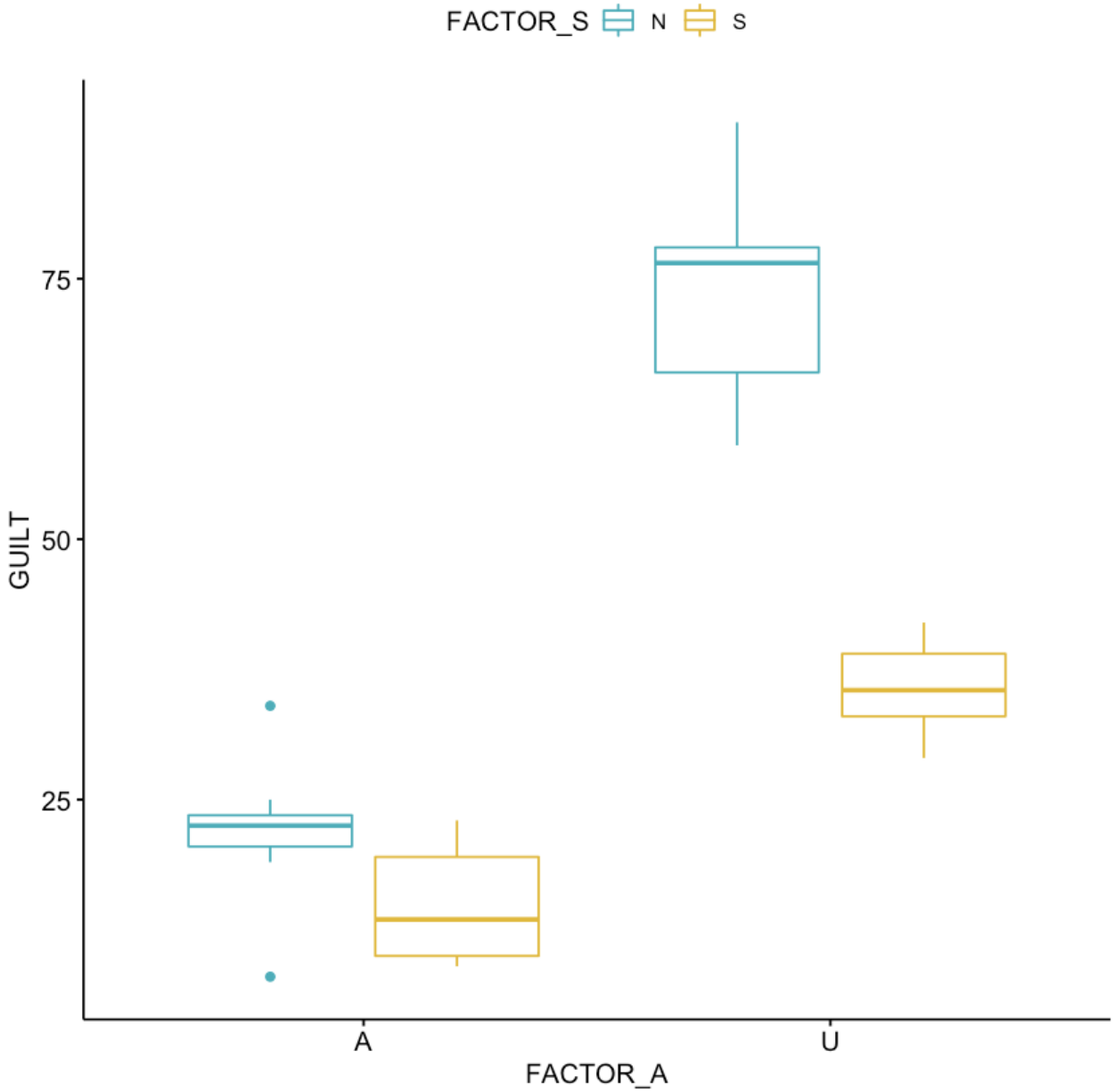
```
------------------------------------------------------------------------------
You have loaded plyr after dplyr - this is likely to cause problems.
If you need functions from both plyr and dplyr, please load plyr first, then d
plyr:
library(plyr); library(dplyr)
------------------------------------------------------------------------------

Attaching package: ‘plyr’

The following objects are masked from ‘package:dplyr’:

    arrange, count, desc, failwith, id, mutate, rename, summarise,
    summarize


  FACTOR_A   mean
1        A 18.375
2        U 54.625
  FACTOR_S    mean
1        N 47.6875
2        S 25.3125
```

In [5]:
```
# Create a cute little table of n for each cell

table(my_anova_data$FACTOR_A, my_anova_data$FACTOR_S)
```

```
   N S
A  8 8
U  8 8
```

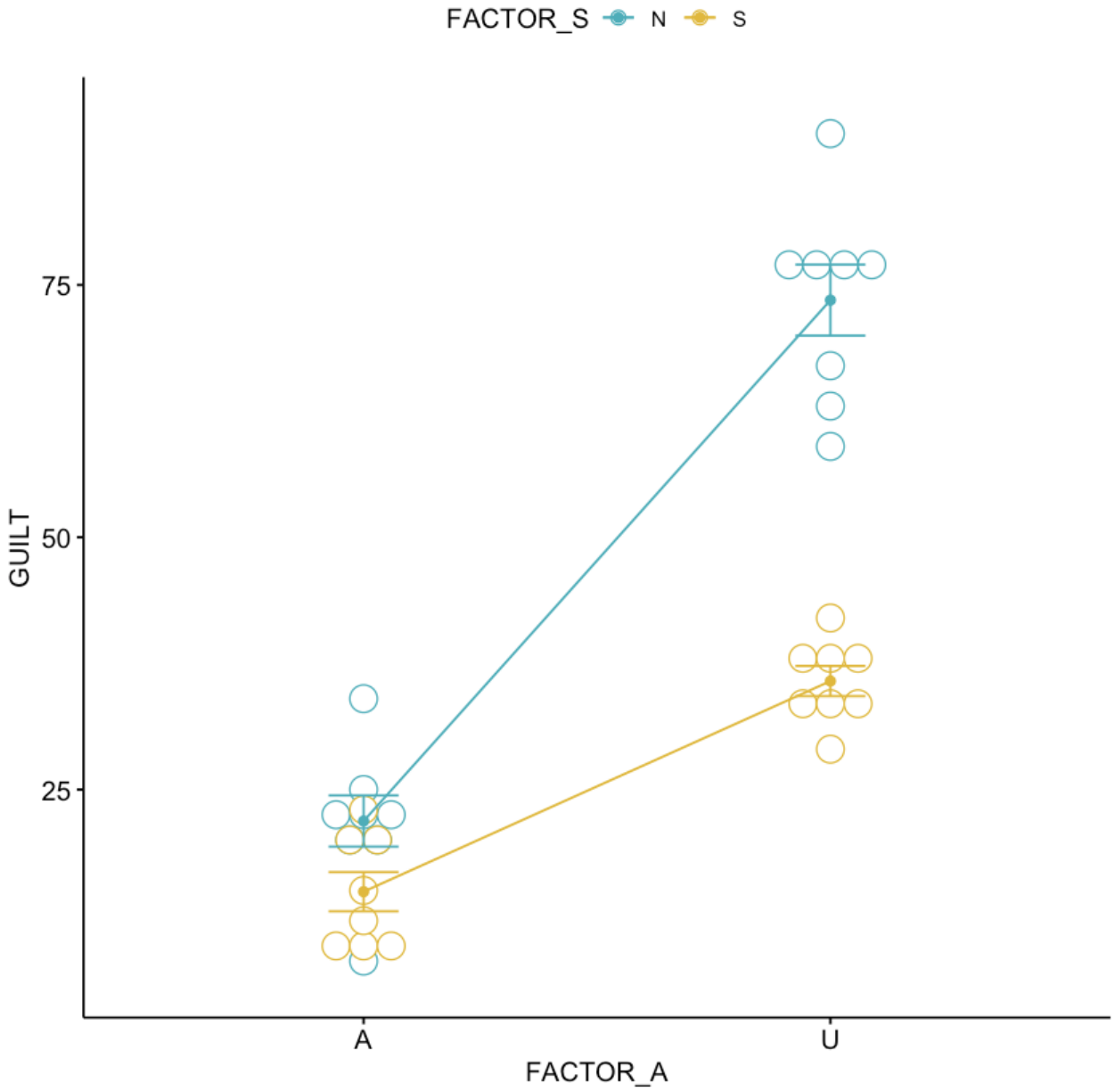
In [6]:
```
# Create a box plot with multiple groups
# Plot GUILT by FACTOR_A and color box plot by FACTOR_S

library("ggpubr")
ggboxplot(my_anova_data, x = "FACTOR_A", y = "GUILT", color = "FACTOR_S",
          palette = c("#00AFBB", "#E7B800"))
```

```
Loading required package: ggplot2
Loading required package: magrittr

Attaching package: ‘ggpubr’

The following object is masked from ‘package:plyr’:

    mutate
```

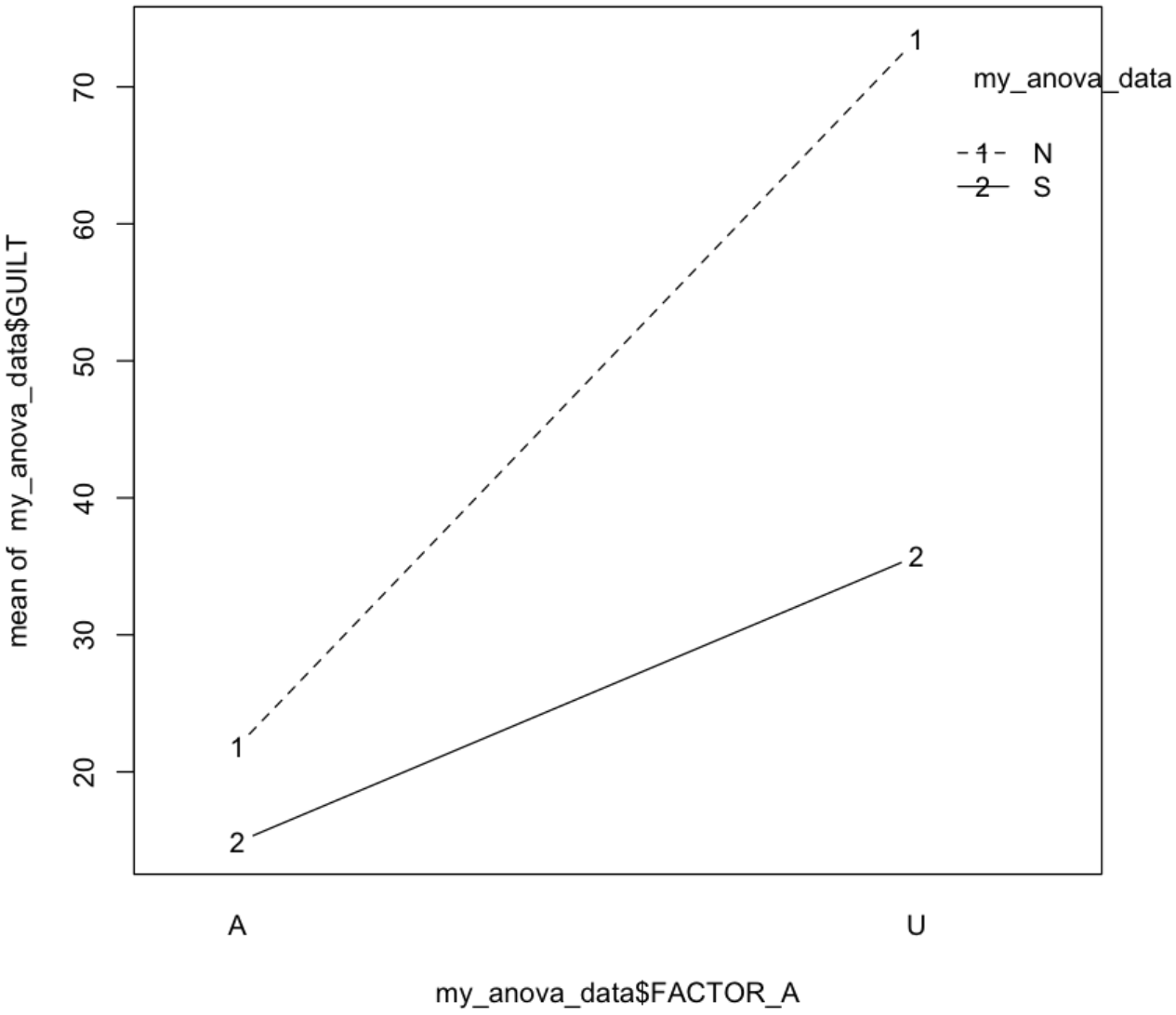


In [7]:
```
# Create a ine plot with multiple groups
# Plot GUILT by FACTOR_A and color box plot by FACTOR_S
# Add error bars: mean_se
# (other values include: mean_sd, mean_ci, median_iqr, ....)

ggline(my_anova_data, x = "FACTOR_A", y = "GUILT", color = "FACTOR_S",
       add = c("mean_se", "dotplot"),
       palette = c("#00AFBB", "#E7B800"))
```

```
`stat_bindot()` using `bins = 30`. Pick better value with `binwidth`.
```



In [8]:
```
# Simpler plot with simpler code using the interaction.plot() function

interaction.plot(x.factor=my_anova_data$FACTOR_A, trace.factor=my_anova_data$FACTO
R_S,
                 response=my_anova_data$GUILT, type='b')
```



In [9]:
```
# Do the ANOVA using the aov() function!

my_anova <- aov(GUILT ~ FACTOR_A + FACTOR_S + FACTOR_A:FACTOR_S, data = my_anova_d
ata)
summary(my_anova)
```

```
                  Df Sum Sq Mean Sq F value   Pr(>F)
FACTOR_A           1  10513   10513  211.57 1.40e-14 ***
FACTOR_S           1   4005    4005   80.61 9.83e-10 ***
FACTOR_A:FACTOR_S  1   1891    1891   38.06 1.16e-06 ***
Residuals         28   1391      50
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

In [10]:
```
# Just for fun let's do some Tukey Honest Significant Differences (HSD) tests.

TukeyHSD(my_anova, which = "FACTOR_A")
TukeyHSD(my_anova, which = "FACTOR_S")
```

```
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = GUILT ~ FACTOR_A + FACTOR_S + FACTOR_A:FACTOR_S, data = my_
anova_data)

$FACTOR_A
     diff      lwr      upr p adj
U-A 36.25 31.14501 41.35499     0

  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = GUILT ~ FACTOR_A + FACTOR_S + FACTOR_A:FACTOR_S, data = my_
anova_data)

$FACTOR_S
       diff       lwr       upr p adj
S-N -22.375 -27.47999 -17.27001     0
```

Resources

- This notebook: http://ratthing.com/u/3b (http://ratthing.com/u/3b)
- R homepage: r-project.org (http://r-project.org)
- R Studio: rstudio.com (http://rstudio.com)
- Beginner's Guide to R: ratthing.com/u/3a (http://ratthing.com/u/3a)
- Anaconda: anaconda.com (https://www.anaconda.com/)
- YouTube R Programming Tutorial: https://www.youtube.com/watch?v=_V8eKsto3Ug (https://www.youtube.com/watch?v=_V8eKsto3Ug)
- Coursera R course: https://www.coursera.org/learn/r-programming (https://www.coursera.org/learn/r-programming)

In [ ]: