Repeated Measures and Mixed Designs in ANOVAs

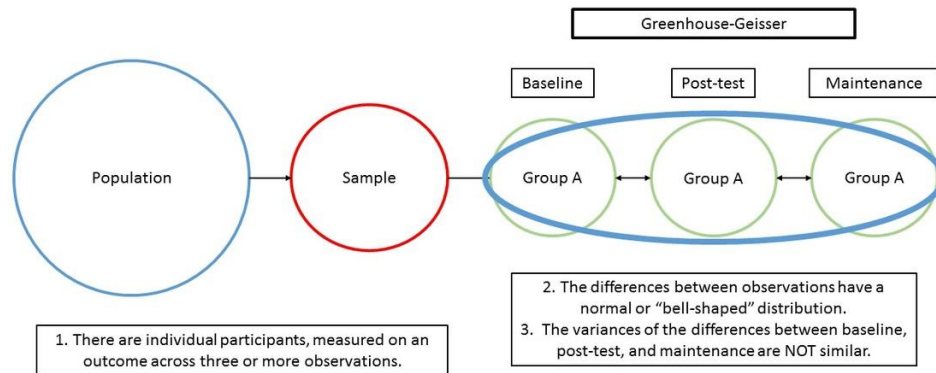Gemma Wallace & Neil Yetz
PSY 653 Module 5 Lab
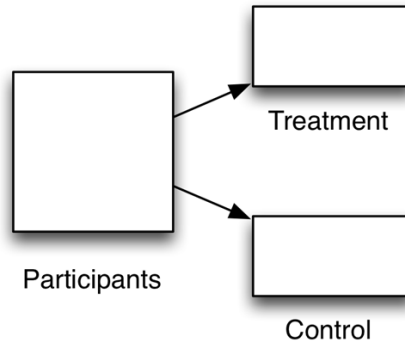Feb 26, 2020

Key terms

- **Repeated Measures**
  - When subjects participate in all conditions of an experiment or provide data at multiple timepoints
- **Sphericity**
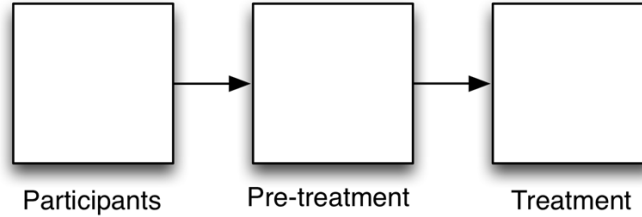 - Equality of variances of the *differences* between treatment levels

Greenhouse-Geisser

Baseline   Post-test   Maintenance

Population   Sample   Group A   Group A   Group A

1. There are individual participants, measured on an outcome across three or more observations.

2. The differences between observations have a normal or "bell-shaped" distribution.
3. The variances of the differences between baseline, post-test, and maintenance are NOT similar.

Between-subjects design

Participants → Treatment

Participants → Control

Compares treatment and control

Within-subjects design

Participants → Pre-treatment → Treatment

Compares pre-treatment and treatment

Mixed design

Participants → Pre-treatment → Treatment

Participants → Pre-treatment → Control
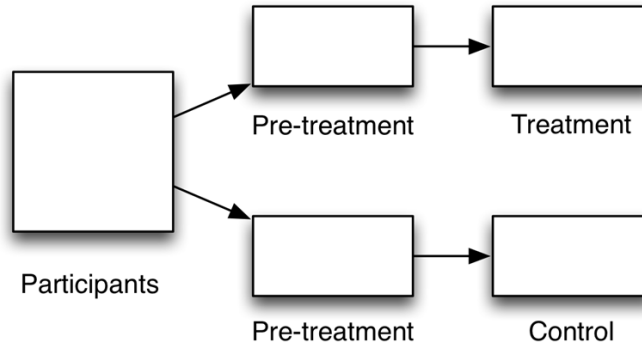
Compares change in treatment group and change in control group

Between-subjects design
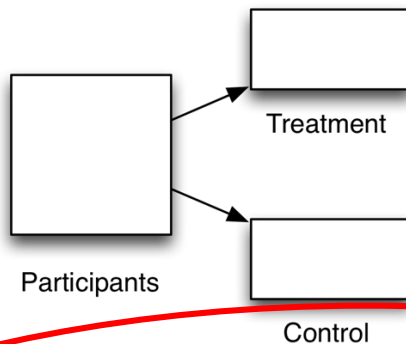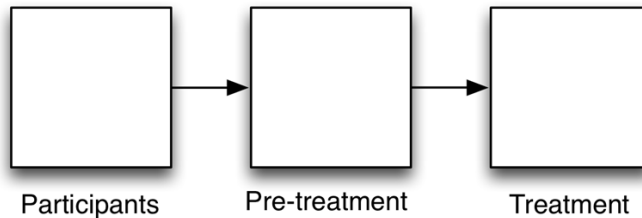
Participants → Treatment
Participants → Control

Compares treatment and control

Within-subjects design

Participants → Pre-treatment → Treatment

Compares pre-treatment and treatment

Mixed design

Participants → Pre-treatment → Treatment
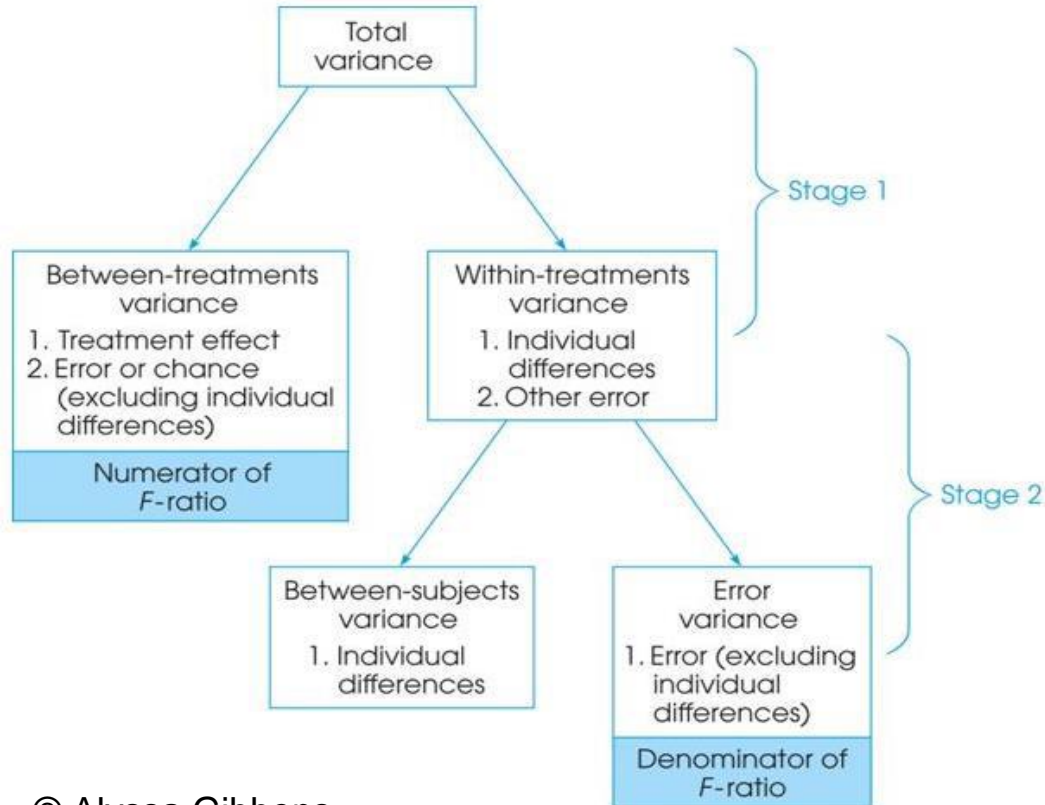Participants → Pre-treatment → Control
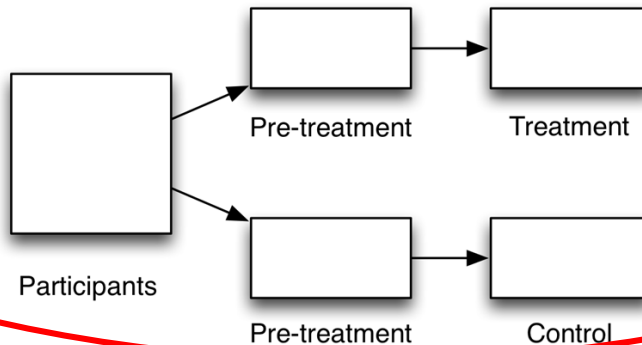
Compares change in treatment group and change in control group

Partitioning the variance

Class example

A researcher is interested in the length of time it takes to say 2 syllable, 3 syllable, and 4 syllable words. She first times how long it takes each participant to say the 2 syllable word, then the 3 syllable word, then the 4 syllable word. However, half the participants are put in a condition in which there is a distracting noise in the background. She is interested if there is a difference between the control condition and the noise condition.

Source: Henderson, L., Coltheart, M., & Woodhouse, D. (1973). Failure to find a syllabic effect in number naming. Memory & Cognition, 1(3), 304-306. Retrieved from: http://users.stat.ufl.edu/~winner/data/

Our variables and research design

- Noise Condition = between-subjects factor
  - Every participant is only exposed to one condition, either control or noisy

- # of syllables = within-subjects factor
  - Every participant reads words of all three syllable lengths

- Length of time to say each word = outcome variable

Mixed design
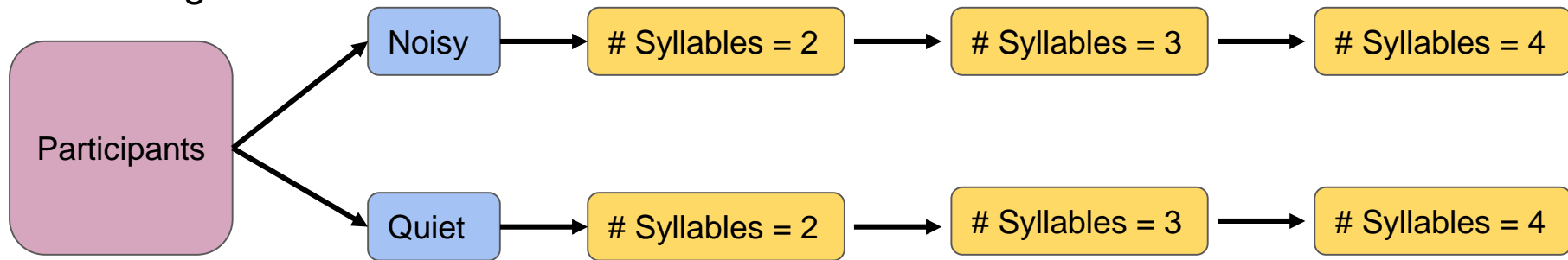
Start the ANOVA table and list df for each

Df numerator = (k-1)

N = 48

	Df numerator
Noise Condition (between-subjects)	(2-1) = 1
# Syllables (within-subjects)	(3-1) = 2
Noise condition * # syllables	(2 * 1) = 2

Load libraries

```r
# Load libraries
```{r}
library(tidyverse)
library(ez)
library(psych)
```
```

Read in the data

```r
13   # Read in data
14   ```{r}
15   syl <- read_csv("syllables.csv")
16   ```
```

```
Parsed with column specification:
cols(
  ID = col_double(),
  length = col_double(),
  cond = col_double(),
  time = col_double()
)
```

17

- ID = subject id
- length = # of syllables in word (2, 3, or 4)
- cond = condition (0 = control, 1 = noise condition)
- time = milliseconds it took to say the word (outcome variable)

Factor the variables

```r
18   # Factor variables
19   ```{r}
20   syl <- mutate(syl,
21                 ID     = factor(ID),
22                 cond   = factor(cond),
23                 length = factor(length)
24                 )
25   ```
26
27
```

*Note: ezANOVA will do this automatically, but it's nice to remove the error message

The ezANOVA() Function

ModelName <- ezANOVA(data = dataframe, dv = .(outcome_variable), wid = .(variable_that_identifies_participants), within = .(repeated_measures_predictors), between = .(between_group_predictors), detailed = TRUE, type = 3)

If there are multiple predictor variables for each category, separate them with a comma e.g., .(x,y)
The period before each variable category specifies that you will list variables

The ezANOVA() Function

ModelName <- ezANOVA(data = dataframe, dv = .(outcome_variable), wid = .(variable_that_identifies_participants), within = .(repeated_measures_predictors), between = .(between_group_predictors), detailed = TRUE, type = 3)

- We are using Type II sum of squares in these examples
  - The default for this function is Type II; Type III is often preferred when there is an interaction
  - Need to specify orthogonal contrasts

- Some resources to help refresh your memory:
  - https://mcfromnz.wordpress.com/2011/03/02/anova-type-iiiiii-ss-explained/
  - "Jane Superbrain" Box 11.1 in Field, Miles, & Field (2012), pp. 475-476

Analysis 1: Run a repeated measures ANOVA (ignoring condition for now)

```r
28 ▾  # Repeated measures ANOVA
29 ▾  ```{r}
30    ezANOVA(
31             data=syl,
32             dv=time,
33             wid=ID,
34             within= length,
35             detailed=TRUE,
36             type = 3
37          )
38     ```
```

Our question: Does length of time to read each word significantly differ by word syllable length?

```r
28 ▾  # Repeated measures ANOVA
29 ▾  ```{r}
30    ezANOVA(
31            data=syl,
32            dv=time,
33            wid=ID,
34            within= length,
35            detailed=TRUE,
36            type = 3
37            )
38    ```
```

- data = dataset
- dv = dependent variable
- wid = ID grouping variable
- within = within subject variable
- "detailed = TRUE" indicates we want detailed output
- "type = 3" indicates we would like it to perform a type 3 ANOVA

4 windows will be outputted!
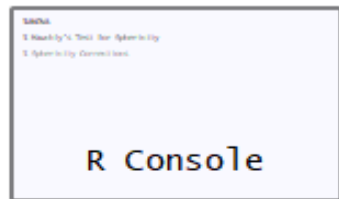
$ANOVA

$`Mauchly's Test for Sphericity`

$`Sphericity Corrections`

R console
(Errors will be reported here)

ANOVA table

Sphericity test

Greenhouse-Geisser & Huynh-Feldt corrections

First, check if sphericity is violated

Sphericity = the variances of the differences between all possible pairs of within-subject conditions (i.e., levels of the categorical predictor) are equal

Effect <chr>	W <dbl>	p <dbl>	p<.05 <chr>
2 length	0.8402584	0.2957264	

1 row

A *non-significant* p value (i.e., >0.05) means that the condition of sphericity has been met

Check if sphericity is violated

Effect <chr>	W <dbl>	p <dbl>	p<.05 <chr>
2 length	0.8402584	0.2957264	

1 row

Was it violated?

Check if sphericity is violated

ANOVA table

Effect <chr>	W <dbl>	p <dbl>	p<.05 <chr>
2 length	0.8402584	0.2957264	

1 row

Was it violated?

NO!

(therefore we don't need to deal with window 4)

Next, view the ANOVA table (since sphericity wasn't violated)

	Effect <chr>	DFn <dbl>	DFd <dbl>	SSn <dbl>	SSd <dbl>	F <dbl>	p <dbl>	p<.05 <chr>	ges <dbl>
1	(Intercept)	1	15	12962565.333	133137.333	1460.43544	2.303569e-16	*	0.98953873
2	length	2	30	2688.167	3901.167	10.33601	3.848535e-04	*	0.01923875

2 rows

39

Visualize the effect

```{r}


syl_sum <- group_by(syl, length)
syl_sum <- summarise(syl_sum, time = mean(time))
syl_sum <- ungroup(syl_sum)

ggplot(syl_sum, aes(x = length, y = time, group = length, fill = length)) +
  geom_col(width = .5) +
  theme_bw()

```
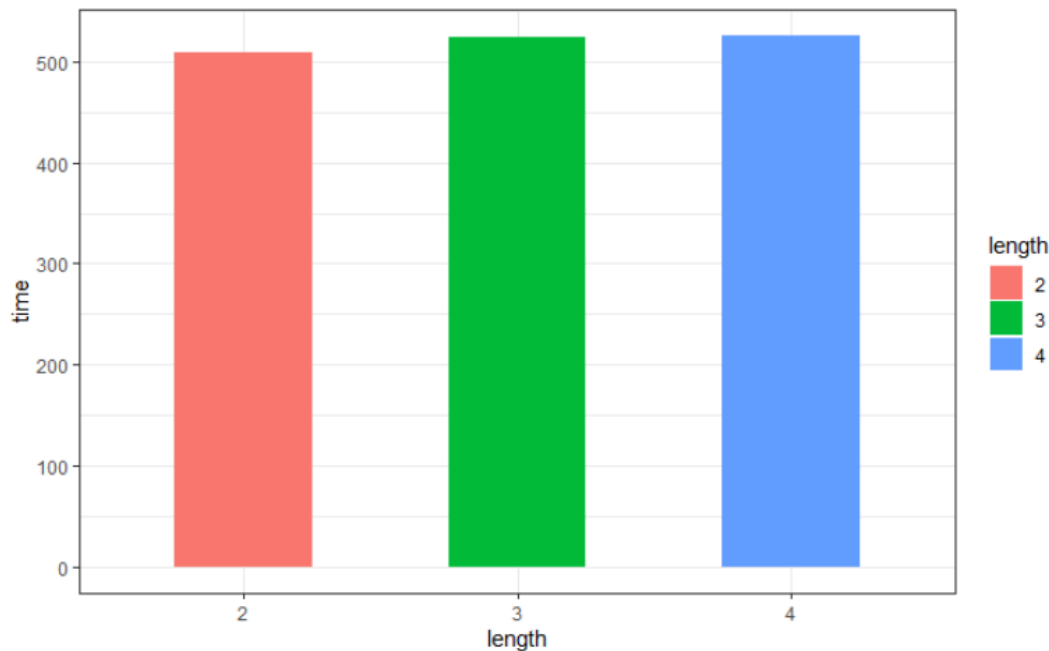

Visualize the effect of syllable length on time to read each word

Analysis 2: Run a mixed effects ANOVA to evaluate effects of both # of syllables and noise condition on time

```r
58   ## Mixed design
59   ```{r}
60   ezANOVA(
61           data=syl,
62           dv=time,
63           wid=ID,
64           within= length,
65           between = cond,
66           detailed=TRUE,
67           type = 3
68           )
69   ```
```

Our question: Does length of time to read each word significantly differ by word syllable length AND by noise condition?

First, check if sphericity was violated

	Effect <chr>	W <dbl>	p <dbl>	p<.05 <chr>
3	length	0.8953253	0.4873887	
4	cond:length	0.8953253	0.4873887	

2 rows

First, check if sphericity was violated

	Effect <chr>	W <dbl>	p <dbl>	p<.05 <chr>
3	length	0.8953253	0.4873887	
4	cond:length	0.8953253	0.4873887	

2 rows

Was the assumption violated?

Next, view the ANOVA table (since sphericity wasn't violated)

| | R Console | data.frame 4 x 9 | data.frame 2 x 4 | data.frame 2 x 7 |

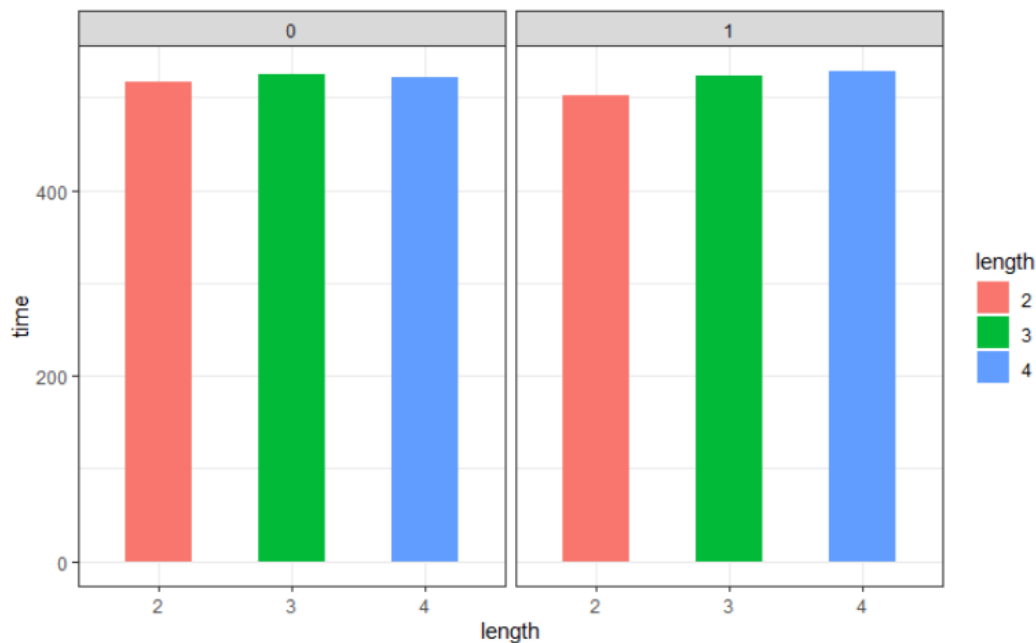|	Effect <chr>	DFn <dbl>	DFd <dbl>	SSn <dbl>	SSd <dbl>	F <dbl>	p <dbl>	p<.05 <chr>	ges <dbl>
1	(Intercept)	1	14	1.296257e+07	132976	1.364727e+03	2.342147e-15	*	0.989620054
2	cond	1	14	1.613333e+02	132976	1.698552e-02	8.981607e-01		0.001185200
3	length	2	28	2.688167e+03	2986	1.260359e+01	1.249189e-04	*	0.019388124
4	cond:length	2	28	9.151667e+02	2986	4.290802e+00	2.368832e-02	*	0.006686043

4 rows

SSd = an error term: the amount of unexplained variance across the conditions of the within-subjects variable

What should you do if the sphericity assumption is violated?

We didn't violate the assumption in this demo activity, but if we had:

Use the output from Window 4 and apply a correction to the model F Ratio,and then use that value in your model interpretations.

(p. 554 in Field, Miles, & Field, 2012)

Extra Practice and Readings

- Chapters 13-14 in the Field, Miles, & Field 2012 textbook describe these steps in detail

  - Includes instructions for planned contrasts and post-hoc analyses