Introduction to experimental design

EXPERIMENTAL DESIGN IN R

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Intro to experimental design

- Starts with a question (hypothesis)
- Collecting & analyzing the data

Steps of an experiment

- Planning
  - dependent variable = outcome
  - independent variable(s) = explanatory variables
- Design
- Analysis

Key components of an experiment

- Randomization
- Replication
- Blocking

Randomization

- Evenly distributes any variability in outcome due to outside factors across treatment groups
- Example:
  - double-blind medical trials
  - neither patient nor doctor knows which group has been assigned
  - group assignment is made randomly by 3rd party

Recap: t-tests

- t-tests help answer research questions

```
data("mtcars")
```

```
t.test(x = mtcars$mpg, alternative = "two.sided", mu = 40)
```

```
library(broom)
```

```
tidy()
```

Let's practice!

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Replication and blocking

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Replication

- Must repeat an experiment to fully assess variability
- If we only conduct a drug efficacy experiment on one person, how can we properly generalize those results? (We can't!)

```
library(dplyr)
mtcars %>%
    count(cyl)
```

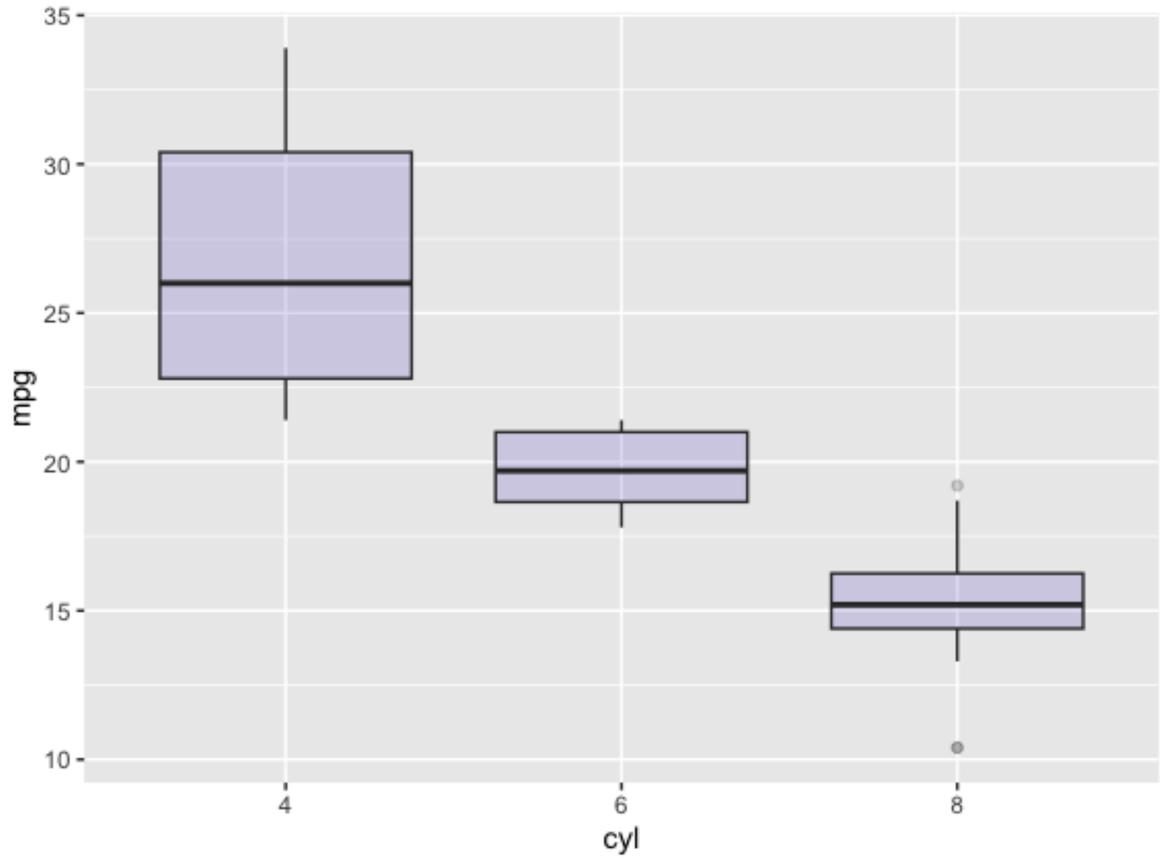
```
  cyl  n
1   4     11
2   6      7
3   8     14
```

Blocking

- Helps control variability by making treatment groups more alike
- Inside of groups, differences will be minimal. Across groups, differences will be larger
- One example is blocking treatment groups by sex

Boxplots

```
# Boxplot of MPG by Car Cylinders
ggplot(mtcars, aes(x=as.factor(cyl),
                   y=mpg)) +
  geom_boxplot(fill="slateblue",
               alpha=0.2) +
  xlab("cyl")
```



Functions for modeling

- Linear models

```
lm(formula, data, na.action,...)
```

- One-way ANOVA model

```
aov(formula, data = NULL, ...)
```

- Nested ANOVA model

```
anova(object,...)
```

Let's practice!

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Hypothesis testing

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Breaking down hypothesis testing:

- **Null hypothesis**:
  - there is no change
  - no difference between groups
  - the mean, median, or observation = a number
- **Alternative hypothesis**:
  - there is a change
  - difference between groups
  - mean, median, or observation is >, <, or != to a number

Power and sample size

- **Power**: probability that the test correctly rejects the null hypothesis when the alternative hypothesis is true.
- **Effect size**: standardized measure of the difference you're trying to detect.
- **Sample size**: How many experimental units you need to survey to detect the desired difference at the desired power.

Power and sample size calculations

```
library(pwr)
pwr.anova.test(k = 3,
               n = 20,
               f = 0.2,
               sig.level = 0.05,
               power = NULL)
```

```
 Balanced one-way analysis of variance power calculation
              k = 3
              n = 20
              f = 0.2
      sig.level = 0.05
          power = 0.2521043
 NOTE: n is number in each group
```

Let's practice!

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