R Take-Home Assignment 5: Statistics with Penguins

Your Name

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Overview

In this assignment you will practice simple statistical tests in R using the **palmerpenguins** dataset. We will ask biological questions about penguin body mass, learn to run standard tests in R, and interpret the results. Each section starts with a short story to explain why we are doing this step.

Source

`palmerpenguins` package

Skills

`t-tests, ANOVA, post-hoc tests, effect sizes, diagnostics`

Preparation

You will need: `dplyr`, `ggplot2`, `palmerpenguins`, `broom`, `effectsize`.

```
## Task: load packages
## library(dplyr)
## library(ggplot2)
## library(palmerpenguins)
## library(broom)
## library(effectsize)
```

1. Load the dataset

Before we can analyze penguins, we need to load the dataset. Real-world data often contain missing values, which can cause errors in analysis, so we will remove them first.

Task: Load the `penguins` dataset and remove missing values.

```
## Task: load penguins dataset (hint: data(penguins))
## Task: remove rows with missing values (hint: drop_na())
```

2. Two-sample t-test

Imagine you are a biologist asking: *Do male and female penguins of the same species differ in body mass?* The **t-test** compares the means of two groups. It answers whether the difference is large enough that it is unlikely to be due to chance.

Task: Filter the dataset to one species (e.g. Adelie) and compare male vs female body mass with a t-test.

```
## Task: filter to one species (hint: filter(species == "Adelie"))
## Task: run t.test(body_mass_g ~ sex, data = ...)
```

3. ANOVA

Now suppose we want to compare *all three species at once*. Do Gentoo, Adelie, and Chinstrap penguins differ in body mass?
An **ANOVA (Analysis of Variance)** extends the t-test to more than two groups.

Task: Run an ANOVA with species as the predictor.

```
## Task: run aov(body_mass_g ~ species, data = penguins)
## Task: check summary()
```

4. Post-hoc tests

ANOVA tells us if there is *some* difference between groups, but not *which groups differ*. For that, we run a **Tukey HSD post-hoc test**.

Task: Use `TukeyHSD()` on your ANOVA model to see which pairs of species differ.

```
## Task: run TukeyHSD() on your ANOVA model
```

5. Effect sizes

Statistical significance is not enough: we also want to know *how large the difference is*.
- For t-tests, we use **Cohen's d** (small 0.2, medium 0.5, large 0.8).
- For ANOVA, we use ^{2} **(eta squared)** (small .01, medium .06, large .14).

Task: Calculate Cohen's d for your t-test and ^{2} for your ANOVA.

```
## Task: use effectsize::cohens_d() and effectsize::eta_squared()
```

6. Diagnostics (checking assumptions)

Every statistical test makes assumptions. For ANOVA, the two most important are:

1. **Equal spread of errors (homoscedasticity):**
   The variation in the data should be roughly the same across all groups.
2. **Normally distributed errors:**
   The differences between the observed data and the model's predictions (residuals) should follow a bell-shaped curve.

We can check these assumptions using two standard diagnostic plots:

- **Residuals vs Fitted plot**
  - Each dot is one observation.
  - The x-axis shows what the model predicts, the y-axis shows the "error" (residual).
  - What to look for: the dots should look like random noise.
    - If you see a curve → the relationship might not be captured well.
    - If you see a funnel shape → group variances may not be equal.
- **Normal QQ plot**
  - This compares your residuals to what would be expected if they were perfectly normal.
  - What to look for: the dots should fall roughly along the diagonal line.
    - If they bend away strongly → residuals may not be normally distributed.

Task: Create both plots for your ANOVA model and then write 2–3 sentences interpreting them.

```
## Task: residual vs fitted
## Task: QQ plot
```

7. Reflection

Statistics are not just numbers: they help answer real questions. Think like a biologist preparing a short report.

Task: Write 3–4 sentences: what did you learn about differences in penguin body mass across species and sexes? How strong are the effects?