

# R Cheat Sheet: Regression & Experimental Analysis

## Quick Reference for Lab Session

### Linear Regression

#### Fitting Models

```
# Simple regression
model <- lm(dependent_var ~ independent_var, data = mydata)

# Multiple regression
model <- lm(dependent_var ~ var1 + var2, data = mydata)

# With log transformation
model <- lm(log(dependent_var) ~ independent_var, data = mydata)
```

#### Examining Results

```
summary(model)          # Full model summary
coef(model)             # Extract coefficients
confint(model)          # Confidence intervals
summary(model)$r.squared # R2
```

#### Model Diagnostics

```
# Extract values
fitted_values <- fitted(model)      # Fitted values (predictions)
residuals_values <- residuals(model) # Residuals

# Diagnostic plots
plot(fitted_values, residuals_values) # Residuals vs Fitted
qqnorm(residuals_values)            # Q-Q plot
qqline(residuals_values)           # Add reference line
```

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#### t-Tests

##### Independent Samples t-test

```
# Basic syntax
t.test(outcome ~ group, data = mydata)

# With equal variances assumed
t.test(outcome ~ group, data = mydata, var.equal = TRUE)

# With unequal variances (Welch's test)
t.test(outcome ~ group, data = mydata, var.equal = FALSE)
```

## Paired t-test

```
t.test(after ~ before, data = mydata, paired = TRUE)
```

## Effect Size (Cohen's d)

```
library(effectsize)
cohens_d(outcome ~ group, data = mydata)
```

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# ANOVA

## One-Way ANOVA

```
# Using aov()
model <- aov(outcome ~ group, data = mydata)
summary(model)

# Using lm() (gives same results)
model <- lm(outcome ~ group, data = mydata)
anova(model)
```

## Effect Size ( $\eta^2$ )

```
library(effectsize)
eta_squared(model)
```

## Post-Hoc Tests

```
# Tukey HSD (for aov models)
TukeyHSD(model)

# Alternative using emmeans (works with lm too)
library(emmeans)
emmeans(model, pairwise ~ group)
```

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# Assumption Checking

## Normality Tests

```
# Shapiro-Wilk test (H0: data is normally distributed)
shapiro.test(mydata$variable)

# For residuals
shapiro.test(residuals(model))

# Visual check
qqnorm(mydata$variable)
qqline(mydata$variable)
```

## Equal Variances Test

```
library(car)
# Levene's test (H0: variances are equal)
leveneTest(outcome ~ group, data = mydata)
```

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# Data Transformation

## Log Transformation

```
# Create new variable
mydata <- mydata %>%
  mutate(log_var = log(variable))

# Interpretation: coefficients = % change
# Formula: percentage_change = (exp(coefficient) - 1) * 100
```

## Square/Quadratic

```
# For U-shaped or inverted-U relationships
mydata <- mydata %>%
  mutate(var_squared = variable^2)

model <- lm(outcome ~ variable + var_squared, data = mydata)
```

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# Visualization (ggplot2)

## Scatter Plot with Regression Line

```
ggplot(data, aes(x = predictor, y = outcome)) +
  geom_point() +
  geom_smooth(method = "lm", se = TRUE)
```

## Boxplot for Group Comparisons

```
ggplot(data, aes(x = group, y = outcome, fill = group)) +
  geom_boxplot() +
  geom_jitter(width = 0.2, alpha = 0.5) +
  stat_summary(fun = mean, geom = "point", shape = 23, size = 3, fill = "red")
```

## Bar Plot with Error Bars

```
# First calculate means and SE
summary_data <- data %>%
  group_by(group) %>%
  summarise(
    mean = mean(outcome),
    se = sd(outcome) / sqrt(n())
  )

# Then plot
ggplot(summary_data, aes(x = group, y = mean)) +
  geom_col(fill = "steelblue") +
  geom_errorbar(aes(ymin = mean - 1.96*se, ymax = mean + 1.96*se),
                width = 0.2)
```

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## Common dplyr Operations

```
library(dplyr)

# Filter rows
data %>% filter(variable > 10)

# Select columns
data %>% select(var1, var2)

# Create new variables
data %>% mutate(new_var = var1 + var2)

# Group operations
data %>%
  group_by(group) %>%
  summarise(
    mean = mean(outcome),
    sd = sd(outcome),
    n = n()
  )
```

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# Interpretation Guidelines

## p-values

- **p < 0.05:** Statistically significant (reject null hypothesis)
- **p ≥ 0.05:** Not statistically significant (fail to reject null)
- Report exact p-values when possible (not just “p < 0.05”)

## Effect Sizes

### Cohen's d (for t-tests)

- **Small:** d = 0.2
- **Medium:** d = 0.5
- **Large:** d = 0.8

### $\eta^2$ (eta-squared, for ANOVA)

- **Small:**  $\eta^2 = 0.01$  (1% of variance)
- **Medium:**  $\eta^2 = 0.06$  (6% of variance)
- **Large:**  $\eta^2 = 0.14$  (14% of variance)

### R<sup>2</sup> (for regression)

- Proportion of variance explained
- Range: 0 to 1 (or 0% to 100%)
- Higher is better, but context matters!

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## Quick Troubleshooting

### Common Errors

Error	Likely Cause	Solution
object not found	Variable name typo or data not loaded	Check spelling, use <code>head(data)</code>
non-numeric argument	Using categorical where numeric expected	Check variable type with <code>str(data)</code>
missing values	NA values in data	Use <code>na.omit()</code> or check with <code>sum(is.na(data))</code>
Package not found	Library not installed	Run <code>install.packages("packagename")</code>

## Getting Help in R

```
?function_name          # Help for specific function
??search_term            # Search help files
example(lm)              # See examples
str(data)                # Structure of data
head(data)               # First 6 rows
summary(data)            # Summary statistics
```

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## Essential Packages to Load

```
library(ggplot2)      # Visualization
library(dplyr)        # Data manipulation
library(broom)         # Model tidyng (optional, but useful)
library(effectsize)   # Effect size calculations
library(car)           # Assumption tests (Levene's test)
```

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## Statistical Decision Tree

Do you have...

1 continuous outcome + 1 continuous predictor?  
→ Linear Regression (lm)

1 continuous outcome + 2+ continuous predictors?  
→ Multiple Regression (lm)

1 continuous outcome + 1 categorical predictor (2 groups)?  
→ Independent t-test (t.test)

1 continuous outcome + 1 categorical predictor (3+ groups)?  
→ One-Way ANOVA (aov or lm)

Non-linear relationship?  
→ Consider transformation (log, quadratic)

Binary outcome (0/1)?  
→ Logistic Regression (glm, family = binomial)

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**Tip:** Keep this sheet handy during the exercise portion. Most questions can be answered by adapting these templates to your specific variable names!