METRIC TESTS (TWO-SAMPLE SITUATIONS)

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1. Background

2. Analyses
   - Mann-Whitney U Test / Wilcoxon Rank-Sum Test
   - Wilcoxon Signed Rank Test

3. Our Data
   - Choice Of Variables
   - Methods
   - Research Questions

Introduction

Metric tests are used to compare parameters of metric/ordinal variable values among groups/individuals.

Prominent metric tests for two-sample situations include:

- **Mann-Whitney U Test**
- **Wilcoxon Signed Rank Test**
- t Test (dealt with in seminar 12)
- ...

Some of these tests rely on the **assumption of independence**:

The assumption of independence is a **crucial prerequisite** to many statistical procedures!

Independence

Theory:

- Even the smallest dependence in your data can turn into heavily biased results (which may be undetectable).
- A dependence is a connection between/within the data.
- The assumption of independence relies on the absence of any connection in your data that haven't been accounted for in your approach (accounting for it is difficult).

Independent data:

- *Between Groups*
  Groups of data records should be pulled from different individuals.
- *Within Groups*
  Data values within the same group are not to influence one another.
- *Within Individuals*
  Data values recorded for one individual should not influence each other. This is often an issue with repeated measurement approaches.

$\rightarrow$ Fixing this *after data collection* is **almost impossible**!

Purpose And Assumptions

Mann-Whitney U Test

`wilcox.test(..., paired = FALSE)` in base `R`

Purpose: To identify whether groups of variable values are different from one another.

H_0 *There is no difference in characteristics of the response variable values in dependence of the classes of the predictor variable.*

Assumptions:

- Predictor variable is binary
- Response variable is ordinal or metric
- Variable values are **independent** (not paired)

Minimal Working Example

Let's use the `wilcox.test(..., paired = FALSE)` function to test whether the medians of an unnamed variable of two unconnected populations (`a` and `b`) with 10 individuals each are truly different:

```
set.seed(42)
a <- rnorm(n = 10, mean = 10, sd = 3)
b <- rnorm(n = 10, mean = 5, sd = 3)
wilcox.test(a, b, paired = FALSE)
```

```
##
##  Wilcoxon rank sum test
##
## data:  a and b
## W = 92, p-value = 7e-04
## alternative hypothesis: true location shift is not equal to 0
```

The medians are significantly different (p = 7.25×10^{-4}). Keep in mind that the **populations do not have to be of the same size** for this!

Purpose And Assumptions

Wilcoxon Signed Rank Test

`wilcox.test(..., paired = TRUE)` in base `R`

Purpose: To identify whether groups of variable values in a repeated sampling set-up are different from one another.

H_0 *There is no difference in characteristics of the response variable values in dependence of the classes of the predictor variable.*

Assumptions:

- Predictor variable is binary
- Response variable is ordinal or metric
- Variable values are **dependent** (paired)

Minimal Working Example

Let's use the `wilcox.test(..., paired =TRUE)` function to test whether the medians of an unnamed variable of two connected samples (`a` and `b`) with 10 individuals each (i.e. one re-sampled population) are truly different:

```
set.seed(42)
a <- rnorm(n = 10, mean = 10, sd = 3)
b <- rnorm(n = 10, mean = 5, sd = 3)
wilcox.test(a, b, paired = TRUE)
```

```
##
##  Wilcoxon signed rank test
##
## data:  a and b
## V = 52, p-value = 0.01
## alternative hypothesis: true location shift is not equal to 0
```

The medians are significantly different (p = 0.01). Keep in mind that the **samples have to be of the same size** for this (i.e. there is one data record in `b` that corresponds to one data record in `a`)!

Variables We Can Use

Response variables (metric/ordinal)

- Weight
- Height
- Wing Chord
- Nesting Height
- Number of Eggs
- Egg Weight
- Home Range

Predictor variables (binary)

- Population Status (Introduced vs. Native)
- Sex (Male vs. Female)
- Nesting Site (Tree vs. Shrub)
- Predator Presence (Yes vs. No)
- Predator Type (Avian vs. Non-Avian)
- Climate (Continental vs. Coastal)

The `with()` function I

The `with()` function can be used to **make** your **code**:
- easier to **write** and **read**
- more **accessible**

You might hear someone refer to it as *soft attach* because it **works** a lot **like** the `attach()` function in `R` but **causes none of its problems**

You use `with()` to refer to data contained within a data object inside `R`:

```
with(data.object,
     expression(reference.to.object.within.data.object)
     )
```

The `with()` function II

```
WithFrame <- data.frame(First = 1:10, Second = 11:20)
WithFrame$First
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```
WithFrame$Second
```

```
##  [1] 11 12 13 14 15 16 17 18 19 20
```

Now let's try two operations:

```
WithFrame$First + WithFrame$Second
```

```
##  [1] 12 14 16 18 20 22 24 26 28 30
```

```
with(WithFrame, First + Second)
```

```
##  [1] 12 14 16 18 20 22 24 26 28 30
```

The results are the same!

Research Questions And Hypotheses

So which of our major research questions (seminar 6) can we answer?

Mann Whitney U Test

- *Climate Warming/Extremes:* Does sparrow morphology depend on climate?
- *Predation:* Does nesting height depend on predator characteristics?
- *Competition:* Does home range depend on climate?
- *Sexual Dimorphism:* Does sparrow morphology depend on sex?

Use the `1 - Sparrow_Data_READY.rds` data set for these analyses.

Wilcoxon Signed Rank Test (suppose a resettling program)

- *Climate Warming/Extremes:* Does sparrow morphology change depend on climate?
- *Predation:* Does nesting height depend on predator characteristics?
- *Competition:* Does home range depend on climate?

Use the `2b - Sparrow_ResettledSIUK_READY.rds` data set for these analyses.