Analyzing the Ringelmann Effect with the Repeated Measures ANOVA

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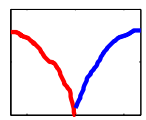
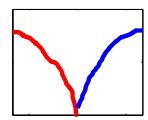
The Ringelmann Effect

- Maximilian Ringelmann (1861-1931):
  - French professor of agricultural ingeneering
- Work performance depends of number of group size
- Decreasing individual performance with increasing group size
- Example: Pulling weights with different sized groups



Overview

- The Ringelmann Effect can be investigated with an experimental design
  - Dependent Variable: Indivual performance
  - Independent Variable / Factor: Group size
  - Realization of different factor levels
- For our purpose: Data simulation Quantlet Data Simulation



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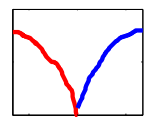

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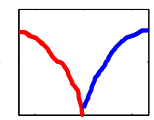

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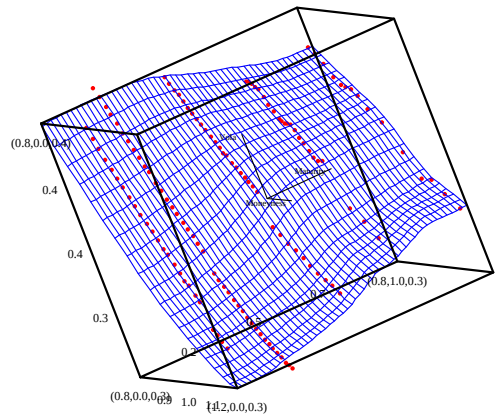

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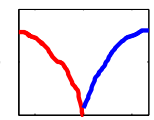


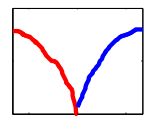
The Repeated Measures ANOVA: The ANOVA model

- ANOVA: Analysis of Variance
- Comparison of the k factor level means

$$H_0 : \mu_1 = \mu_2 = ... = \mu_k$$

$$H_1 : \exists i \neq j : \mu_i \neq \mu_j$$

- Test is accomplished by decomposition of variance components



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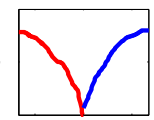
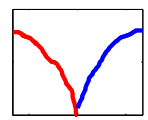


The Repeated Measures ANOVA: An Advantegeous Model

- Problem: In case of large variance between different subjects
  $\Rightarrow$ High error variance $\Rightarrow$ Loss of power in F-Test
- Repeated Measures ANOVA considers the between subject variance separately
  $\Rightarrow$ Relatively low error variance $\Rightarrow$ Gain of power in F-Test

Reduction of error variance



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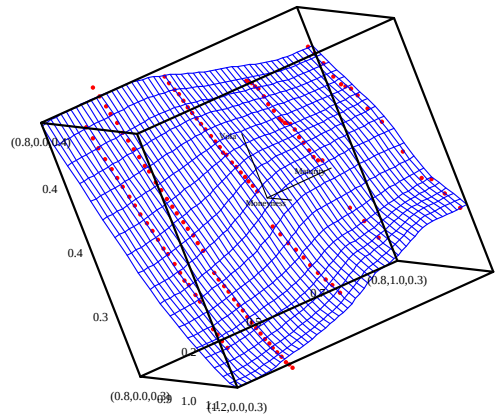

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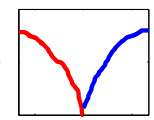
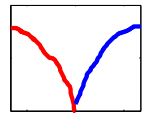


The Repeated Measures ANOVA: An Advantegeous Model

- Design Requirement: Each subject hast to be measured under all factor levels

Title	Title
2.13	1.45
3.14	6.85

Table 1: Example Data Matrix



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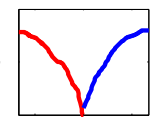

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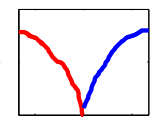
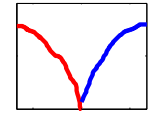


The Repeated Measures ANOVA: Confidence Intervals

- The computation of the confidence intervals has to be adjusted in the Repeated Measures ANOVA  Confidence Intervals



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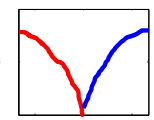

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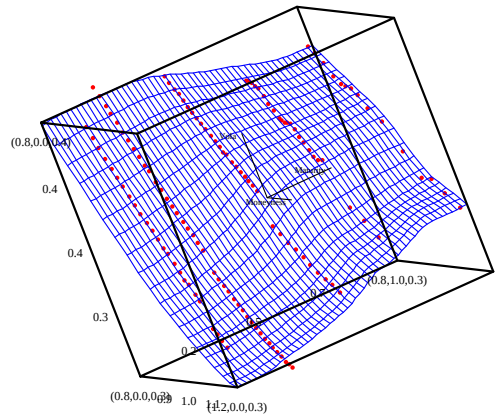

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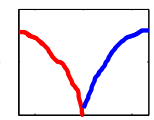
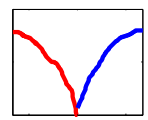


The Repeated Measures ANOVA: Effect Size Measures

- Two measures of effect size:

- η^2
- η_p^2



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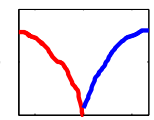

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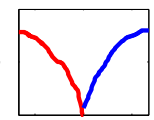

An Important Requirement

- Sphericity: The variance of differences are equal for each pair of factor levels
- Test for sphericity: Mauchly test
- Measurement of sphericity ($\epsilon \in [0, 1]$):
  - Greenhouse & Geisser: ϵ_{GG}
  - Box: ϵ_B
  - Huynh & Feldt: ϵ_{HF}
- These can be used to correct the degrees of freedom and therefore adjust the p-values if sphericity is violated