Applied Analysis of Variance and Experimental Design

401–0625–00G

Marianne Müller

mlm@ethz.ch

Introduction

- Content
- Learning Material
- Exercises
- Organisation

Consumer research: New type of beer

Has it potential?

- Business survey on sales figures
- Consumer survey on attitudes, preferences among beer drinkers
- Controlled Experiment: subjects test the new beer. Comparison with other beers.

Planning of Experiments I

1. Statement of problem, empirically testable hypotheses
2. Collecting information
3. Choice of variables:
   - outcome, response variable
   - Influencing factors: factors are categorical, explanatory variables. The values of a factor are called levels.
4. Choice of measurement methods
5. Choice of design
6. Conducting the experiment

Planning of Experiments II

7. Data scrutiny, plausibility tests
8. Data analysis: exploratory, graphically, model fitting and checking
9. Interpretation

Important principles of experimental design

- Replication
- Randomisation
- Blocking

RCT for heart disease patients

50 people get heart drugs only (group 1), another 50 people get diet instructions and heart drugs (group 2), response variable is the regularity of heart beat one month later.

Design 1: 50 women for group 1 and 50 men for group 2.

Design 2: 100 male patients, group 1 is treated in hospital 1, group 2 in hospital 2.

Design 3: 100 patients in hospital 1, the first 50 patients are treated with drugs only, the remaining 50 patients get drugs and diet instructions.

Confounding

A confounding variable is correlated with both the outcome and an explanatory variable. Effects cannot be distinguished.

Example: Coronary Drug Project (1980)

	Medication	Placebo
5 Year Mortality	20%	21%

Experimental group:

	Compliance	
	high	low
5 Year Mortality	15%	25%

Same effect in Placebo group

	Compliance	
	high	low
5 Year Mortality	15%!	28%

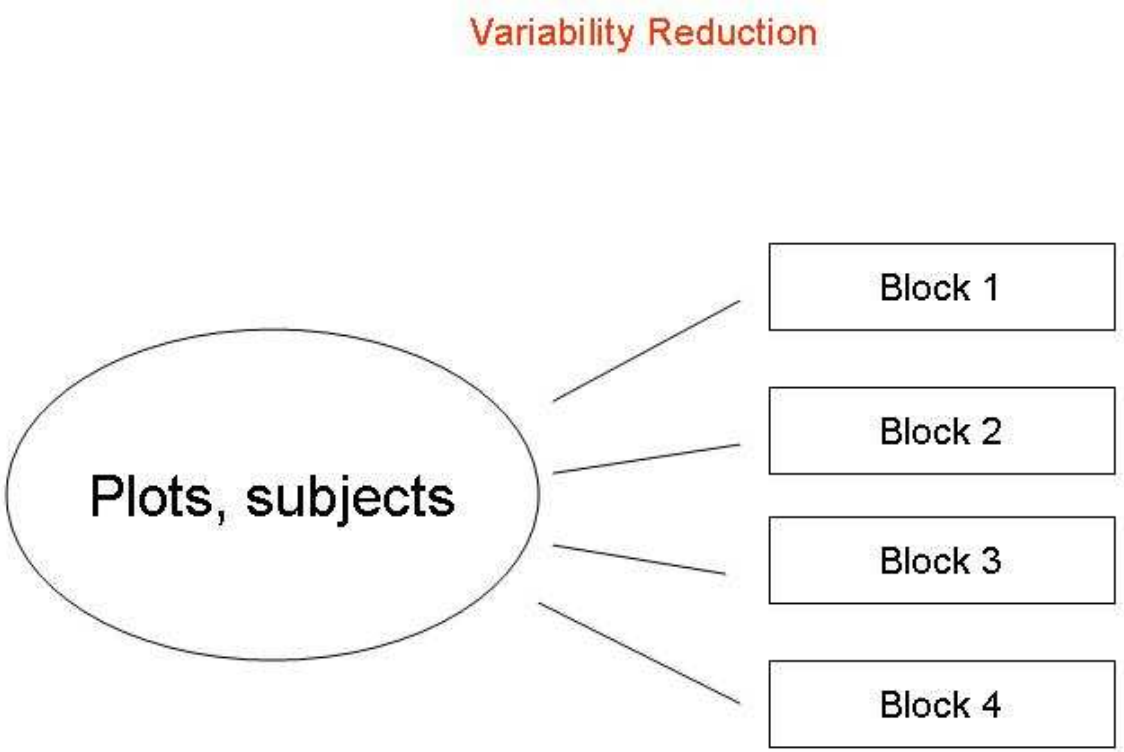
Randomisation

Random allocation of plots or subjects to experimental conditions to avoid selection bias

Example: Planting of varieties A and B

poor design: A A A A A B B B B B
better design: A A B A B A B B B A

Block design



Crossover design

Subject = Block

subject 1	Treatment 1	Treatment 2	Treatment 3
subject 2	Treatment 1	Treatment 2	Treatment 3
subject 3	Treatment 1	Treatment 2	Treatment 3
subject n	Treatment 1	Treatment 2	Treatment 3

Complex Effects

- Effect of coffee and whisky on reaction time in car driving, experiment in simulator
- Results:
  without coffee/with one glas of whisky: +0.45 sec
  without alcohol/with one cup of coffee: – 0.2 sec
- What happens after several cups of coffee and glasses of whisky? Are the effects linear and additive?
  linear: 4 cups of coffee: -0.8
  additive: 1 whisky and 1 coffee: +0.25
  linear and additive: 10 whisky and 23 coffee: -0.1

Full Example: Sewage treatment

- Procedure:
  - Mechanical process, grit chamber and bar screen, to remove large objects
  - biological process, bacteria, to remove organic contaminants
  - chemical process, microfiltration and disinfection, to remove sulphate and nitrate.
- New development: resin treatment, relatively cheap.

Can sulphate levels be reduced?

- Experiment: compare samples from treated water with average level of untreated water
- Analysis: one-sample t test
- Result: statistically significant reduction, but still too high levels.

Is a more intensive treatment helpful?

- Experiment: comparison of two groups of samples with normal and intensive treatment.
- Analysis: two-sample t test
- Result: no significant difference.

Comparison with standard

- Experiment: comparison with five commercially available treatments.
- Analysis: one-way analysis of variance
- Result: resin treatment is at least as good.

Are there other important factors?

- Experiment: treatment under various controlled conditions of amount of water, flow speed, tank size
- Design and Analysis: factorial design
- Result: there is a combination which produces acceptable water quality

Is the resin treatment successful under realistic conditions?

- Experiment: Treatment under a very large number of conditions.
- Design and Analysis: Fractional factorial design
- Result: Treatment is successful under most common conditions

Further steps

How can quality be optimized at minimal cost?

- Design and Analysis: Response surface design

Quality management

- Method: Quality control charts and variance components analysis

Application of experimental design

- agriculture and biology
- medicine
- engineering and industry
- market research
- psychology

Material

- Program, literature, organisational details

`stat.ethz.ch/education/semesters/as2012/anova`

- Recommended textbook: Montgomery, D.C (2012). *Design and Analysis of Experiments*, Wiley, New York.
- Slides, exercises, datasets, solutions see website above.
- Lecture notes and any additional material on `ILIAS`, accessible via „myStudies“ and „course catalog“.

Participants

- Electronic registration: 88
- Study programmes: Food 47, Earth 2, Biol , Math 19, Engin 8
- Degree: BSc 10, MSc 62, Dr 11, Mobil 3
- Language: German 65, English 3, Chinese 5, French 1, Italian 2, Rhaeto-Romanic 1, others 11
- Previous statistical education: ?????

Organisation of Exercises

- Assistants:
  Fabio Sigrist, sigrist@stat.math.ethz.ch
  Christian Kerkhoff, kerkhoff@stat.math.ethz.ch
- Introduction into R on 8/10/12 13 - 15 pm in HG E 19 and HG E 27.
- Afterwards every two weeks according to program in HG G3.
- External auditors who need an account send an email to an assistant.

Exam

- No confirmation required, keine Testatbedingung
- Session examination:
  - written exam
  - open book, simple pocket calculator
  - duration 120 minutes
  - 4 credits

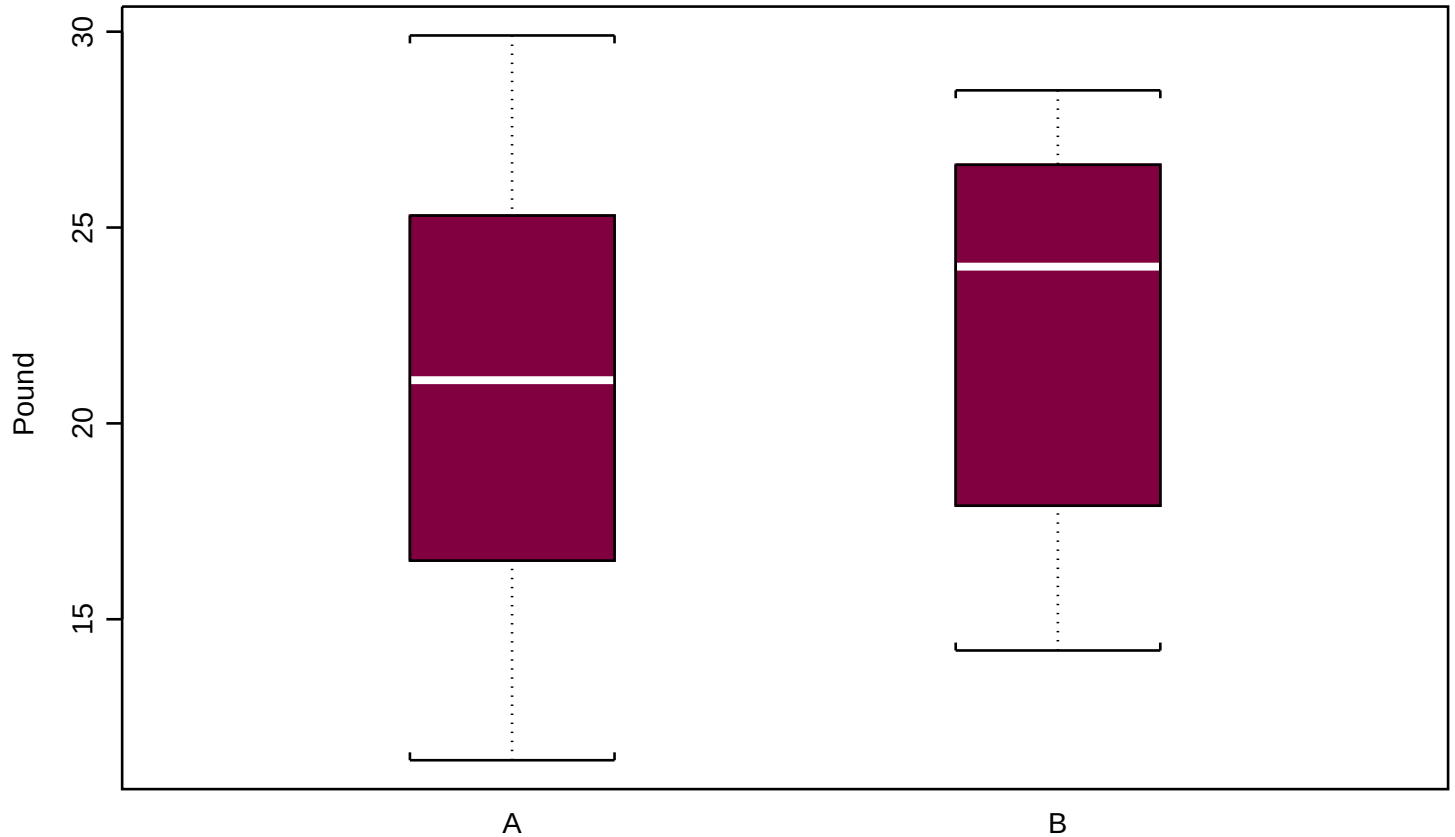
Comparison of two groups

- Effect of fertilizer mixture on yield of tomato plants. 11 plants in a single row: 5 were given standard A, 6 were given (improved?) mixture B.
- Is there a difference? How large is the difference?

A and B are randomly allocated to plants.

1	2	3	4	5	6	7	8	9	10	11
A	A	B	B	A	B	B	B	A	A	B
29.9	11.4	26.6	23.7	25.3	28.5	14.2	17.9	16.5	21.1	24.3

Boxplots



Two-sample t Test

```
> t.test(A,B)
    Standard Two-Sample t-Test

t = -0.4437, df = 9, p-value = 0.6677
alt. hypothesis: true difference in means
is not equal to 0
95 percent confidence interval:
 -10.326908   6.940241
sample estimates:
 mean of x mean of y
     20.84  22.53333
```