Design of Experiments - Exercises

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Tasks for Exercise 01: Introduction

Task 01

Sir Austin Bradford Hill, called Tony Hill, (* July 8, 1897 in London; † April 18, 1991) was a British epidemiologist, statistician and pioneer of clinical trials. Together with Richard Doll, he was the first to establish a relation between smoking and lung cancer. In 1948, Hill published the results of a study1 he had conducted on the treatment of tuberculosis with the antibiotic streptomycin. Have a look at Table II from the publication and discuss a possible research design that Hill may have chosen and the results of the study.

TABLE II.—*Assessment of Radiological Appearance at Six Months as Compared with Appearance on Admission*

Radiological Assessment	Streptomycin Group		Control Group	
Considerable improvement ..	28	*51%*	4	*8%*
Moderate or slight improvement	10	*18%*	13	*25%*
No material change	2	*4%*	3	*6%*
Moderate or slight deterioration	5	*9%*	12	*23%*
Considerable deterioration ..	6	*11%*	6	*11%*
Deaths	4	*7%*	14	*27%*
Total	55	*100%*	52	*100%*

Figure 1: Study Table

Answer

Bradford and Doll may have used an experimental study design with randomization and Blinding to ensure the most authentic results.

Task 02

Confounding means that a factor (confounder) that is not directly investigated is associated with both the independent variable and the dependent variable and accordingly causes the relationship between the two variables (Spurious Correlation). Given the definition above, interpret the following three statements

Answer

- The more firefighters fight a fire, the greater is the damage: We look at this statement in the wrong direction. The greater the damage (caused by a big fire), the more fire fighter are necessary to extinguish a fire.
- The fewer storks nest in an area, the lower the human birth rate is in that area: No, smaller areas provide less space for humans and storks, which can cause fewer stork nests and lower birth rate
- The more books a family owns, the better the children are able to read: Maybe, but it's manly cause by the level of education instead of the number of book. Educated families are more likely to own more books than less educated families.

Tasks for Exercise 02: Principles

Task 01

Which study design would you choose?

Description of the study – summary

Research question: Which title for the quarterly newsletter for current customers (made at least one purchase) will increase the open rate? There are three versions for the newsletter: The current title, a title that announces a competi- tion, and a title that announces a gift. The mailing list has approx. 12,000 customer names.

Answer

We are going to run a experimnet. We can allocaed the suer randomly. So we use a A/B test, RCT with 3 versions.

Description of the study – summary

In an article the newspaper «Blick» wants to know how its readers are doing. Readers interested in the question can access this page with one click

Answer

We run an observation. Without group comparison. So we use a Descriptive Study -> Survey Study.

Description of the study – summary

Swisscom is updating its «TV Air» browser for laptops and desktops. Three weeks after the release, it evaluates the user responses by the «community». The responses are divided into «satisfied users» and «unsatisfied users.» Their profiles make it possible to extract the following information, among other things: Browser type, operating system, download speed.

Answer

We run an observation. In this cas with group comparison. So we use a Analytical Study -> Case Study.

Task 02

A study will be conducted to answer these research questions:

- Do different language learning media affect the intensity of situational interest of two-year-old children?
- How do different language learning media affect vocabulary growth?
- Does adult company while using language learning media have an impact on vocabulary growth?

These two language learning media are in focus:

- App for learning vocabulary
- Viewing of picture cards

Which study type would you choose? In which areas of empirical research would you situate the study?

Answer

To answer the research questions, we will run an experiment. We randomly allocated the users to the different learning media. So we run randomized controlled (suitable for hypothesis testing).

Tasks for Exercise 03: Introduction to Design of Experiments (DoE)

Task 01

A study on sustainable development focuses on measuring climate data at a specific location. Among other things, the daytime temperature on a winter day is recorded over a period of 24

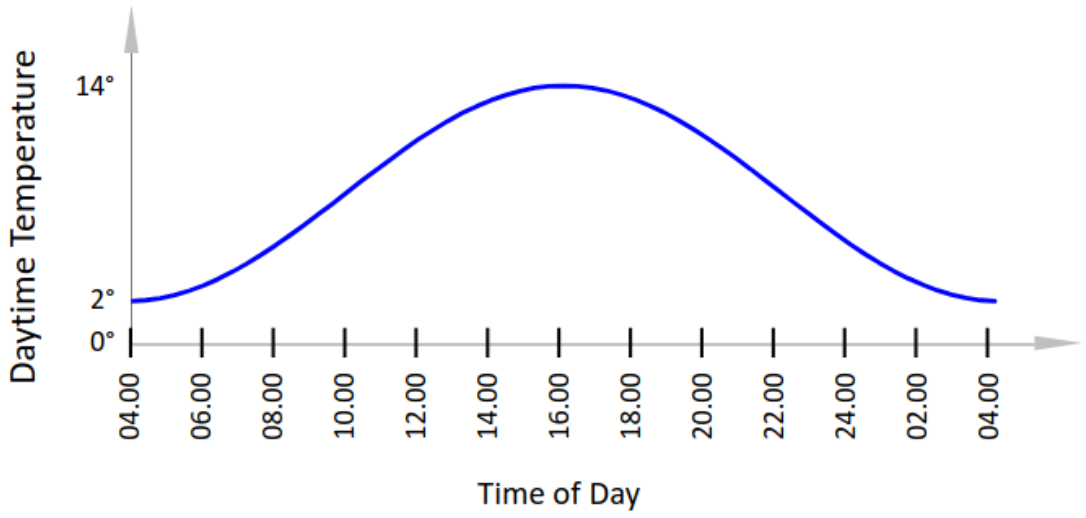

Figure 2: Daytime Temp

Two independent research teams, A and B, conduct temperature measurements. In retrospect, it turns out that the thermometers were defective: Team A: Thermometer always measures 6° C, regardless of actual temperature. Team B: Thermometer consistently measures 2° C too high. The research teams do not know that the thermometers are defective. Which research team delivers the "better" measurement results?

Answer

On the one hand, we could argue that Team B delivers 'better' results than Team A, as Team B can still identify a global pattern in their data. Conversely, Team A's results would produce a straight line in the plot, indicating a measurement error. Team A would be much more likely to detect the error than Team B.

Task 02

Show how variance can be maximized, controlled and minimized in the following descriptions of studies. First determine the relevant variables:

- Dependent variable (DV)
- Central independent variable(s) (IV)
- Nuisance variables

Description of the study – Summary

Research question: What title for a quarterly newsletter to existing customers (who have made at least one purchase) will increase the open rate? There are three title variations: The current title, a title that announces a competition, and a title that announces a gift. The mailing list has approx. 12,000 customer names.

Answer

- How can primary variance be maximized?: Use 3 distinct title variations.
- How can secondary variance be controlled?: Random allocate the customers to the the variants.
- How can error variance be minimized?: Use all possible customers.

Description of the study – Summary

Research question: Can tuberculosis be cured by treating patients with the antibiotic streptomycin? Two groups of patients are planned: Treated (Streptomycin) vs. Control (No treatment). The total sample size includes 100 patients

Answer

- How can primary variance be maximized?: The two manifestations of the central independent variable maximize "automatically" the primary variance as much as possible, since they are predetermined.
- How can secondary variance be controlled?: Random allocate the patients to one of the groups.
- How can error variance be minimized?: Increase the sample size

Tasks for Exercise 04: Properties of DoE

Task 01

Compare the descriptions and the advantages and disadvantages of the following DoE types.

Answer

Trial and error

- Description: Combination of parameters have no structure and are mixed randomly.
- Advantages: Easy to implement und run.
- Disadvantages: No idea what factors influence how.

One-factor-at-a-time (OFAT)

- Description: Vary the first factor and then measure fuel consumption. Keep the setting with the lowest consumption and then vary the next factor.
- Advantages: Easy to implement and run
- Disadvantages: Interaction between factors are not recognized. Research question is answered neither systematically nor exhaustively.

Full factorial design – e.g. 2k factorial design

- Description: Two levels (+/-) are defined per factor. All possible combinations of factor levels are varied.
- Advantages: All main effects and all interactions can be determined. Can be used as a screening experiment to identify potentially important variables.
- Disadvantages: he effort involved increases rapidly as the number of factors increases. Each additional factor doubles the number of combinations.

Task 02

Develop two experiments, A and B, with these features

- Experiment A → External and internal validity are both minimal
- Experiment B → External and internal validity are both maximal

Explain your choice.

Answer

Experiment A

- Description: Exists when changes in dependent variables (DV) are attributed to independent variables (IV). Increases with decreasing impact of nuisance variables.
- Explanation: Laboratory Study

Experiment B

- Description: Exists when experimental results from a sample can be generalized to the entire population. Increases with increasing naturalness.
- Explanation: Field Study

Tasks for Exercise 05: Sampling

Task 01

You want to conduct a survey that involves all residents of the city of Zurich. Discuss the criteria you would choose in order to define the population

Answer

1. In terms of geographical aspects: Only involving all residents of the **city of Zurich**.
2. In terms of temporal aspects: Only **residents** of the city of Zurich (e. g. no guests)
3. In terms of factual / content-related aspects: What happens to those who live in collective households?

Task 02

Evaluate the effect of the following sampling restrictions on the type of sampling error

1. Non-sampling error
2. Sampling error
3. Variability of sample means

Answer

1. You are using an incorrect equation to calculate the mean -> **Sampling error**
2. You are conducting a survey with a sample of n = 5 -> **Sampling error**
3. You take an online survey on cosmetic products and ask, among others, about the age of the interviewee at the beginning of the questionnaire. -> **Non-sampling error**
4. You conduct a telephone survey for a lifestyle product 20% of the 20 to 39-year-olds can no longer be reached via landline phone. -> **Sampling error**
5. The city of Zurich is conducting a study on the topic of sustainability. Attitudes towards sustainability are also surveyed in a neighborhood with high unemployment, poverty, a high proportion of illegal migrants, etc. -> **Non-sampling error**
6. A local television station conducts a telephone survey during the evening news, which is only announced in this broadcast. -> **Variability of sample means**

Task 03

Given is an address list address.csv Use R to draw a simple random sample with n = 50 elements from this data set. Insert also the R-code, the R-output and if necessary, R-plots in your answer.

```
library(readr)
data <- read_csv("address.csv")
data_sample <- sample(data, 50, replace=FALSE) # Take 50 random sample from data
View(data_sample)
```