

Data Analytics for Data Scientists

Design of Experiments (DoE)

Suggested solutions for Exercise 04: Properties of DoE

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Suggested solution 01

Types of DoE

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

Trial and error

Description Unsystematic change of many factors at different times. In principle, this method is not thought of being among the DoE methods. In practice, however, trial and error is applied in the sense of "quick-and-dirty".	
Advantages Quick and easy to implement	Disadvantages Reproducible, scientific knowledge cannot be obtained.

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

Description Systematic change of one factor at a time while keeping all other factors constant.	
Advantages Simple application and interpretation	Disadvantages Interactions between factors not recognized Inefficient: High number of trials needed

Full factorial designs – e.g. 2^k factorial designs

Description Factor levels are determined before the experiment. All possible factor combinations are systematically varied and investigated.	
Advantages All main effects and all interactions can be determined.	Disadvantages Effort involved increases rapidly as the number of factors increases.

Fractional factorial design – e.g. 2^{k-1} factorial design

Description Factor levels are determined before the experiment. Only a selected (balanced) number of factor combinations are varied and investigated.	
Advantages Experiment involves significantly less effort compared to full factorial designs.	Disadvantages Interactions cannot be captured and modeled by this type of experiment. In general, it is not possible to determine in advance whether interactions exist.

Suggested solution 02

Quality aspects of DoE

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.

Experiment A

Description

Research question: How much do the ingredients influence the taste of cookies?

Research design: Study of type «trial and error» or worse.

Dependent variable: «Taste», surveyed by number of pronounced "Oh!" by randomly present family members.

Independent variables: The quantity and number of ingredients added freehand. Different baking temperatures.

Experiment conditions: No conditions are specified. Simply what happens during baking.

Sampling: The presence of family members may not be entirely random but subject to some unknown factors, like the children's schedule.

Sample size: Very small

Statistical analysis: Perceived majority of family members with a high proportion of "Oh!"

Explanation

All elements that help to increase external and internal validity are almost completely at the minimal level – see above under «Description».

Experiment B

Description

The "Polio" experiment carried out in the US in 1954 (→ Lecture 01) in principle has very high external and internal validity. Only a few restrictions had to be taken into account during implementation.

Justification **internal validity**

Primary variance: The two versions of the independent variable (vaccinated / not vaccinated) «automatically» maximize the primary variance as much as possible because they are pre-scribed.

Secondary variance: Randomized double-blind experiments in principle meet the highest standard for controlling secondary variance.

Error variance: Is low because administering the treatment (vaccination / no vaccination) and measuring the dependent variables (health / sickness) is not very susceptible to random fluctuations and errors.

All the "usual" sources of errors are also present (noise, etc.)

Justification **external validity**

Population validity: The aim was to carry out a census, which was not possible in full only because of administrative and technical restraints. However, sample size was large.

Situation validity: The procedure of (mass) vaccination of children developed in this experiment has since become the standard.

Variable validity: Transferability to other forms of operationalization of IV & DV is possible without restriction in the case of vaccination (IV) with «Vaccinated / Not Vaccinated» and in the measurement of disease (DV) with «Sick / Not Sick».