

Design of Experiments (DOE)

W. M. Song 桑慧敏

Tsing Hua Univ. 清華大學

2015.12.02

1 What is DOE?

2 Song of DOE

3 Examples

4 Confound

5 Randomization

What is DOE?

- Abbreviation (縮寫) of
 - Design of Experiments, 實驗設計
 - Department of Energy, 能源署
 - Department of Environment, 環保署
 - More...
- a female deer, 母鹿
- 請不要侷限你的答案在自己的習慣領域

Do Re Mi DOE (真善美電影歌曲)

- **Doe** a deer a female deer
- **Ray** a drop of golden sun
- **Me** a name I call myself
- **Far** a long long way to run
- **Sew** a needle pulling thread
- **La** a note to follow Sew
- **Tea** a drink with jam and bread
- That will bring us back to **Doe** oh-oh-oh

- **Q: What is "Doe"?**

Song: DOE (小星星調)

Design of Experiments: DOE

- Design, Design, DOE,
- Factors, response, 因果關係
- interaction, main effect
- Confound, alias, 分不清
- Block whatever you can block and
- Randomize what you can't block
- Distinguish DOE and Regression
- Q: List and explain "key words" in the above song
- A: Design, DOE, Factors, response, 因果關係, interaction (交互作用), main effect (主效應), Confound (block-factor and non-block-factor 混淆), alias (non-block-factor and non-block-factor 混淆), Block, Randomize

Purpose of DOE

To perform experiments to

- precisely estimate the **effects** of the factors on the response (by Ronald A. Fisher)
- screening out **unimportant factors** (2^k **factorial design**)
- find a set of “**optimal**” treatments (**response surface methodology**)
- find a **robust design** (by Taguchi)

Common Terms in DOE

- Experiment
- **Factors:** experimental variables (ex. fertilizer, land)
 - Factors of interest: experimental variables (ex. fertilizer)
 - Factors of not interest: land, **blocking variable**, refers to a relatively homogeneous experimental unit
- **Levels:** condition of factor
- **Treatments:** combination of factors
- **Run:** each observation in the experiment
- **Error:** differences between the real observation and expected value

肥料與稻子產量



A型肥料



甲



B型肥料



乙

- List factors, response, block,...
- How to assign fertilizers to lands?

小兒麻痺症與疫苗

- 1916年美國首次發現急性骨髓灰白質炎, 其後的40年間數以萬計的病人感染。
- 1951年底全球進入嚴重的小兒麻痺症流行, 病人感染死亡或身體部份變麻痺, 其中受害者以兒童居多, 故又稱為小兒麻痺症 (polio)



注射疫苗



口服疫苗

- 沙克注射疫苗: 注射4次, 估計有95%接種者產生免疫
- 沙賓口服疫苗: 接種3次, 估計有95%以上種接者產生免疫

沙克疫苗實驗一

- 歷史上規模最大的醫學實驗, 總共花費超過 500 萬美元
- sponsored by 美國小兒麻痺基金會 (National foundation for Infantile Paralysis, NFIP)。NFIP 是由得到小兒麻痺症的那位美國總統羅斯福 (Franklin D. Roosevelt, 1882 1945) 成立的慈善機構。
- Design:
 - (a) 約二百萬名孩童 (一至三年級兒童參與這實驗) 參加, NFIP 負責檢驗血液, 以證明接種的小孩有免疫力。
 - (b) 獲得家長同意的二年級小學生注射疫苗, 約 50 萬接受疫苗 (處理組)
 - (c) 一年級和三年級學童 (約 100 萬) 則不予注射疫苗 (控制組)
- 沙克疫苗實驗一是成功還是失敗? 有何設計缺點?

沙克疫苗實驗二: DBRC 雙盲隨機控制實驗設計

- **Block**(區集方式): 處理組與控制組的學童須從與“相同的群體”中選出
- **Randomization** (隨機化): 隨機化過程分配學童至二組, 其中處理組接受疫苗, 控制組接受看來像疫苗的安慰劑
- **DB, Double Blind** (雙盲): 兒童本身與檢查者均不知道兒童是否接受疫苗
- **NFIP 設計一與二之區別?**

Confounding



- Q: 貓與狸分別代表什麼?
- A: One is factor and the other is block. "Confounding" means that the effect of factors and blocks are mixed.

Randomization



- A wonderful location to dive! or not?

Randomization



- If the locations are randomly selected, the risk will be much lower!