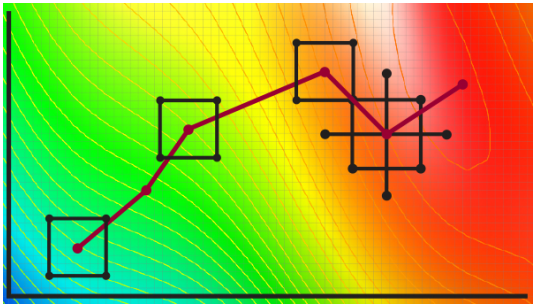
Experimentation for Improvement



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Design and Analysis of Experiments

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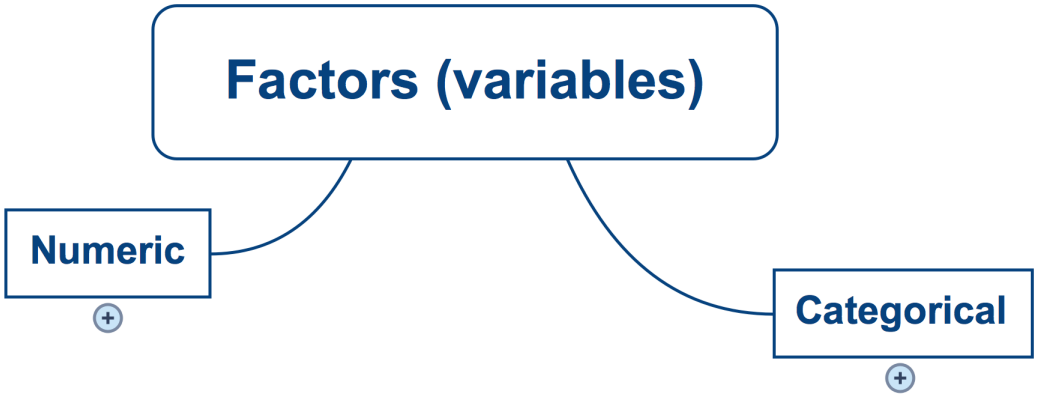
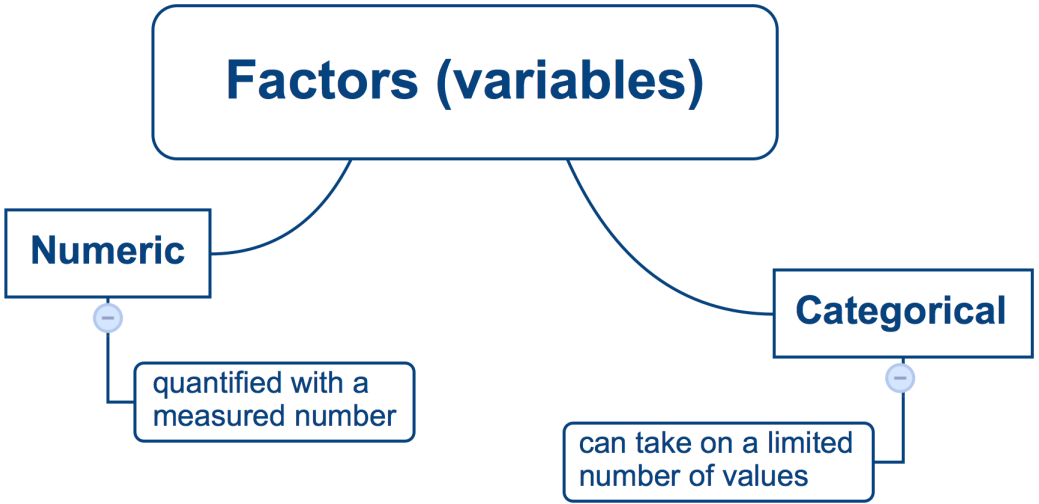
Two-factor experiments: a recap from the last module



Two-factor experiments: a recap from the last module




Flickr: ed_welker 4137738962

A systematic approach

1. What's my outcome?
2. What's my objective?
3. Which factors?
4. At what levels?
5. Plan the experiment
6. Implement the experiment
7. Analyze the results
8. Repeat (if required)

Outcome

Number of popped corn

Objective

Maximizing number of popped corn

This is equivalent to:
"*minimize the number of unpopped corn*"

[Flickr: booleansplit 13193465325]

Factors

A: time on the stove

160 secs or 200 secs

low level high level

B: type of kernel used

white corn or yellow corn

low level high level

Factor A: "time"
160 seconds or 200 seconds

Factor B: "type of corn"
white corn or yellow corn

$$2^2 = 4$$

$$2^k$$

k = number of factors

number of levels for the factors

Always run experiments in random order

Always run experiments in random order

Various options for selecting the random order of experiments

Let's assume you need 8 random numbers:

1. write numbers 1, 2, ... 8 on pieces of paper / cards
2. spreadsheets: use the following code (ignore any duplicates)

```
=1 + INT( 8 * RAND() )
```

3. some spreadsheets have a special function

```
=RANDBETWEEN(1, 8)
```

4. In R (statistical software)

```
sample(8)
```

Factor A: "time"
160 seconds or 200 seconds

− +

Factor B: "type of corn"
white corn or yellow corn

− +

Standard order	Actual order	A = time	B = corn	Outcome
1	2	−	−	52
2	4	+	−	74
3	1	−	+	62
4	3	+	+	80

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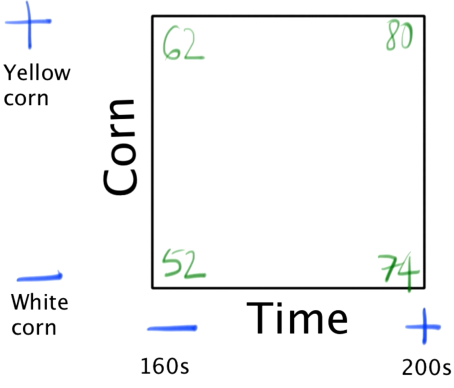

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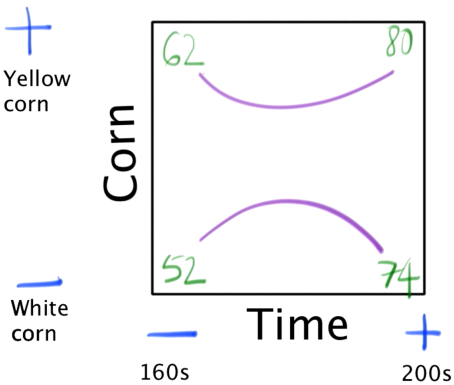


Time effect (A):

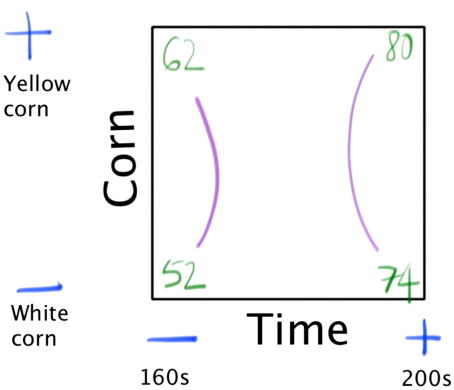
Yellow corn: 80 − 62 = 18

White corn. 74 − 52 = 22

Average = 20

20 unit increase when going from 160s to 200s of cooking time

Standard order	Actual order	A = time	B = corn	Outcome
1	2	−	−	52
2	4	+	−	74
3	1	−	+	62
4	3	+	+	80



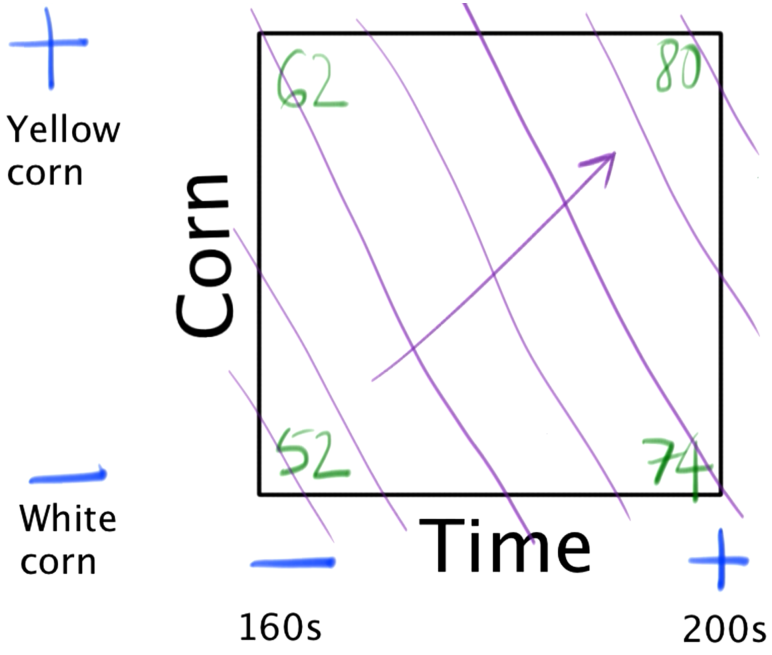
Corn type (B):

Long time: $80 - 74 = 6$

Short time: $62 - 52 = 10$

Average = 8

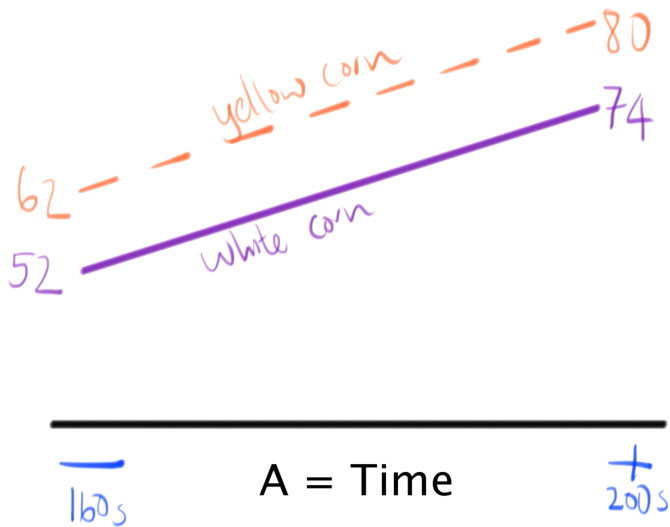
8 unit increase when changing from white to yellow popcorn


Yellow corn
White corn
Corn
Time
62
80
52
74
160s
200s

Always ask:

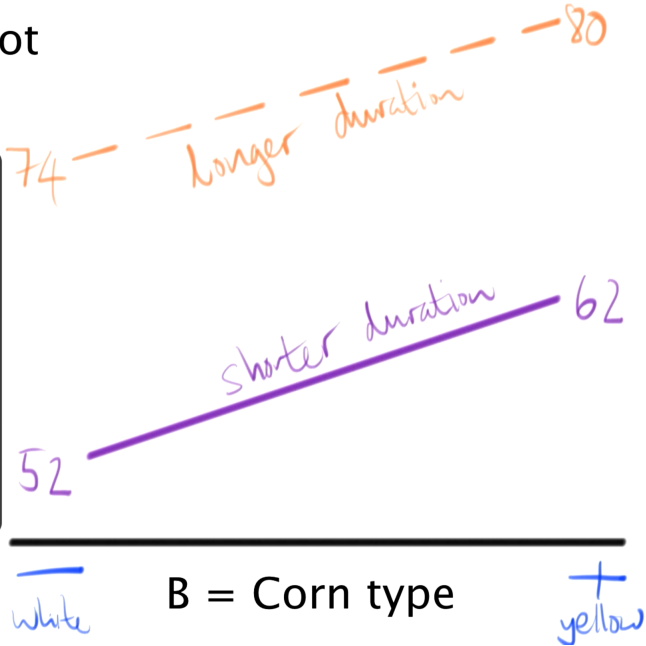
Where should I run my next experiment?

Interaction plot



Interaction plot

More correct would be to say, they are "*approximately parallel*". From a practical point, they are parallel.



$$\hat{y} = 67 + 10x_A + 4x_B$$

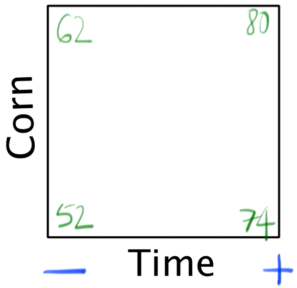
Question
What is the predicted popcorn amount for white corn and a cooking time of **180 seconds**?

Simple visualization of these factorial designs are powerful!

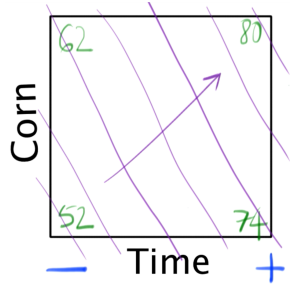
1. Tables show numeric trends

A = time	B = corn	Outcome
−	−	52
+	−	74
−	+	62
+	+	80

2. Cube plots indicate important factors



3. Contour plots show where to move next



4. Interaction plots show synergies [next...]