

# **HOW TO APPLY THE MULTIPHASE OPTIMIZATION STRATEGY (MOST) IN YOUR INTERVENTION DEVELOPMENT RESEARCH**

## **Module 3 Introduction to the optimization trial**

### **Lesson 3: Fundamental differences between the factorial experiment and the RCT**



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# In the previous lesson you learned how to:

- Describe the factorial experiment and what it is intended to estimate: main effects and interactions.
- Recognize that coding can have implications for interpretation of results.



# **In this lesson you will learn how to:**

- Express the fundamental differences between the logical underpinnings of an RCT and those of a factorial experiment.
- Explain why the factorial experiment usually requires many fewer experimental participants than alternative designs.

# **Developing an intervention aimed at reducing viral load among HIV+ heavy drinkers**

Suppose there are only 4 candidate components:

- Motivational interviewing (no, yes)
- Peer mentoring (no, yes)
- Text message support (no, yes)
- Mindfulness meditation (no, yes)

**Let's consider some different ways of  
experimentally examining these 4  
components**

# Design option A: Four individual treatment/control experiments

Treatment	Control
Motivational interviewing = Yes	Motivational interviewing = No
Treatment	Control
Peer mentoring = Yes	Peer mentoring = No
Treatment	Control
Text message support = Yes	Text message support = No
Treatment	Control
Mindfulness meditation = Yes	Mindfulness meditation = No

# Choosing an experimental design: Comparison of options

Comparison of Features of Design Alternatives for Hypothetical HIV Study			
Design	Number of Experimental Conditions	Number of Participants Needed to Maintain Power $\geq .8$ ( $d = .3$ )	Can Interactions Be Estimated?
A: Individual experiments	8	1,408	No



# Design option B: Comparative treatment experiment

Experimental conditions:

Treatment conditions				Control
Motivational interviewing = yes  All others = no or low	Peer mentoring = yes  All others = no or low	Text message support = yes  All others = no or low	Mindfulness meditation = yes  All others = no or low	All = no or low

# Choosing an experimental design: Comparison of options

Comparison of Features of Design Alternatives for Hypothetical HIV Study			
Design	Number of Experimental Conditions	Number of Participants Needed to Maintain Power $\geq .8$ ( $d = .3$ )	Can Interactions Be Estimated?
A: Individual experiments	8	1,408	No
B: Comparative treatment experiment	5	880	No

# Design option C

- $2^4$  factorial experiment
- This will have 16 experimental conditions
- We will use abbreviations for the independent variable names

Experimental conditions in a factorial experiment with four factors:

*MI*, *PEER*, *TEXT*, and *MIND*

Experimental condition	<i>MI</i>	<i>PEER</i>	<i>TEXT</i>	<i>MIND</i>	<i>Outcome</i>
1	No	No	No	No	$\bar{Y}_1$
2	No	No	No	Yes	$\bar{Y}_2$
3	No	No	Yes	No	$\bar{Y}_3$
4	No	No	Yes	Yes	$\bar{Y}_4$
5	No	Yes	No	No	$\bar{Y}_5$
6	No	Yes	No	Yes	$\bar{Y}_6$
7	No	Yes	Yes	No	$\bar{Y}_7$
8	No	Yes	Yes	Yes	$\bar{Y}_8$
9	Yes	No	No	No	$\bar{Y}_9$
10	Yes	No	No	Yes	$\bar{Y}_{10}$
11	Yes	No	Yes	No	$\bar{Y}_{11}$
12	Yes	No	Yes	Yes	$\bar{Y}_{12}$
13	Yes	Yes	No	No	$\bar{Y}_{13}$
14	Yes	Yes	No	Yes	$\bar{Y}_{14}$
15	Yes	Yes	Yes	No	$\bar{Y}_{15}$
16	Yes	Yes	Yes	Yes	$\bar{Y}_{16}$

# Choosing an experimental design:

## Comparison of options

Comparison of Features of Design Alternatives for Hypothetical HIV Study			
Design	Number of Experimental Conditions	Number of Participants Needed to Maintain Power $\geq .8$ ( $d = .3$ )	Can Interactions Be Estimated?
A: Individual experiments	8	1,408	No
B: Comparative treatment experiment	5	880	No
C: Factorial (main effect)	16	352	Yes

# **A fundamental difference between the RCT and the factorial experiment**

- The purpose of the RCT is direct comparison of experimental condition means.
- This is NOT the purpose of a factorial experiment.

The purpose of this experiment is NOT direct comparison of the 16 experimental condition means.

Experimental condition	<i>MI</i>	<i>PEER</i>	<i>TEXT</i>	<i>MIND</i>	<i>Outcome</i>
1	No	No	No	No	$\bar{Y}_1$
2	No	No	No	Yes	$\bar{Y}_2$
3	No	No	Yes	No	$\bar{Y}_3$
4	No	No	Yes	Yes	$\bar{Y}_4$
5	No	Yes	No	No	$\bar{Y}_5$
6	No	Yes	No	Yes	$\bar{Y}_6$
7	No	Yes	Yes	No	$\bar{Y}_7$
8	No	Yes	Yes	Yes	$\bar{Y}_8$
9	Yes	No	No	No	$\bar{Y}_9$
10	Yes	No	No	Yes	$\bar{Y}_{10}$
11	Yes	No	Yes	No	$\bar{Y}_{11}$
12	Yes	No	Yes	Yes	$\bar{Y}_{12}$
13	Yes	Yes	No	No	$\bar{Y}_{13}$
14	Yes	Yes	No	Yes	$\bar{Y}_{14}$
15	Yes	Yes	Yes	No	$\bar{Y}_{15}$
16	Yes	Yes	Yes	Yes	$\bar{Y}_{16}$

# **A fundamental difference between the RCT and the factorial experiment**

- The purpose of the RCT is direct comparison of experimental condition means.
- The purpose of the factorial experiment is estimation of main effects and interactions.



MAIN EFFECT OF  
*MI* is mean of  
conditions 9—16  
MINUS mean of  
conditions 1—8

Experimental condition	<i>MI</i>	<i>PEER</i>	<i>TEXT</i>	<i>MIND</i>	<i>Outcome</i>
1	No	No	No	No	$\bar{Y}_1$
2	No	No	No	Yes	$\bar{Y}_2$
3	No	No	Yes	No	$\bar{Y}_3$
4	No	No	Yes	Yes	$\bar{Y}_4$
5	No	Yes	No	No	$\bar{Y}_5$
6	No	Yes	No	Yes	$\bar{Y}_6$
7	No	Yes	Yes	No	$\bar{Y}_7$
8	No	Yes	Yes	Yes	$\bar{Y}_8$
9	Yes	No	No	No	$\bar{Y}_9$
10	Yes	No	No	Yes	$\bar{Y}_{10}$
11	Yes	No	Yes	No	$\bar{Y}_{11}$
12	Yes	No	Yes	Yes	$\bar{Y}_{12}$
13	Yes	Yes	No	No	$\bar{Y}_{13}$
14	Yes	Yes	No	Yes	$\bar{Y}_{14}$
15	Yes	Yes	Yes	No	$\bar{Y}_{15}$
16	Yes	Yes	Yes	Yes	$\bar{Y}_{16}$

MAIN EFFECT  
OF *PEER* is mean  
of conditions 5—  
8 and 13—16  
MINUS mean of  
conditions 1—4  
and 9—12

Experimental condition	<i>MI</i>	<i>PEER</i>	<i>TEXT</i>	<i>MIND</i>	<i>Outcome</i>
1	No	No	No	No	$\bar{Y}_1$
2	No	No	No	Yes	$\bar{Y}_2$
3	No	No	Yes	No	$\bar{Y}_3$
4	No	No	Yes	Yes	$\bar{Y}_4$
5	No	Yes	No	No	$\bar{Y}_5$
6	No	Yes	No	Yes	$\bar{Y}_6$
7	No	Yes	Yes	No	$\bar{Y}_7$
8	No	Yes	Yes	Yes	$\bar{Y}_8$
9	Yes	No	No	No	$\bar{Y}_9$
10	Yes	No	No	Yes	$\bar{Y}_{10}$
11	Yes	No	Yes	No	$\bar{Y}_{11}$
12	Yes	No	Yes	Yes	$\bar{Y}_{12}$
13	Yes	Yes	No	No	$\bar{Y}_{13}$
14	Yes	Yes	No	Yes	$\bar{Y}_{14}$
15	Yes	Yes	Yes	No	$\bar{Y}_{15}$
16	Yes	Yes	Yes	Yes	$\bar{Y}_{16}$

MAIN EFFECT OF  
*TEXT* is mean of  
conditions  
3,4,7,8,11,12,15,  
and 16 MINUS  
mean of  
conditions  
1,2,5,6,9,10, 13,  
and 14

Experimental condition	<i>MI</i>	<i>PEER</i>	<i>TEXT</i>	<i>MIND</i>	<i>Outcome</i>
1	No	No	No	No	$\bar{Y}_1$
2	No	No	No	Yes	$\bar{Y}_2$
3	No	No	Yes	No	$\bar{Y}_3$
4	No	No	Yes	Yes	$\bar{Y}_4$
5	No	Yes	No	No	$\bar{Y}_5$
6	No	Yes	No	Yes	$\bar{Y}_6$
7	No	Yes	Yes	No	$\bar{Y}_7$
8	No	Yes	Yes	Yes	$\bar{Y}_8$
9	Yes	No	No	No	$\bar{Y}_9$
10	Yes	No	No	Yes	$\bar{Y}_{10}$
11	Yes	No	Yes	No	$\bar{Y}_{11}$
12	Yes	No	Yes	Yes	$\bar{Y}_{12}$
13	Yes	Yes	No	No	$\bar{Y}_{13}$
14	Yes	Yes	No	Yes	$\bar{Y}_{14}$
15	Yes	Yes	Yes	No	$\bar{Y}_{15}$
16	Yes	Yes	Yes	Yes	$\bar{Y}_{16}$

MAIN EFFECT OF  
*MIND* is mean of  
the even-  
numbered  
conditions  
MINUS mean of  
the odd-  
numbered  
conditions

Experimental condition	<i>MI</i>	<i>PEER</i>	<i>TEXT</i>	<i>MIND</i>	<i>Outcome</i>
1	No	No	No	No	$\bar{Y}_1$
2	No	No	No	Yes	$\bar{Y}_2$
3	No	No	Yes	No	$\bar{Y}_3$
4	No	No	Yes	Yes	$\bar{Y}_4$
5	No	Yes	No	No	$\bar{Y}_5$
6	No	Yes	No	Yes	$\bar{Y}_6$
7	No	Yes	Yes	No	$\bar{Y}_7$
8	No	Yes	Yes	Yes	$\bar{Y}_8$
9	Yes	No	No	No	$\bar{Y}_9$
10	Yes	No	No	Yes	$\bar{Y}_{10}$
11	Yes	No	Yes	No	$\bar{Y}_{11}$
12	Yes	No	Yes	Yes	$\bar{Y}_{12}$
13	Yes	Yes	No	No	$\bar{Y}_{13}$
14	Yes	Yes	No	Yes	$\bar{Y}_{14}$
15	Yes	Yes	Yes	No	$\bar{Y}_{15}$
16	Yes	Yes	Yes	Yes	$\bar{Y}_{16}$

- In factorial analysis of variance
  - Of data from a  $2^k$  experiment
  - Using effect coding
- Each main effect and interaction effect estimate is based on *all* participants
- Participants are “recycled”

# The main effect as an average across experimental conditions

Fisher (1971, p. 102):

*“...any conclusion... has a wider inductive basis when inferred from an experiment in which the quantities of other ingredients have been varied, than it would have from any amount of experimentation, in which these had been kept strictly constant...”*

(quote continues onto next slide)

# **The main effect as an average across experimental conditions**

*...In fact, as the factorial arrangement well illustrates, we may, by deliberately varying in each case some of the conditions of the experiment, achieve a wider inductive basis for our conclusions, without in any degree impairing their precision.”*

# **The main effect as an average across experimental conditions**

Consider how this relates to examination of intervention components!

Very few interventions are made up of a single components



# Fundamental differences between the RCT and the factorial experiment

## RCT

- Designed for direct comparison of a small number of experimental conditions
- Effects estimated via direct comparison of individual experimental conditions
- Each participant usually contributes to a single effect estimate

## Factorial experiment

- Designed for estimation of main effect of each factor and interactions involving  $> 1$  factor
- Effects estimated via construction of combinations of experimental conditions
- Each participant contributes to multiple effect estimates

# **In this lesson you learned how to:**

- Express the fundamental differences between the logical underpinnings of an RCT and those of a factorial experiment.
- Explain why the factorial experiment usually requires many fewer experimental participants than alternative designs.

# In the next lesson you will learn how to:

- Explain why it is often possible to examine additional factors in a factorial experiment without the need to increase the number of participants to maintain power.
- Explain why factorial experiments can have very small per-condition  $n$ 's and still be well-powered.



# References cited

- Collins, L.M., Dziak, J.J., & Li, R. (2009). Design of experiments with multiple independent variables: A resource management perspective on complete and reduced factorial designs. *Psychological Methods*, 14, 202-224.
- Fisher, R. A. (1971). The design of experiments. New York, NY: Hafner Publishing.



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