C H A P T E R 2

Experimental Designs:   
 An Oveview

2. d. (i) RB-3 design (ii)  *H*0: µ.1 = µ.2 = µ.3 (iii)  *Yij* = µ + α*j* + π*i* + ε*ij* (*i* = 1, . . . ,

14; *j* = 1, . . . , 3)

e. (i) *t* test for dependent samples (ii)  *H*0: µ.1 ≤ µ.2, where µ.1 and µ.2 denote the

population means for English-Canadian and French-Canadian students, respectively.

(iii) *Yij* = µ + α*j* + π*i* + ε*ij* (*i* = 1, . . . , 50; *j* = 1, 2)

f. (i) CRF-62 design (ii)  *H*0: µ1. = µ2. = . . . = µ6.; *H*0: µ.1 = µ.2 ; *H*0: µ*jk* - µ*jk*!

– µ *j*!*k* + µ *j*! *k*! = 0 for all *j* and *k* (iii)  *Yijk* = µ + α*j* + β*k* + (αβ)*jk* + ε*i*(*jk*) (*i* = 1, . . . ,

50; *j* = 1, . . . , 6; *k* = 1, 2)

g. (i) CR-3 design (ii)  *H*0: µ1 = µ2 = µ3 (iii) *Yij* = µ + α*j* + ε*i*(*j*) (*i* = 1, . . . , 30; *j*

= 1, . . . , 3)

3. a. The grand mean is the average value around which the treatment means vary.

b. A treatment effect is the deviation of the grand mean from a treatment mean.

c. An error effect is all effects not attributable to a treatment level or treatment   
 combination.

4. b. A completely randomized design is the simplest design to lay out and analyze. The   
 randomization procedures for the randomized block and Latin square designs are more   
 complex than those for the completely randomized design, but the latter designs enable   
 a researcher to isolate the effects of one nuisance variable or, in the case of the Latin   
 square design, two nuisance variables.

5. c.  *a*1*b*1, *a*1*b*2, *a*1*b*3, *a*2*b*1, *a*2*b*2, *a*2*b*3, *a*3*b*1, *a*3*b*2, *a*3*b*3

d.  *a*1*b*1, *a*1*b*2, *a*2*b*1, *a*2*b*2, *a*3*b*1, *a*3*b*2, *a*4*b*1, *a*4*b*2

e.  *a*1*b*1*c*1, *a*1*b*1*c*2, *a*1*b*2*c*1, *a*1*b*2*c*2, *a*2*b*1*c*1, *a*2*b*1*c*2, *a*2*b*2*c*1, *a*2*b*2*c*2, *a*3*b*1*c*1, *a*3*b*1*c*2, *a*3*b*2*c*1,   
 *a*3*b*2*c*2

3

Chapter 2 Experimental Designs: An Overview

6. d. CR-5 design with *n* = 6

Group1

Group2

Group3

Group4

Group5

!

"

#

!

"

#

!

"

#

!

"

#

!

"

#

Subject1



Subject6

Subject1



Subject6

Subject1



Subject6

Subject1



Subject6

Subject1



Subject6

Treat. Dep.

Level Var.

*a*1 *Y*11

 

*a*1 *Y*61

Y. 1

*a*2 *Y*12

 

*a*2 *Y*62

Y. 2

*a*3 *Y*13

 

*a*3 *Y*63

Y. 3

*a*4 *Y*14

 

*a*4 *Y*64

Y. 4

*a*5 *Y*15

 

*a*5 *Y*65

Y. 5

e.  *t* test for dependent samples with *n* = 7

Treat. Dep. Treat. Dep.

Level Var. Level Var.

Block1 *a*1 *Y*11 *a*2 *Y*12

Block2 *a*1 *Y*21 *a*2 *Y*22

Block3 *a*1 *Y*31 *a*2 *Y*32

    

Block7 *a*1 *Y*71 *a*2 *Y*7 2

Y. 1 Y. 2

4

Chapter 2 Experimental Designs: An Overview

f. RB-4 design with *n* = 6

Treat. Dep. Treat. Dep. Treat. Dep. Treat. Dep.

Level Var. Level Var. Level Var. Level Var.

Block1 *a*1 *Y*11

Block2 *a*1 *Y*21

Block3 *a*1 *Y*31

  

Block6 *a*1 *Y*61

Y. 1

*a*2 *Y*12 *a*3

*a*2 *Y*22 *a*3

*a*2 *Y*32 *a*3

  

*a*2 *Y*62 *a*3

Y. 2

*Y*13 *a*4 *Y*14 Y

*Y*23 *a*4 *Y*24 Y

*Y*33 *a*4 *Y*34 Y

   

*Y*63 *a*4 *Y*64 Y

Y. 3 Y. 4

1.

2.

3.

6.

g. CRF-222 design with *n* = 3

Group1

! Subject1

#

" Subject2

Treat. Dep.

Comb. Var.

*a*1*b*1*c*1 *Y*1111

*a*1*b*1*c Y*2111

#

$

Group2

Group3

Group8

Subject3

! ubject1# S

" Subject2

#

$ Subject3

! ubject1# S

" Subject2

#

$ Subject3



! ubject1# S

" Subject2

1

*a*1*b*1*c*1 *Y*3111

Y .111

*a*1*b*1*c*2 *Y*1112

*a*1*b*1*c*2 *Y*2112

*a*1*b*1*c*2 *Y*3112

Y. 112

*a*1*b*2*c*1 *Y*1121

*a*1*b*2*c*1 *Y*2121

*a*1*b*2*c*1 *Y*3121

Y .121

 

*a*2*b*2*c*2 *Y*1222

*a*2*b*2*c*2 *Y*2222

#

$ Subject3

*a*2*b*2*c*2 *Y*3222

Y. 222

5

Chapter 2 Experimental Designs: An Overview

h. LS-3 design with *n* = 3

! Subject1

Treat. Dep.

Comb. Var.

*a*1*b*1*c*1 *Y*1111

Group1

Group2

#

" Subject2

#

$ Subject3

! ubject1# S

" Subject2

*a*1*b*1*c Y*2111

1

*a*1*b*1*c*1 *Y*3111

Y .111

*a*1*b*2*c*3 *Y*1123

*a*1*b*2*c*3 *Y*2123

#

$

!

Subject3

ubject1

*a*1*b*2*c*3 *Y*3123

Y. 123

*a*1*b*3*c*2 *Y*1132

Group3

# S

" Subject2

*a*1*b*3*c*2 *Y*2132

#

$

!

Subject3

ubject1

*a*1*b*3*c*2 *Y*3132

Y. 132

*a*2*b*1*c*2 *Y*1212

Group4

# S

" Subject2

*a*2*b*1*c*2 *Y*2212

#

$

!

Subject3



ubject1

*a*2*b*1*c*2 *Y*3212

Y. 212

 

*a*3*b*3*c*1 *Y*1331

Group9

# S

" ubject2# S

$

*a*3*b*3*c*1 *Y*2331

Subject3 *a*3*b*3*c*1 *Y*3331

Y. 331

6

Chapter 2 Experimental Designs: An Overview

8. d. RB-3 design with *n* = 14

Treat. Dep. Treat. Dep. Treat. Dep.

Level Var. Level Var. Level Var.

Block1 *a*1 *Y*11

Block2 *a*1 *Y*21

Block3 *a*1 *Y*31

  

Block14 *a*1 *Y*14, 1

Y. 1

*a*2 *Y*12 *a*3 *Y*13 Y

*a*2 *Y*22 *a*3 *Y*23 Y

*a*2 *Y*32 *a*3 *Y*33 Y

    

*a*2 *Y*14, 2 *a*3 *Y*14, 3 Y

Y. 2 Y. 3

1.

2.

3.

14.

e.  *t* test for dependent samples with *n*1 and *n*2 = 50

Treat. Dep. Treat. Dep.

Level Var. Level Var.

Block1 *a*1 *Y*11 *a*2 *Y*12

Block2 *a*1 *Y*21 *a*2 *Y*22

Block3 *a*1 *Y*31 *a*2 *Y*32

    

Block50 *a*1 *Y*50, 1 *a*2 *Y*50, 2

Y. 1 Y. 2

7

Chapter 2 Experimental Designs: An Overview

f. CRF-62 design with *n* = 50

Group1

Group2

Group3

!

#

"

#$

!

#

"

#$

!

#

"

#

Subject1



Subject50

Subject1



Subject50

Subject1



Treat. Dep.

Comb. Var.

*a*1*b*1 *Y*111

 

*a*1*b*1 *Y*50, 11

Y. 11

*a*1*b*2 *Y*112





*a*1*b*2 *Y*50, 12

Y. 12

*a*2*b*1 *Y*121





*Y*50, 21

Group4

Group12

$

!

#

"

#$

!

#

"

#

Subject50

Subject1



Subject50



Subject1



*a*2*b*1

*a*2*b*2



*a*2*b*2



*a*6*b*2



Y. 21

*Y*122



*Y*50, 22

Y. 22



*Y*162



*Y*50, 62

$ Subject50

*a*6*b*2

Y. 62

8

Chapter 2 Experimental Designs: An Overview

g. CR-3 design with *n* = 30

Group1

Group2

#

"

#

#

"

#

Animal1



Animal30

Animal1



Treat. Dep.

Level Var.

*a*1 *Y*11

 

*a*1 *Y*30,1

Y. 1

*a*2 *Y*12

 

*Y*30,

Group3

9. a.

9

8

7

6

5

4

#

"

#

*b*

Animal30

Animal1



Animal30

*b b*

*a*2

*a*3



*a*3

*a*1

*a*2   
*a*3

2

Y. 2

*Y*13



*Y*30,3

Y. 3

9

8

7

6

5

4

*b*1

*b*2

*b*3

*a*1 *a*

1 2 3

10 hrs. 15 hrs. 20 hrs.

Hours of deprivation

2 *a*3

Small Medium Large   
Magnitude of reinforcement

b. As the number of hours of deprivation increases, the difference in running time among   
 the three reinforcement conditions decreases.

12. a. A scientific hypothesis is a testable supposition that is tentatively adopted to account   
 for certain facts and to guide in the investigation of others. A statistical hypothesis is a   
 statement about one or more parameters of a population or the functional form of a   
 population.

b. (i) Alternative hypothesis (ii) Null hypothesis

15. a. State the null and alternative hypotheses—*H*0: µ = 45, *H*1: µ ≠ 45. Specify the test   
 statistic—*t* = (*Y* ! µ0 ) / ( " / *n* ) . Specify the sample size—*n* = 27, and the sampling   
 distribution—*t* distribution. Specify the level of significance—α = .05. Obtain random

9

Chapter 2 Experimental Designs: An Overview

samples of size *n* = 27, compute *t*, and make a decision.

b. Reject the null hypothesis if *t* falls in either the lower or upper 2.5% of the sampling   
 distribution of *t*; otherwise, do not reject the null hypothesis. If the null hypothesis is   
 rejected, conclude that the mean for children in the experimental program is not equal   
 to the mean for ninth-graders who have been observed during the past several years; if   
 the null hypothesis is not rejected, do not draw this conclusion.

c.

Critical region Critical region

*f* (*t*) ! = .025 ! = .025

*t*

Reject Don't reject *H*0 Reject

*H*0 *H*0

*Y*!µ0 52.5! 45.0 7.5

d. *t*= = = = 2.60, *p* = .015.

"/ *n* 15/ 27 2.89

The population mean for children in the experimental program was not equal to the   
mean for ninth-graders who have been observed during the past several years. The   
difference between children who did or did not participate in the experimental program,

52.5 versus 45.0, was statistically significant, *t*(26) = 2.60, *p* = .015.

e. d= 52.5 ! 45 / 15 = 0.5 ; this is a medium size effect.

"

f.

*t*.05/2, 26 *t*.05/2, 26 "

*Y*! <µ<*Y*+

*n n*

2.056(15) 2.056(15)

52.5 ! <µ <52.5+

27 27

46.6 < µ < 58.4

The researcher can be 95% confident that µis greater than 46.6 or less than 58.4. The

null hypothesis is not tenable.

g.

*t*.05/2, 26 !

*Y*.05 =µ0 + = 45 +

*n*

*Y*.05 !µ" 50.935!52.5

2.056(15)

= 50.935

27

*t*= = = ~~!~~~~1.565~~ = !0.54

#/ *n* 15/ 27 2.887

TDIS(0.54,26,1) =.30 = !ˆ ; 1 - !ˆ =.70

10

Chapter 2 Experimental Designs: An Overview

h.

True Situation

µ = 45 µ! = 52.5

Correct acceptance Type II error

1 - α = 1 - .05 ˆ

µ = 45 ! = .30

Researcher’s   
 Decision

µ ≠ 45

= .95

Type I error Correct rejection

ˆ

α = .05 1 - ! = 1 - .30

= .70

16. c. Correct rejection   
 e. Correct rejection

d. Correct acceptance

f. Type I error

17. The power of an experiment can be increased by (1) adopting a lower level of

significance, (2) increasing the size of the sample, (3) refining the experimental

methodology so as to decrease the size of the population standard deviation, and (4) increasing the magnitude of the treatment effects considered worth detecting. Increasing the sample size is often the simplest way to increase power. The other ways of increasing power may lead to problems or may not be feasible. For example, the adoption of α > .05 may preclude the publication of the research. Refining the experimental methodology so as to decrease the size of the population standard deviation may be prohibitively expensive. Increasing the magnitude of the treatment effects considered worth detecting may not be appropriate.

18. a. State the null and alternative hypotheses—*H*0: µ1 - µ2 ≤ 0, *H*1: µ1 - µ2 > 0. Specify the

test statistic—*t* = (*Y*.1!*Y*.2)/ "

2 # 1

Pooled %

1 &

+   
 ( . Specify the sample size—*n*1 = 24, *n*2

$ *n*1 *n*2'

= 23, and the sampling distribution—*t* distribution. Specify the level of significance—α   
= .05. Randomly assign *N* = 47 subjects to the two game types, compute *t*, and make a   
decision.

b. Reject the null hypothesis if *t* falls in the upper 5% of the sampling distribution of *t*;   
 otherwise, do not reject the null hypothesis. If the null hypothesis is rejected, conclude   
 that the risk-related cognitions of men who play racing video games is higher than that   
 for the men who play the neutral games; if the null hypothesis is not rejected, do not   
 draw this conclusion.

11

Chapter 2 Experimental Designs: An Overview

c.

Critical region

f(*t*) ! = .05

*t*

Reject Don't reject *H*0

*H*0

2 2

(n1"1)!2 +(n2 "1)! (23 " 1)(1.2)

d. !2ooled =

(n1"1)+ (n2 "1)

2 # 1

2

1

=(24"1)(1.3)2 +   
 (24 " 1) + (23 " 1)

& "

= 1.568

1 1 %

*t* = (*Y*.1!*Y*.2)/ "

Pooled

+

%

$ *n*1

= (7.54 ! 6.41) / 1.568 +

( $ '

*n*2' # 24 23&

= 1.13 / 0.365 = 3.09 . The *p* value is less than .002.

The mean risk-related cognitions for men who played the racing video games was higher than that for the men who played the neutral games. The difference between the means, 7.54 versus 6.41, was statistically significant, *t*(45) = 3.09, *p* < .002.

e. *g*= *Y*.1 !*Y*.2 / "Pooled =

7.54 ! 6.41 / 1.25 = 0.90 ; this is a large effect.

2 # 1 1 &

f. (*Y*.1 ! *Y*.2 ) ! *t*.05,45 "

Pooled %

+

( <µ1 !µ2

$ *n*1 *n*2'