

*Multivariate Analysis for the Behavioral Sciences,*  
Second Edition (Chapman and Hall/CRC, 2019)

**Exercises of Chapter 16:**  
**Confirmatory Factor Analysis and Structural**  
**Equation Models**

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**Exercises**

**Exercise 16.1**

Use the matrix **R** below, modifying the related R code given in the **Examples of Chapter 16**. (See also Exercise 15.4.)

```
R <- c(
  1.00,-0.04, 0.61, 0.45, 0.03,-0.29,-0.30, 0.45, 0.30,
-0.04, 1.00,-0.07,-0.12, 0.49, 0.43, 0.30,-0.31,-0.17,
  0.61,-0.07, 1.00, 0.59, 0.03,-0.13,-0.24, 0.59, 0.32,
  0.45,-0.12, 0.59, 1.00,-0.08,-0.21,-0.19, 0.63, 0.37,
  0.03, 0.49, 0.03,-0.08, 1.00, 0.47, 0.41,-0.14,-0.24,
-0.29, 0.43,-0.13,-0.21, 0.47, 1.00, 0.63,-0.13,-0.15,
-0.30, 0.30,-0.24,-0.19, 0.41, 0.63, 1.00,-0.26,-0.29,
  0.45,-0.31, 0.59, 0.63,-0.14,-0.13,-0.26, 1.00, 0.40,
  0.30,-0.17, 0.32, 0.37,-0.24,-0.15,-0.29, 0.40, 1.00
)
R <- matrix(R, ncol = 9, byrow = TRUE)
R
```

| ## |      | [,1]  | [,2]  | [,3]  | [,4]  | [,5]  | [,6]  | [,7]  | [,8]  | [,9]  |
|----|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| ## | [1,] | 1.00  | -0.04 | 0.61  | 0.45  | 0.03  | -0.29 | -0.30 | 0.45  | 0.30  |
| ## | [2,] | -0.04 | 1.00  | -0.07 | -0.12 | 0.49  | 0.43  | 0.30  | -0.31 | -0.17 |
| ## | [3,] | 0.61  | -0.07 | 1.00  | 0.59  | 0.03  | -0.13 | -0.24 | 0.59  | 0.32  |
| ## | [4,] | 0.45  | -0.12 | 0.59  | 1.00  | -0.08 | -0.21 | -0.19 | 0.63  | 0.37  |
| ## | [5,] | 0.03  | 0.49  | 0.03  | -0.08 | 1.00  | 0.47  | 0.41  | -0.14 | -0.24 |
| ## | [6,] | -0.29 | 0.43  | -0.13 | -0.21 | 0.47  | 1.00  | 0.63  | -0.13 | -0.15 |
| ## | [7,] | -0.30 | 0.30  | -0.24 | -0.19 | 0.41  | 0.63  | 1.00  | -0.26 | -0.29 |
| ## | [8,] | 0.45  | -0.31 | 0.59  | 0.63  | -0.14 | -0.13 | -0.26 | 1.00  | 0.40  |
| ## | [9,] | 0.30  | -0.17 | 0.32  | 0.37  | -0.24 | -0.15 | -0.29 | 0.40  | 1.00  |

## Exercise 16.2

Use the matrices below, modifying the related R code given in the **Examples of Chapter 16**.

**Source of data:** Yule, W., Berger, M., Butler, S., Newham, V. and Tizard, J. (1969). The WPPSI: An empirical evaluation with a British sample. *British Journal of Educational Psychology*, 39, 1–13.

```
#install.packages("lavaan")
library(lavaan)
```

```
## This is lavaan 0.6-3
```

```
## lavaan is BETA software! Please report any bugs.
```

```
# 'good' readers:
goodCov <- getCov('
  6.92
  2.75 6.55
  2.23 1.86 6.50
  1.62 1.55 1.88 5.20
  2.45 2.23 1.77 1.14 3.72
 -0.28 0.78 1.24 1.31 0.85 4.84
  0.63 1.36 1.24 0.99 1.06 2.27 7.02
 -0.64 -0.34 0.59 0.38 0.78 1.70 2.41 6.00
  1.07 0.20 1.67 1.50 1.34 0.23 1.00 2.55 8.76
  0.63 0.97 2.36 1.96 1.09 1.32 2.81 2.38 2.20 5.06 ')

# 'poor' readers:
poorCov <- getCov('
  9.06
  6.12 10.05
  4.76 4.43 5.71
  3.90 4.11 2.42 5.62
  5.36 6.10 3.88 3.06 7.95
  3.05 2.01 2.12 2.45 1.27 6.97
  4.07 3.86 3.28 2.40 3.18 2.53 5.43
  4.08 3.28 2.42 1.59 3.52 1.61 3.86 8.70
  3.54 2.45 2.96 1.69 3.08 0.82 1.64 3.69 9.55
  3.43 4.29 3.13 2.05 2.83 3.06 3.17 4.70 2.97 5.95 ')

```

### Exercise 16.3

Use the matrix R below, modifying the related R code given in the **Examples of Chapter 16**.

**Source of data:** Smith, D. A. and Patterson, E. B. (1984). Applications and a generalization of MIMIC models to criminological research. *Journal of Research in Crime and Delinquency*, 21, 333–352.

```
#install.packages("lavaan")
library(lavaan)

R <- cov2cor(getCov('
  1.00
  0.58 1.00
  0.54 0.60 1.00
  0.17 0.24 0.25 1.00
-0.01 -0.14 -0.13 -0.18 1.00
-0.02 -0.09 -0.09 -0.15 0.24 1.00
  0.22 0.22 0.18 0.17 -0.03 -0.10 1.00 '))

varNames <- c("Robbery", "Burglary", "Vandalism", "Prior V", "Age", "Female", "VRATE")
dimnames(R) <- list(varNames, varNames)
R
```

| ##           | Robbery | Burglary | Vandalism | Prior V | Age   | Female | VRATE |
|--------------|---------|----------|-----------|---------|-------|--------|-------|
| ## Robbery   | 1.00    | 0.58     | 0.54      | 0.17    | -0.01 | -0.02  | 0.22  |
| ## Burglary  | 0.58    | 1.00     | 0.60      | 0.24    | -0.14 | -0.09  | 0.22  |
| ## Vandalism | 0.54    | 0.60     | 1.00      | 0.25    | -0.13 | -0.09  | 0.18  |
| ## Prior V   | 0.17    | 0.24     | 0.25      | 1.00    | -0.18 | -0.15  | 0.17  |
| ## Age       | -0.01   | -0.14    | -0.13     | -0.18   | 1.00  | 0.24   | -0.03 |
| ## Female    | -0.02   | -0.09    | -0.09     | -0.15   | 0.24  | 1.00   | -0.10 |
| ## VRATE     | 0.22    | 0.22     | 0.18      | 0.17    | -0.03 | -0.10  | 1.00  |