Advanced Measurement Theory Course Notebook

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Contents

Introduction to the Course

Welcome to Advanced Measurement Theory!

Chapter 1

Classic Test Theory

In the notes for this chapter, I demonstrate aspects of classical test theory, reliability and generalizability theory using data from a study exploring the motivation of R package authors (Mair et al., 2015). This tutorial is based on Chapter 1 of Mair (2018), which can be consulted for a more indepth exposition of the underlying theory. Here I focus on demonstrating some of those concepts in R, as well as describing how to get certain results in R.

First, I load the packages used in this tutorial:

```
# Packages used:
library(psych)
library(MPsychoR)
```

Next, I load the full data set from the `MPsychoR` package (Mair, 2020), then as in the chapter, I subset the data to only include hybrid motivation items, followed by removing rows with missing values.

```
data("Rmotivation")

# Create data frame with only Hybrid Motivation items.
HybMot <- subset(Rmotivation,
                         select = grep("hyb", names(Rmotivation)))
# Remove rows  with any missing data.
HybMot <- na.omit(HybMot)
```

This leads to a data set with 777 authors and 19 items.

```
# How many authors(rows) and items(columns)?
dim(HybMot)
```

```
[1] 777  19
```

```
# Note they are all dichotomous items.
head(HybMot)
```

```
  hyb1 hyb2 hyb3 hyb4 hyb5 hyb6 hyb7 hyb8 hyb9 hyb10 hyb11
1    1    0    1    0    1    1    0    0    0     1     1
3    0    0    1    0    1    0    0    0    0     1     0
4    1    1    1    1    1    0    1    0    0     1     0
5    1    0    0    1    1    0    0    0    0     1     1
8    1    1    1    1    1    1    1    1    1     1     0
9    1    0    0    1    1    0    0    0    0     1     0
  hyb12 hyb13 hyb14 hyb15 hyb16 hyb17 hyb18 hyb19
1     1     1     0     1     1     1     1     1
3     1     1     0     1     0     0     1     0
4     1     1     0     0     1     1     1     1
5     1     1     0     1     0     1     1     1
8     1     1     1     1     1     1     1     1
9     0     1     0     0     1     1     1     1
```

```
vcmat <- cov(HybMot)

scroll_box(kable(vcmat, digits = 2), width = "100%")
```

	hyb1	hyb2	hyb3	hyb4	hyb5	hyb6	hyb7	hyb8	hyb9	hyb10	hyb11	hyb12
hyb1	0.18	0.06	0.04	0.03	0.03	0.05	0.01	0.05	0.04	0.04	0.03	0.03
hyb2	0.06	0.25	0.06	0.05	0.03	0.05	-0.01	0.04	0.05	0.02	0.04	0.04
hyb3	0.04	0.06	0.23	0.13	0.03	0.05	0.00	0.03	0.05	0.04	0.05	0.06
hyb4	0.03	0.05	0.13	0.21	0.03	0.04	0.01	0.03	0.04	0.03	0.05	0.05
hyb5	0.03	0.03	0.03	0.03	0.11	0.02	0.00	0.01	0.01	0.03	0.03	0.03
hyb6	0.05	0.05	0.05	0.04	0.02	0.24	0.01	0.11	0.15	0.05	0.06	0.06
hyb7	0.01	-0.01	0.00	0.01	0.00	0.01	0.22	0.04	0.01	0.03	0.00	0.02
hyb8	0.05	0.04	0.03	0.03	0.01	0.11	0.04	0.25	0.10	0.06	0.05	0.06
hyb9	0.04	0.05	0.05	0.04	0.01	0.15	0.01	0.10	0.20	0.04	0.04	0.05
hyb10	0.04	0.02	0.04	0.03	0.03	0.05	0.03	0.06	0.04	0.15	0.03	0.06
hyb11	0.03	0.04	0.05	0.05	0.03	0.06	0.00	0.05	0.04	0.03	0.23	0.10
hyb12	0.03	0.04	0.06	0.05	0.03	0.06	0.02	0.06	0.05	0.06	0.10	0.23
hyb13	0.03	0.03	0.02	0.02	0.03	0.02	0.00	0.02	0.01	0.03	0.03	0.04
hyb14	0.03	0.03	0.02	0.02	0.02	0.07	0.00	0.04	0.05	0.02	0.04	0.03
hyb15	0.04	0.03	0.06	0.04	0.04	0.06	0.01	0.06	0.04	0.04	0.10	0.11
hyb16	0.05	0.03	0.02	0.02	0.02	0.05	0.02	0.05	0.04	0.04	0.03	0.04
hyb17	0.04	0.01	0.03	0.03	0.02	0.05	0.02	0.05	0.03	0.04	0.03	0.03
hyb18	0.03	0.00	0.02	0.02	0.01	0.02	0.01	0.03	0.01	0.03	0.01	0.02
hyb19	0.06	0.03	0.04	0.04	0.03	0.07	0.02	0.06	0.05	0.05	0.02	0.04

```
k <- ncol(HybMot)
sigma2_Xi <- tr(vcmat) # trace of matrix or sum(diag(vmat))
sigma2_X <- sum(vcmat)
```

1.1 Classical True Score Model

The true score model is:

$$X = T + E$$

where X is the **observed score**, T is the **true score**, which is unknown, and E is the **error**

1.2 Reliability

$$\text{reliability} = \frac{\sigma_T^2}{\sigma_X^2} = \frac{\sigma_T^2}{\sigma_T^2 + \sigma_E^2} = \rho_{XT}^2$$

1.2.1 Cronbach's α

1.2.2 Other Reliability Coefficients

1.3 Generalizability Theory

1.3.1 Reliability and Generalizability

1.3.2 Multiple Sources of Error

Chapter 2

Factor Analysis

Chapter 3

Path Analysis and Structural Equation Modeling

We describe our methods in this chapter.

Chapter 4

Item Response Theory

Some *significant* applications are demonstrated in this chapter.

4.1 Example one

4.2 Example two

Chapter 5

Principal Components Analysis

We have finished a nice book.

Chapter 6

Correspondence Analysis

Chapter 7

Gifi Methods

Chapter 8

Multidimensional Scaling

Chapter 9

Graphing Multidimensional Data

Chapter 10

Networks

Chapter 11

Modeling Trajectories and Time Series

Bibliography

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