

R Workshop: Factor Analysis

Brier Gallihugh, M.S.

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Creating Data

```
library(tidyverse)
library(pastecs)
library(GPArotation)
library(psych)
set.seed(10311993)

data <- psych::bfi ①

proposed_scale <- psych::bfi[,1:15]

proposed_scale <- proposed_scale %>% na.omit()

proposed_scale <- proposed_scale[sample(nrow(proposed_scale), size=500),]

cor_proposed_scale <- cor(proposed_scale, use = "pairwise.complete.obs")②

apaTables::apa.cor.table(cor_proposed_scale,filename = "CorTable.doc") ③
```

```
# For Readability
round(cor(proposed_scale, use = "pairwise.complete.obs"),2)
```

④

- ① Create a data set using the `bfi` dataset in the `psych` package
- ② Create a correlation matrix of the `bfi` items using the `cor()` function
- ③ Create an APA Style correlation output within Word
- ④ Round correlation matrix to 2 decimal places for readability in R

Means, standard deviations, and correlations with confidence intervals

| Variable | M | SD | 1 | 2 | 3 | 4 |
|----------|-------|------|------------------------|-----------------------|---------------------|-----------------------|
| 1. A1 | 0.01 | 0.32 | | | | |
| 2. A2 | 0.17 | 0.36 | -.77** [-.92, -.43] | | | |
| 3. A3 | 0.18 | 0.37 | -.73** [-.91, -.35] | .85** [.59, .95] | | |
| 4. A4 | 0.15 | 0.32 | -.60* [-.85, -.13] | .72** [.32, .90] | .69** [.28, .89] | |
| 5. A5 | 0.18 | 0.37 | -.65** [-.87, -.21] | .77** [.43, .92] | .90** [.73, .97] | .70** [.30, .89] |
| 6. C1 | 0.12 | 0.33 | -.20 [-.65, .35] | .36 [-.19, .73] | .23 [-.32, .66] | .31 [-.24, .71] |
| 7. C2 | 0.15 | 0.33 | -.24 [-.67, .31] | .38 [-.17, .75] | .21 [-.34, .65] | .38 [-.16, .75] |
| 8. C3 | 0.12 | 0.32 | -.28 [-.69, .28] | .34 [-.21, .73] | .18 [-.37, .63] | .22 [-.33, .66] |
| 9. C4 | -0.01 | 0.38 | .33 [-.22, .72] | -.57* [-.84, -.08] | -.43 [-.77, .11] | -.54* [-.82, -.03] |
| 10. C5 | -0.01 | 0.36 | .33 [-.22, .72] | -.57* [-.84, -.08] | -.49 [-.80, .03] | -.61* [-.86, -.14] |

| | | | | | | | |
|--------|-------|------|------|-------------|--------------|--------------|--------------|
| 11. E1 | -0.02 | 0.38 | .42 | | -.71** | -.75** | -.61* |
| | | | | [-.11, .77] | [-.89, -.30] | [-.91, -.40] | [-.85, -.13] |
| 12. E2 | -0.03 | 0.41 | .43 | | -.72** | -.77** | -.65** |
| | | | | [-.10, .77] | [-.90, -.33] | [-.92, -.42] | [-.87, -.20] |
| 13. E3 | 0.17 | 0.37 | -.47 | | .69** | .80** | .62* |
| | | | | [-.79, .05] | [.28, .89] | [.48, .93] | [.15, .86] |
| 14. E4 | 0.14 | 0.39 | -.45 | | .66** | .75** | .64** |
| | | | | [-.78, .08] | [.22, .88] | [.39, .91] | [.19, .87] |
| 15. E5 | 0.15 | 0.35 | -.35 | | .67** | .58* | .57* |
| | | | | [-.73, .19] | [.24, .88] | [.10, .84] | [.08, .84] |
| 5 | 6 | 7 | 8 | 9 | 10 | | |

.24
[-.31, .67]

.18 .78**
[-.37, .63] [.44, .92]

.15 .66** .74**
[-.39, .62] [.22, .87] [.38, .91]

-.45 -.81** -.85** -.77**
[-.78, .08] [-.93, -.50] [-.95, -.60] [-.92, -.42]

-.49 -.75** -.76** -.70** .86**

| | | | | | |
|--------------|--------------|--------------|--------------|--------------|--------------|
| [-.80, .03] | [-.91, -.38] | [-.92, -.41] | [-.89, -.30] | [.63, .95] | |
| -.79** | -.32 | -.20 | -.12 | .39 | .39 |
| [-.93, -.46] | [-.71, .23] | [-.65, .35] | [-.60, .42] | [-.15, .75] | [-.15, .75] |
| -.81** | -.40 | -.28 | -.20 | .49 | .54* |
| [-.93, -.50] | [-.76, .14] | [-.70, .27] | [-.65, .35] | [-.03, .80] | [.04, .83] |
| .83** | .30 | .21 | .10 | -.41 | -.51 |
| [.55, .94] | [-.25, .70] | [-.34, .65] | [-.44, .58] | [-.76, .13] | [-.81, .01] |
| .84** | .30 | .18 | .11 | -.41 | -.49 |
| [.58, .95] | [-.25, .70] | [-.37, .63] | [-.43, .59] | [-.76, .12] | [-.80, .03] |
| .59* | .52* | .55* | .47 | -.70** | -.69** |
| [.10, .84] | [.01, .81] | [.06, .83] | [-.06, .79] | [-.89, -.30] | [-.89, -.27] |
| 11 | 12 | 13 | 14 | | |

.89**
[.70, .96]

-.86** -.89**
[-.95, -.62] [-.96, -.70]

-.88** -.93** .86**
[-.96, -.66] [-.98, -.80] [.61, .95]

-.72** -.78** .69** .64*
[-.90, -.34] [-.92, -.45] [.28, .89] [.18, .87]

Note. M and SD are used to represent mean and standard deviation, respectively.
Values in square brackets indicate the 95% confidence interval.
The confidence interval is a plausible range of population correlations
that could have caused the sample correlation (Cumming, 2014).
* indicates $p < .05$. ** indicates $p < .01$.

| | A1 | A2 | A3 | A4 | A5 | C1 | C2 | C3 | C4 | C5 | E1 | E2 |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| A1 | 1.00 | -0.36 | -0.31 | -0.19 | -0.23 | 0.00 | -0.02 | -0.08 | 0.12 | 0.10 | 0.13 | 0.14 |
| A2 | -0.36 | 1.00 | 0.51 | 0.35 | 0.40 | 0.14 | 0.20 | 0.19 | -0.20 | -0.16 | -0.26 | -0.26 |
| A3 | -0.31 | 0.51 | 1.00 | 0.33 | 0.59 | 0.08 | 0.11 | 0.10 | -0.09 | -0.14 | -0.28 | -0.29 |
| A4 | -0.19 | 0.35 | 0.33 | 1.00 | 0.35 | 0.10 | 0.22 | 0.06 | -0.16 | -0.23 | -0.16 | -0.19 |
| A5 | -0.23 | 0.40 | 0.59 | 0.35 | 1.00 | 0.09 | 0.07 | 0.09 | -0.14 | -0.13 | -0.29 | -0.31 |
| C1 | 0.00 | 0.14 | 0.08 | 0.10 | 0.09 | 1.00 | 0.44 | 0.32 | -0.38 | -0.32 | -0.09 | -0.13 |
| C2 | -0.02 | 0.20 | 0.11 | 0.22 | 0.07 | 0.44 | 1.00 | 0.41 | -0.42 | -0.31 | 0.02 | -0.02 |
| C3 | -0.08 | 0.19 | 0.10 | 0.06 | 0.09 | 0.32 | 0.41 | 1.00 | -0.35 | -0.30 | 0.04 | 0.01 |
| C4 | 0.12 | -0.20 | -0.09 | -0.16 | -0.14 | -0.38 | -0.42 | -0.35 | 1.00 | 0.52 | 0.16 | 0.22 |
| C5 | 0.10 | -0.16 | -0.14 | -0.23 | -0.13 | -0.32 | -0.31 | -0.30 | 0.52 | 1.00 | 0.08 | 0.26 |
| E1 | 0.13 | -0.26 | -0.28 | -0.16 | -0.29 | -0.09 | 0.02 | 0.04 | 0.16 | 0.08 | 1.00 | 0.54 |
| E2 | 0.14 | -0.26 | -0.29 | -0.19 | -0.31 | -0.13 | -0.02 | 0.01 | 0.22 | 0.26 | 0.54 | 1.00 |
| E3 | -0.08 | 0.32 | 0.44 | 0.26 | 0.47 | 0.14 | 0.12 | 0.02 | -0.06 | -0.17 | -0.38 | -0.43 |
| E4 | -0.09 | 0.27 | 0.37 | 0.30 | 0.50 | 0.13 | 0.06 | 0.04 | -0.10 | -0.16 | -0.44 | -0.55 |
| E5 | 0.00 | 0.34 | 0.25 | 0.23 | 0.24 | 0.21 | 0.31 | 0.25 | -0.28 | -0.24 | -0.30 | -0.36 |

| | E3 | E4 | E5 |
|----|-------|-------|-------|
| A1 | -0.08 | -0.09 | 0.00 |
| A2 | 0.32 | 0.27 | 0.34 |
| A3 | 0.44 | 0.37 | 0.25 |
| A4 | 0.26 | 0.30 | 0.23 |
| A5 | 0.47 | 0.50 | 0.24 |
| C1 | 0.14 | 0.13 | 0.21 |
| C2 | 0.12 | 0.06 | 0.31 |
| C3 | 0.02 | 0.04 | 0.25 |
| C4 | -0.06 | -0.10 | -0.28 |
| C5 | -0.17 | -0.16 | -0.24 |
| E1 | -0.38 | -0.44 | -0.30 |
| E2 | -0.43 | -0.55 | -0.36 |
| E3 | 1.00 | 0.47 | 0.36 |
| E4 | 0.47 | 1.00 | 0.26 |
| E5 | 0.36 | 0.26 | 1.00 |

EFA Assumptions

```
#Barlett Test for New Scale
cortest.bartlett(cor_proposed_scale, n = 500)
```

①

```
#KMO for New Scale
KMO(cor_proposed_scale)
```

②

```
#Determinent for New Scale
det(cor_proposed_scale)
```

③

- ① Run a Bartlett test on the correlation matrix. Ideally, this should have a p value of less than .05
- ② Run a KMO on the proposed correlation matrix. Ideally this is greater than $KMO = .90$
- ③ Find the determinant of the correlation matrix. This should be less than .00001

```
$chisq
[1] 2225.86
```

```
$p.value
[1] 0
```

```
$df
[1] 105
```

```

Kaiser-Meyer-Olkin factor adequacy
Call: KMO(r = cor_proposed_scale)
Overall MSA = 0.82
MSA for each item =
  A1  A2  A3  A4  A5  C1  C2  C3  C4  C5  E1  E2  E3  E4  E5
0.73 0.86 0.85 0.86 0.83 0.83 0.77 0.79 0.76 0.78 0.85 0.80 0.88 0.84 0.85
[1] 0.0109611

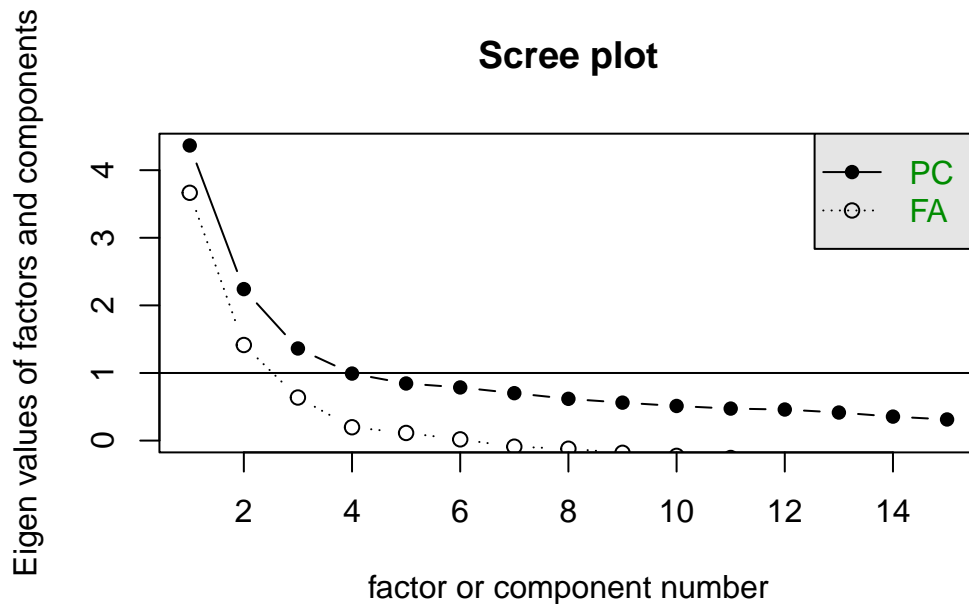
```

EFA Factor Structure

```
psych::scree(cor_proposed_scale)
```

①

- ③ Run an orthogonal rotation factor analysis using the `fa()` function
- ④ Print the output fit measures using the `print.psych()` function. The `SORT = TRUE` argument sorts the factor loading by loading magnitude.
- ⑤ Run an oblique rotation factor analysis using the `fa()` function
- ⑥ Print the output again using the `print.psych()` function

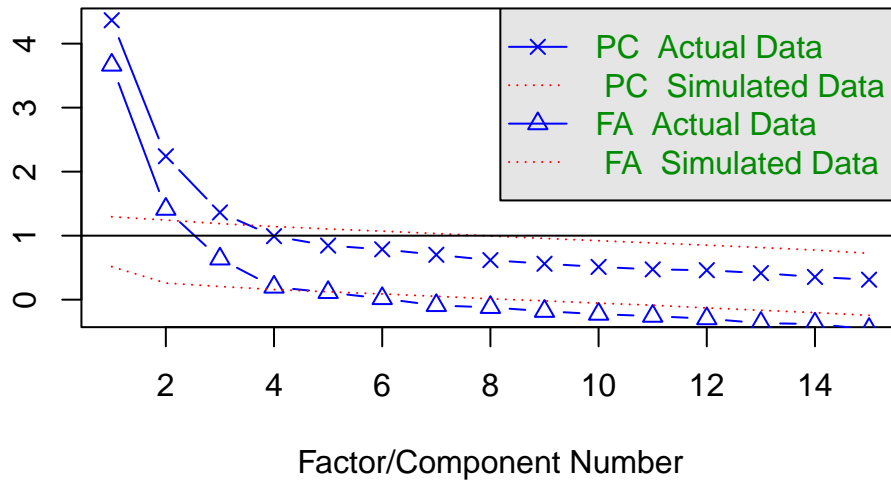


```
fa.parallel(cor_proposed_scale, n.obs = 500)
```

②

envalues of principal components and factor an

Parallel Analysis Scree Plots



```
# Suggests 4 Factor Solution
```

```
# Orthogonal (Non Correlated)
```

```
orthoFA3 <- fa(r = cor_proposed_scale, nfactors = 4, rotate = 'varimax', use = "pairwise.complete.obs")
```

```
#Show All Info
```

```
print.psych(orthoFA3, sort = TRUE)
```

④

```
# Oblique (Correlated)
```

```
obliqueFA3 <- fa(r = cor_proposed_scale, nfactors = 4, rotate = 'oblimin', use = "pairwise.complete.obs")
```

```
print.psych(obliqueFA3, sort = TRUE)
```

⑥

Parallel analysis suggests that the number of factors = 4 and the number of components = 3

Factor Analysis using method = minres

Call: fa(r = cor_proposed_scale, nfactors = 4, rotate = "varimax",
use = "pairwise.complete.obs")

Standardized loadings (pattern matrix) based upon correlation matrix

| | item | MR1 | MR2 | MR3 | MR4 | h2 | u2 | com |
|----|------|------|------|------|-------|------|------|-----|
| A3 | 3 | 0.73 | 0.05 | 0.17 | -0.19 | 0.60 | 0.40 | 1.3 |
| A5 | 5 | 0.67 | 0.05 | 0.27 | -0.07 | 0.53 | 0.47 | 1.4 |
| A2 | 2 | 0.57 | 0.21 | 0.13 | -0.28 | 0.47 | 0.53 | 1.9 |
| E3 | 13 | 0.53 | 0.07 | 0.45 | 0.16 | 0.51 | 0.49 | 2.2 |

| | | | | | | | | |
|----|----|-------|-------|-------|-------|------|------|-----|
| A4 | 4 | 0.43 | 0.19 | 0.13 | -0.11 | 0.25 | 0.75 | 1.7 |
| C2 | 7 | 0.17 | 0.70 | -0.10 | 0.12 | 0.54 | 0.46 | 1.2 |
| C4 | 9 | 0.03 | -0.69 | -0.18 | 0.23 | 0.57 | 0.43 | 1.4 |
| C1 | 6 | 0.07 | 0.56 | 0.08 | 0.08 | 0.34 | 0.66 | 1.1 |
| C5 | 10 | -0.05 | -0.56 | -0.20 | 0.15 | 0.38 | 0.62 | 1.4 |
| C3 | 8 | 0.11 | 0.55 | -0.10 | -0.03 | 0.33 | 0.67 | 1.2 |
| E5 | 15 | 0.28 | 0.38 | 0.32 | 0.10 | 0.33 | 0.67 | 3.0 |
| E2 | 12 | -0.16 | -0.10 | -0.83 | 0.11 | 0.73 | 0.27 | 1.1 |
| E1 | 11 | -0.22 | -0.01 | -0.60 | 0.07 | 0.42 | 0.58 | 1.3 |
| E4 | 14 | 0.42 | 0.05 | 0.57 | 0.08 | 0.51 | 0.49 | 1.9 |
| A1 | 1 | -0.30 | -0.02 | -0.02 | 0.56 | 0.40 | 0.60 | 1.5 |

| | MR1 | MR2 | MR3 | MR4 |
|-----------------------|------|------|------|------|
| SS loadings | 2.24 | 2.15 | 1.91 | 0.60 |
| Proportion Var | 0.15 | 0.14 | 0.13 | 0.04 |
| Cumulative Var | 0.15 | 0.29 | 0.42 | 0.46 |
| Proportion Explained | 0.32 | 0.31 | 0.28 | 0.09 |
| Cumulative Proportion | 0.32 | 0.64 | 0.91 | 1.00 |

Mean item complexity = 1.6

Test of the hypothesis that 4 factors are sufficient.

df null model = 105 with the objective function = 4.51

df of the model are 51 and the objective function was 0.3

The root mean square of the residuals (RMSR) is 0.03

The df corrected root mean square of the residuals is 0.04

Fit based upon off diagonal values = 0.99

Measures of factor score adequacy

| | MR1 | MR2 | MR3 | MR4 |
|---|------|------|------|------|
| Correlation of (regression) scores with factors | 0.87 | 0.89 | 0.88 | 0.71 |
| Multiple R square of scores with factors | 0.76 | 0.79 | 0.78 | 0.50 |
| Minimum correlation of possible factor scores | 0.51 | 0.57 | 0.56 | 0.00 |

Factor Analysis using method = minres

Call: fa(r = cor_proposed_scale, nfactors = 4, rotate = "oblimin",
use = "pairwise.complete.obs")

Standardized loadings (pattern matrix) based upon correlation matrix

| | item | MR1 | MR2 | MR3 | MR4 | h2 | u2 | com |
|----|------|------|-------|-------|-------|------|------|-----|
| A3 | 3 | 0.78 | -0.03 | -0.01 | -0.01 | 0.60 | 0.40 | 1.0 |
| A5 | 5 | 0.66 | -0.02 | -0.12 | 0.10 | 0.53 | 0.47 | 1.1 |
| A2 | 2 | 0.63 | 0.15 | 0.00 | -0.14 | 0.47 | 0.53 | 1.2 |
| A4 | 4 | 0.43 | 0.15 | -0.03 | 0.00 | 0.25 | 0.75 | 1.2 |

| | | | | | | | | |
|----|----|-------|-------|-------|-------|------|------|-----|
| E3 | 13 | 0.39 | 0.01 | -0.34 | 0.30 | 0.51 | 0.49 | 2.9 |
| C2 | 7 | 0.10 | 0.71 | 0.18 | 0.17 | 0.54 | 0.46 | 1.3 |
| C4 | 9 | 0.08 | -0.68 | 0.19 | 0.21 | 0.57 | 0.43 | 1.4 |
| C1 | 6 | -0.03 | 0.57 | -0.05 | 0.11 | 0.34 | 0.66 | 1.1 |
| C3 | 8 | 0.09 | 0.56 | 0.16 | 0.00 | 0.33 | 0.67 | 1.2 |
| C5 | 10 | 0.01 | -0.55 | 0.18 | 0.11 | 0.38 | 0.62 | 1.3 |
| E5 | 15 | 0.15 | 0.35 | -0.26 | 0.18 | 0.33 | 0.67 | 2.8 |
| E2 | 12 | 0.02 | -0.03 | 0.86 | 0.04 | 0.73 | 0.27 | 1.0 |
| E1 | 11 | -0.11 | 0.05 | 0.60 | -0.01 | 0.42 | 0.58 | 1.1 |
| E4 | 14 | 0.28 | -0.01 | -0.50 | 0.20 | 0.51 | 0.49 | 1.9 |
| A1 | 1 | -0.46 | 0.03 | -0.03 | 0.48 | 0.40 | 0.60 | 2.0 |

| | MR1 | MR2 | MR3 | MR4 |
|-----------------------|------|------|------|------|
| SS loadings | 2.33 | 2.15 | 1.89 | 0.53 |
| Proportion Var | 0.16 | 0.14 | 0.13 | 0.04 |
| Cumulative Var | 0.16 | 0.30 | 0.42 | 0.46 |
| Proportion Explained | 0.34 | 0.31 | 0.27 | 0.08 |
| Cumulative Proportion | 0.34 | 0.65 | 0.92 | 1.00 |

With factor correlations of

| | MR1 | MR2 | MR3 | MR4 |
|-----|-------|-------|-------|-------|
| MR1 | 1.00 | 0.21 | -0.44 | 0.07 |
| MR2 | 0.21 | 1.00 | -0.17 | -0.02 |
| MR3 | -0.44 | -0.17 | 1.00 | -0.08 |
| MR4 | 0.07 | -0.02 | -0.08 | 1.00 |

Mean item complexity = 1.5
 Test of the hypothesis that 4 factors are sufficient.

df null model = 105 with the objective function = 4.51
 df of the model are 51 and the objective function was 0.3

The root mean square of the residuals (RMSR) is 0.03
 The df corrected root mean square of the residuals is 0.04

Fit based upon off diagonal values = 0.99
 Measures of factor score adequacy

| | MR1 | MR2 | MR3 | MR4 |
|---|------|------|------|-------|
| Correlation of (regression) scores with factors | 0.91 | 0.89 | 0.91 | 0.70 |
| Multiple R square of scores with factors | 0.82 | 0.80 | 0.83 | 0.49 |
| Minimum correlation of possible factor scores | 0.64 | 0.60 | 0.65 | -0.02 |

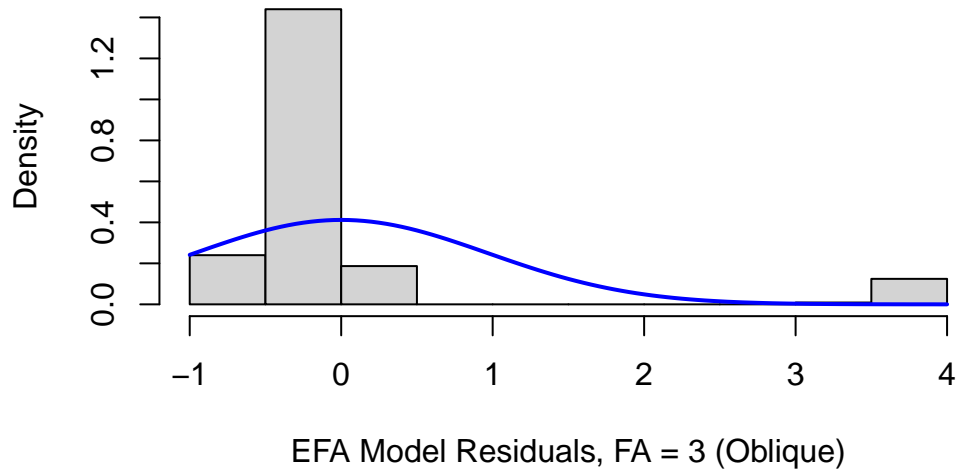
💡 Tip

More often than not, an oblique rotation will be the best fit for your data as it assumes that your items are correlated with one another

EFA Factor Structure Assumptions

```
#Standard Residuals
obliqueFA3Residuals <- scale(obliqueFA3$residual) ①
#Test Normality
shapiro.test(obliqueFA3Residuals) ②
#Histogram
hist(obliqueFA3Residuals, col = 'lightgrey', ③
      main="", xlab = "EFA Model Residuals, FA = 3 (Oblique)",
      probability = TRUE)
curve(dnorm(x, mean = mean(obliqueFA3Residuals),
                        sd = sd(obliqueFA3Residuals)),
      add = TRUE, lwd = 2, col = 'blue')
```

- ① Assess the residuals of your desired factor loading solution using the `scale()` function in combination with extracting the residuals using `object$residuals` notation.
- ② Statistical test of the factor solution residuals using the `shapiro.test()` function.
- ③ Graphical depiction of the solution residuals with a normal curve overlay in the color blue



Shapiro-Wilk normality test

data: obliqueFA3Residuals
 W = 0.46308, p-value < 2.2e-16

Calculating Reliability

```
#Items
Factor1<- c("A1","A2","A3","A4","A5")           ①
Factor2<- c("C1","C2","C3","C4","C5")           ②
Factor3<- c("E1","E2","E3","E4","E5")           ③
Overall <- c("A1","A2","A3","A4","A5","C1","C2","C3","C4","C5","E1","E2","E3","E4","E5")④

#Reliability Factor 1
psych::alpha(proposed_scale[,Factor1], check.keys = TRUE) ⑤
#Reliability Factor 2
psych::alpha(proposed_scale[, Factor2], check.keys = TRUE) ⑥
#Reliability Factor 3
psych::alpha(proposed_scale[, Factor3], check.keys = TRUE) ⑦
#Overall Reliability
psych::alpha(proposed_scale[, Overall], check.keys = TRUE) ⑧
```

- ① Create a subset of items to represent Factor 1
- ② Create a subset of items to represent Factor 2
- ③ Create a subset of items to represent Factor 3
- ④ Create a subset of items to represent Overall
- ⑤ Determine the reliability of Factor 1 using the `alpha()` function in the `psych` package.
`check.keys` ensures that items that load negatively are reverse coded.
- ⑥ Determine the reliability of Factor 2 using the `alpha()` function in the `psych` package.
`check.keys` ensures that items that load negatively are reverse coded.
- ⑦ Determine the reliability of Factor 3 using the `alpha()` function in the `psych` package.
`check.keys` ensures that items that load negatively are reverse coded.
- ⑧ Determine the reliability of Overall using the `alpha()` function in the `psych` package.
`check.keys` ensures that items that load negatively are reverse coded.

Reliability analysis

Call: `psych::alpha(x = proposed_scale[, Factor1], check.keys = TRUE)`

| raw_alpha | std.alpha | G6(smc) | average_r | S/N | ase | mean | sd | median_r |
|-----------|-----------|---------|-----------|-----|-------|------|------|----------|
| 0.73 | 0.74 | 0.72 | 0.36 | 2.8 | 0.019 | 4.7 | 0.92 | 0.35 |

95% confidence boundaries

| | lower | alpha | upper |
|----------|-------|-------|-------|
| Feldt | 0.69 | 0.73 | 0.77 |
| Duhachek | 0.69 | 0.73 | 0.77 |

Reliability if an item is dropped:

| | raw_alpha | std.alpha | G6(smc) | average_r | S/N | alpha | se | var.r | med.r |
|-----|-----------|-----------|---------|-----------|-----|-------|-------|-------|-------|
| A1- | 0.74 | 0.75 | 0.70 | 0.42 | 2.9 | 0.019 | 0.011 | 0.38 | |
| A2 | 0.66 | 0.67 | 0.63 | 0.33 | 2.0 | 0.025 | 0.019 | 0.32 | |
| A3 | 0.64 | 0.65 | 0.59 | 0.31 | 1.8 | 0.027 | 0.007 | 0.35 | |
| A4 | 0.72 | 0.73 | 0.69 | 0.40 | 2.7 | 0.021 | 0.017 | 0.38 | |
| A5 | 0.66 | 0.68 | 0.62 | 0.34 | 2.1 | 0.025 | 0.010 | 0.34 | |

Item statistics

| | n | raw.r | std.r | r.cor | r.drop | mean | sd |
|-----|-----|-------|-------|-------|--------|------|-----|
| A1- | 500 | 0.61 | 0.60 | 0.42 | 0.36 | 4.6 | 1.4 |
| A2 | 500 | 0.73 | 0.75 | 0.66 | 0.57 | 4.8 | 1.1 |
| A3 | 500 | 0.77 | 0.78 | 0.74 | 0.61 | 4.6 | 1.3 |
| A4 | 500 | 0.66 | 0.64 | 0.48 | 0.41 | 4.7 | 1.5 |
| A5 | 500 | 0.73 | 0.73 | 0.66 | 0.55 | 4.5 | 1.3 |

Non missing response frequency for each item

| 1 | 2 | 3 | 4 | 5 | 6 | miss |
|---|---|---|---|---|---|------|
|---|---|---|---|---|---|------|

| | | | | | | | |
|----|------|------|------|------|------|------|---|
| A1 | 0.33 | 0.28 | 0.14 | 0.13 | 0.10 | 0.02 | 0 |
| A2 | 0.01 | 0.05 | 0.05 | 0.19 | 0.40 | 0.30 | 0 |
| A3 | 0.03 | 0.06 | 0.08 | 0.19 | 0.36 | 0.27 | 0 |
| A4 | 0.05 | 0.07 | 0.07 | 0.16 | 0.25 | 0.41 | 0 |
| A5 | 0.03 | 0.06 | 0.09 | 0.23 | 0.33 | 0.26 | 0 |

Reliability analysis

Call: psych::alpha(x = proposed_scale[, Factor2], check.keys = TRUE)

| raw_alpha | std.alpha | G6(smc) | average_r | S/N | ase | mean | sd | median_r |
|-----------|-----------|---------|-----------|-----|-------|------|------|----------|
| 0.75 | 0.75 | 0.72 | 0.38 | 3 | 0.018 | 4.2 | 0.94 | 0.36 |

95% confidence boundaries

lower alpha upper

Feldt 0.71 0.75 0.78

Duhachek 0.71 0.75 0.78

Reliability if an item is dropped:

| | raw_alpha | std.alpha | G6(smc) | average_r | S/N | alpha | se | var.r | med.r |
|-----|-----------|-----------|---------|-----------|-----|-------|--------|-------|-------|
| C1 | 0.71 | 0.71 | 0.67 | 0.38 | 2.5 | 0.021 | 0.0064 | 0.38 | |
| C2 | 0.69 | 0.70 | 0.64 | 0.36 | 2.3 | 0.022 | 0.0061 | 0.33 | |
| C3 | 0.72 | 0.73 | 0.68 | 0.40 | 2.6 | 0.020 | 0.0060 | 0.40 | |
| C4- | 0.67 | 0.68 | 0.63 | 0.35 | 2.2 | 0.024 | 0.0035 | 0.32 | |
| C5- | 0.72 | 0.72 | 0.66 | 0.39 | 2.5 | 0.021 | 0.0021 | 0.39 | |

Item statistics

| | n | raw.r | std.r | r.cor | r.drop | mean | sd |
|-----|-----|-------|-------|-------|--------|------|-----|
| C1 | 500 | 0.67 | 0.70 | 0.57 | 0.49 | 4.5 | 1.2 |
| C2 | 500 | 0.72 | 0.73 | 0.63 | 0.54 | 4.3 | 1.3 |
| C3 | 500 | 0.66 | 0.67 | 0.54 | 0.46 | 4.3 | 1.3 |
| C4- | 500 | 0.75 | 0.75 | 0.67 | 0.59 | 4.4 | 1.3 |
| C5- | 500 | 0.73 | 0.69 | 0.58 | 0.50 | 3.6 | 1.6 |

Non missing response frequency for each item

| | 1 | 2 | 3 | 4 | 5 | 6 | miss |
|----|------|------|------|------|------|------|------|
| C1 | 0.02 | 0.04 | 0.11 | 0.22 | 0.39 | 0.21 | 0 |
| C2 | 0.03 | 0.09 | 0.10 | 0.25 | 0.34 | 0.18 | 0 |
| C3 | 0.03 | 0.08 | 0.11 | 0.27 | 0.35 | 0.16 | 0 |
| C4 | 0.24 | 0.32 | 0.18 | 0.18 | 0.07 | 0.02 | 0 |
| C5 | 0.15 | 0.19 | 0.13 | 0.24 | 0.14 | 0.13 | 0 |

Reliability analysis

Call: psych::alpha(x = proposed_scale[, Factor3], check.keys = TRUE)

```

raw_alpha std.alpha G6(smc) average_r S/N ase mean sd median_r
0.78      0.78      0.75      0.41 3.5 0.015 4.2 1.1      0.41

95% confidence boundaries
      lower alpha upper
Feldt      0.75 0.78 0.81
Duhachek 0.75 0.78 0.81

Reliability if an item is dropped:
      raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
E1-      0.74      0.73      0.69      0.41 2.8      0.019 0.0102 0.40
E2-      0.70      0.70      0.65      0.37 2.3      0.022 0.0063 0.37
E3      0.74      0.73      0.69      0.41 2.8      0.018 0.0144 0.40
E4      0.73      0.72      0.67      0.40 2.6      0.020 0.0065 0.37
E5      0.78      0.78      0.73      0.47 3.5      0.016 0.0043 0.46

Item statistics
      n raw.r std.r r.cor r.drop mean sd
E1- 500 0.75 0.73 0.63 0.56 4.0 1.6
E2- 500 0.81 0.79 0.74 0.65 3.8 1.6
E3 500 0.72 0.73 0.62 0.55 4.1 1.4
E4 500 0.75 0.75 0.67 0.59 4.4 1.5
E5 500 0.60 0.63 0.47 0.41 4.5 1.3

Non missing response frequency for each item
      1 2 3 4 5 6 miss
E1 0.23 0.23 0.15 0.18 0.11 0.10 0
E2 0.19 0.23 0.12 0.22 0.14 0.09 0
E3 0.06 0.10 0.13 0.28 0.28 0.15 0
E4 0.06 0.10 0.09 0.15 0.34 0.26 0
E5 0.04 0.06 0.10 0.24 0.32 0.24 0

Reliability analysis
Call: psych::alpha(x = proposed_scale[, Overall], check.keys = TRUE)

raw_alpha std.alpha G6(smc) average_r S/N ase mean sd median_r
0.82      0.82      0.85      0.23 4.5 0.012 4.3 0.73      0.23

95% confidence boundaries
      lower alpha upper
Feldt      0.79 0.82 0.84
Duhachek 0.79 0.82 0.84

```

Reliability if an item is dropped:

| | raw_alpha | std.alpha | G6(smc) | average_r | S/N | alpha | se | var.r | med.r |
|-----|-----------|-----------|---------|-----------|-----|-------|-------|-------|-------|
| A1- | 0.82 | 0.82 | 0.85 | 0.25 | 4.5 | 0.012 | 0.021 | 0.25 | |
| A2 | 0.80 | 0.80 | 0.84 | 0.22 | 4.0 | 0.013 | 0.023 | 0.22 | |
| A3 | 0.80 | 0.80 | 0.83 | 0.22 | 4.0 | 0.013 | 0.020 | 0.22 | |
| A4 | 0.81 | 0.81 | 0.84 | 0.23 | 4.2 | 0.013 | 0.023 | 0.23 | |
| A5 | 0.80 | 0.80 | 0.83 | 0.22 | 4.0 | 0.013 | 0.020 | 0.22 | |
| C1 | 0.81 | 0.81 | 0.85 | 0.24 | 4.4 | 0.012 | 0.022 | 0.24 | |
| C2 | 0.81 | 0.81 | 0.84 | 0.24 | 4.3 | 0.012 | 0.021 | 0.23 | |
| C3 | 0.81 | 0.82 | 0.85 | 0.24 | 4.5 | 0.012 | 0.020 | 0.23 | |
| C4- | 0.81 | 0.81 | 0.84 | 0.23 | 4.2 | 0.013 | 0.022 | 0.23 | |
| C5- | 0.81 | 0.81 | 0.84 | 0.23 | 4.2 | 0.013 | 0.023 | 0.23 | |
| E1- | 0.81 | 0.81 | 0.84 | 0.23 | 4.2 | 0.013 | 0.020 | 0.23 | |
| E2- | 0.80 | 0.80 | 0.83 | 0.22 | 4.1 | 0.013 | 0.020 | 0.22 | |
| E3 | 0.80 | 0.80 | 0.84 | 0.22 | 4.1 | 0.013 | 0.020 | 0.22 | |
| E4 | 0.80 | 0.80 | 0.84 | 0.22 | 4.0 | 0.013 | 0.020 | 0.22 | |
| E5 | 0.80 | 0.80 | 0.84 | 0.23 | 4.1 | 0.013 | 0.023 | 0.19 | |

Item statistics

| | n | raw.r | std.r | r.cor | r.drop | mean | sd |
|-----|-----|-------|-------|-------|--------|------|-----|
| A1- | 500 | 0.36 | 0.36 | 0.28 | 0.24 | 4.6 | 1.4 |
| A2 | 500 | 0.60 | 0.62 | 0.59 | 0.53 | 4.8 | 1.1 |
| A3 | 500 | 0.61 | 0.61 | 0.59 | 0.52 | 4.6 | 1.3 |
| A4 | 500 | 0.52 | 0.52 | 0.46 | 0.42 | 4.7 | 1.5 |
| A5 | 500 | 0.61 | 0.62 | 0.60 | 0.53 | 4.5 | 1.3 |
| C1 | 500 | 0.43 | 0.45 | 0.39 | 0.33 | 4.5 | 1.2 |
| C2 | 500 | 0.44 | 0.46 | 0.42 | 0.34 | 4.3 | 1.3 |
| C3 | 500 | 0.37 | 0.40 | 0.33 | 0.27 | 4.3 | 1.3 |
| C4- | 500 | 0.52 | 0.52 | 0.49 | 0.42 | 4.4 | 1.3 |
| C5- | 500 | 0.53 | 0.52 | 0.47 | 0.41 | 3.6 | 1.6 |
| E1- | 500 | 0.54 | 0.51 | 0.46 | 0.42 | 4.0 | 1.6 |
| E2- | 500 | 0.62 | 0.59 | 0.57 | 0.52 | 3.8 | 1.6 |
| E3 | 500 | 0.60 | 0.59 | 0.56 | 0.51 | 4.1 | 1.4 |
| E4 | 500 | 0.61 | 0.60 | 0.57 | 0.52 | 4.4 | 1.5 |
| E5 | 500 | 0.58 | 0.58 | 0.54 | 0.49 | 4.5 | 1.3 |

Non missing response frequency for each item

| | 1 | 2 | 3 | 4 | 5 | 6 | miss |
|----|------|------|------|------|------|------|------|
| A1 | 0.33 | 0.28 | 0.14 | 0.13 | 0.10 | 0.02 | 0 |
| A2 | 0.01 | 0.05 | 0.05 | 0.19 | 0.40 | 0.30 | 0 |
| A3 | 0.03 | 0.06 | 0.08 | 0.19 | 0.36 | 0.27 | 0 |
| A4 | 0.05 | 0.07 | 0.07 | 0.16 | 0.25 | 0.41 | 0 |

| | | | | | | | |
|----|------|------|------|------|------|------|---|
| A5 | 0.03 | 0.06 | 0.09 | 0.23 | 0.33 | 0.26 | 0 |
| C1 | 0.02 | 0.04 | 0.11 | 0.22 | 0.39 | 0.21 | 0 |
| C2 | 0.03 | 0.09 | 0.10 | 0.25 | 0.34 | 0.18 | 0 |
| C3 | 0.03 | 0.08 | 0.11 | 0.27 | 0.35 | 0.16 | 0 |
| C4 | 0.24 | 0.32 | 0.18 | 0.18 | 0.07 | 0.02 | 0 |
| C5 | 0.15 | 0.19 | 0.13 | 0.24 | 0.14 | 0.13 | 0 |
| E1 | 0.23 | 0.23 | 0.15 | 0.18 | 0.11 | 0.10 | 0 |
| E2 | 0.19 | 0.23 | 0.12 | 0.22 | 0.14 | 0.09 | 0 |
| E3 | 0.06 | 0.10 | 0.13 | 0.28 | 0.28 | 0.15 | 0 |
| E4 | 0.06 | 0.10 | 0.09 | 0.15 | 0.34 | 0.26 | 0 |
| E5 | 0.04 | 0.06 | 0.10 | 0.24 | 0.32 | 0.24 | 0 |

Tip

If you have more than one factor, your scale is no longer one (or uni) dimensional. As such, the idea of an “overall” reliability is questionable at best. Further, all reliability estimates are sample dependent. For non-sample dependent metrics, one should consider Item Response Theory (IRT)