Homework 3

Applied Mutlivariate Analysis

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1 Workspace

1.1 Packages

```
library(car)
library(knitr)
library(psych)
library(kableExtra)
library(multcomp)
library(lme4)
library(plyr)
library(tidyverse)
library(MVN)
```

1.2 data

The file, Set_5.csv, contains data from a study in which college students completed the NEO-PI Personality Inventory. This 240-item scale purportedly measures the Big Five personality dimensions, assumed to be fairly independent. The inventory is scored on 6 subscales per dimension, listed below. The file contains the subscale scores, rather than the individual items, which should help reduce the impact of the small sample size.

Neuroticism: Anxiety Neuroticism: Angry_Hostility Neuroticism: Depression Neuroticism: Self_Consciousness Neuroticism: Impulsiveness Neuroticism: Vulnerability Extraversion: Warmth Extraversion: Gregariousness Extraversion: Assertiveness Extraversion: Activity Extraversion: Excitement_Seeking Extraversion: Positive_Emotions Openness: Fantasy Openness: Aesthetics Openness: Feelings Openness: Actions Openness: Ideas Openness: Values Agreeableness: Trust Agreeableness: Straightforwardness Agreeableness: Altruism Agreeableness: Compliance Agreeableness: Modesty Agreeableness: Tender_Mindedness Conscientiousness: Competence Conscientiousness: Order Conscientiousness: Dutifulness Conscientiousness: Achievement_Striving: Conscientiousness: Self_Discipline Conscientiousness: Deliberation

```
wd <- "https://github.com/emoriebeck/homeworks/raw/master/multivariate/homeworks/homework5"

dat <- sprintf("%s/Set_5(2).csv", wd) %>%
  read.csv(., stringsAsFactors = F)

head(dat)

##   ID Anxiety Angry_Hostility Depression Self_Consciousness Impulsiveness
## 1  2   2.625           2.000      1.750           2.250000         2.625
```

```
## 2  3   3.625           2.875      3.000           3.500000         4.250
## 3  4   3.000           2.750      2.625           2.875000         3.000
## 4  5   4.375           3.125      4.500           4.000000         3.875
## 5  6   3.500           2.875      3.000           2.571429         3.625
## 6  7   4.000           4.125      2.875           2.375000         4.000
##   Vulnerability   Warmth Gregariousness Assertiveness Activity
## 1      2.166667 4.666667          4.000      3.000000 4.833333
## 2      2.125000 4.500000          2.750      2.625000 3.000000
## 3      2.875000 3.750000          3.125      2.375000 3.250000
## 4      3.750000 3.250000          2.250      2.500000 1.875000
## 5      2.750000 3.750000          3.125      3.285714 3.500000
## 6      3.125000 3.500000          2.625      3.375000 3.125000
##   Excitement_Seeking Positive_Emotions  Fantasy Aesthetics Feelings
## 1              3.500             4.750 3.857143   3.571429 4.666667
## 2              2.875             3.500 3.500000   4.125000 3.625000
## 3              3.875             3.375 3.375000   3.500000 3.250000
## 4              2.750             2.625 3.000000   3.750000 4.250000
## 5              3.750             3.625 3.125000   1.625000 3.125000
## 6              2.000             3.375 3.500000   2.000000 3.250000
##    Actions Ideas Values Trust Straightforwardness Altruism Compliance
## 1 2.571429 4.400  4.600 5.000            2.166667 4.833333      2.750
## 2 3.000000 3.875  3.125 3.250            3.750000 3.625000      3.125
## 3 2.375000 4.125  3.500 3.250            3.125000 4.000000      3.750
## 4 3.375000 2.750  4.125 3.000            3.428571 3.875000      4.000
## 5 2.750000 2.500  3.625 3.375            3.250000 4.125000      3.625
## 6 2.625000 1.125  3.625 2.500            2.875000 3.000000      2.250
##   Modesty Tender_Mindedness Competence Order Dutifulness
## 1   4.000          3.833333       4.50 3.625    3.285714
## 2   2.625          3.250000       3.00 2.250    3.875000
## 3   2.750          3.250000       3.75 3.250    3.750000
## 4   4.125          3.750000       2.75 3.000    2.875000
## 5   3.375          3.375000       3.75 4.000    3.750000
## 6   2.625          3.375000       3.00 3.625    2.625000
##   Achievement_Striving Self_Discipline Deliberation
## 1             4.333333           4.250        2.875
## 2             2.750000           3.750        3.500
## 3             3.375000           3.375        3.125
## 4             2.875000           2.625        3.250
## 5             3.375000           2.875        3.375
## 6             3.000000           2.625        2.625
```

```
source <- tribble(
~Factor, ~Facet,
"Neuroticism", "Anxiety",
"Neuroticism", "Angry_Hostility",
"Neuroticism", "Depression",
"Neuroticism", "Self_Consciousness",
"Neuroticism", "Impulsiveness",
"Neuroticism", "Vulnerability",
"Extraversion", "Warmth",
"Extraversion", "Gregariousness",
"Extraversion", "Assertiveness",
"Extraversion", "Activity",
```

```
"Extraversion", "Excitement_Seeking",
"Extraversion", "Positive_Emotions",
"Openness", "Fantasy",
"Openness", "Aesthetics",
"Openness", "Feelings",
"Openness", "Actions",
"Openness", "Ideas",
"Openness", "Values",
"Agreeableness", "Trust",
"Agreeableness", "Straightforwardness" ,
"Agreeableness", "Altruism",
"Agreeableness", "Compliance",
"Agreeableness", "Modesty",
"Agreeableness", "Tender_Mindedness",
"Conscientiousness", "Competence",
"Conscientiousness", "Order",
"Conscientiousness", "Dutifulness",
"Conscientiousness", "Achievement_Striving",
"Conscientiousness", "Self_Discipline",
"Conscientiousness", "Deliberation"
)

dat <- dat %>% select(ID, source$Facet)
```

2 The Question

Given what you have learned up through exploratory factor analysis, analyze the data in the way you think is appropriate and form conclusions about the claimed number of dimensions and their independence.

2.1 Do we need FA?

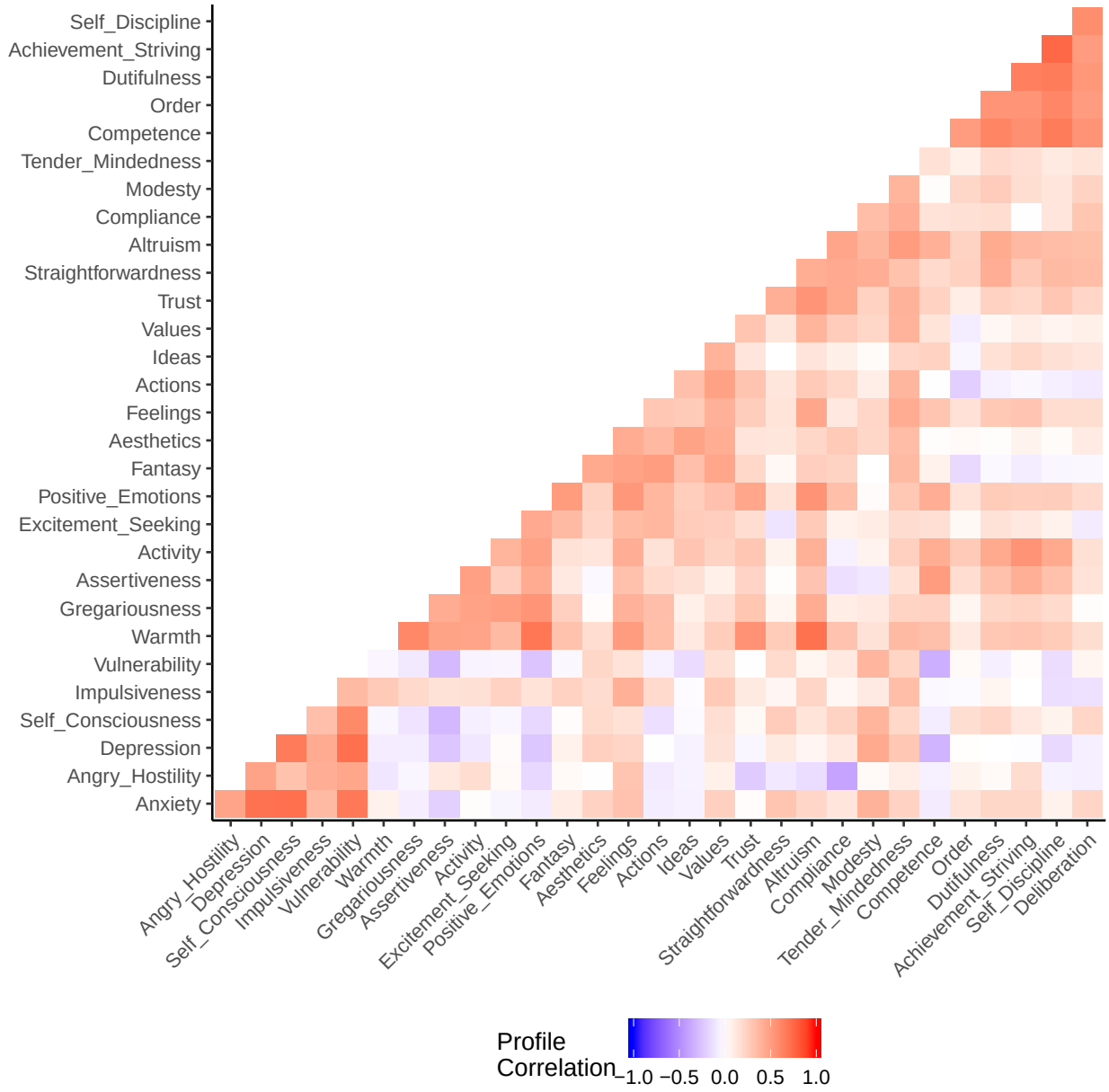
2.1.1 Correlations

```
r <- r_long <- dat %>% select(-ID) %>% cor()
r_long[upper.tri(r_long, diag = T)] <- NA
order <- colnames(dat)[-1]

r_long <- r_long %>% data.frame %>%
  mutate(V1 = rownames(.)) %>%
  gather(key = V2, value = r, -V1, na.rm = T) %>%
  mutate(V1 = factor(V1, levels = order),
         V2 = factor(V2, levels = order))

r_long %>%
  ggplot(aes(x = V1, y = V2, fill = r)) +
    geom_raster() +
    scale_fill_gradient2(low = "blue", high = "red", mid = "white",
       midpoint = 0, limit = c(-1,1), space = "Lab",
       name="Profile\nCorrelation") +
    theme_classic() +
    theme(axis.text.x = element_text(angle = 45, hjust = 1),
          legend.position = "bottom",
```

```
          axis.title = element_blank())
```



There appear to be intercorrelations among the variables.

2.1.2 KMO

```
(KMO1 <- KMO(r))

## Kaiser-Meyer-Olkin factor adequacy
## Call: KMO(r = r)
## Overall MSA =  0.86
## MSA for each item =
##              Anxiety      Angry_Hostility           Depression
##                 0.85                 0.74                 0.81
```

```
##   Self_Consciousness        Impulsiveness        Vulnerability
##                 0.89                 0.87                 0.85
##               Warmth       Gregariousness        Assertiveness
##                 0.88                 0.88                 0.87
##             Activity   Excitement_Seeking    Positive_Emotions
##                 0.88                 0.85                 0.89
##              Fantasy          Aesthetics             Feelings
##                 0.84                 0.80                 0.90
##              Actions                Ideas               Values
##                 0.85                 0.78                 0.84
##                Trust  Straightforwardness            Altruism
##                 0.90                 0.80                 0.91
##           Compliance              Modesty    Tender_Mindedness
##                 0.79                 0.85                 0.90
##           Competence                Order          Dutifulness
##                 0.89                 0.88                 0.90
## Achievement_Striving      Self_Discipline         Deliberation
##                 0.89                 0.87                 0.86
```

The MSA for each item range from 0.74 to 0.91, with a mean of 0.86, indicating strong evidence for using a data reduction technique.

2.1.3 Bartlett's Test

```
(CB_1 <- cortest.bartlett(R=r,n=nrow(dat)))

## $chisq
## [1] 3707.648
##
## $p.value
## [1] 0
##
## $df
## [1] 435
```

In addition, the χ^2 value of the Bartlett test ($\chi^2(435) = 3707.65$), which indicates that the correlation matrix departs significantly from from an identity matrix (independence among indicators).

2.2 How Many Factors?

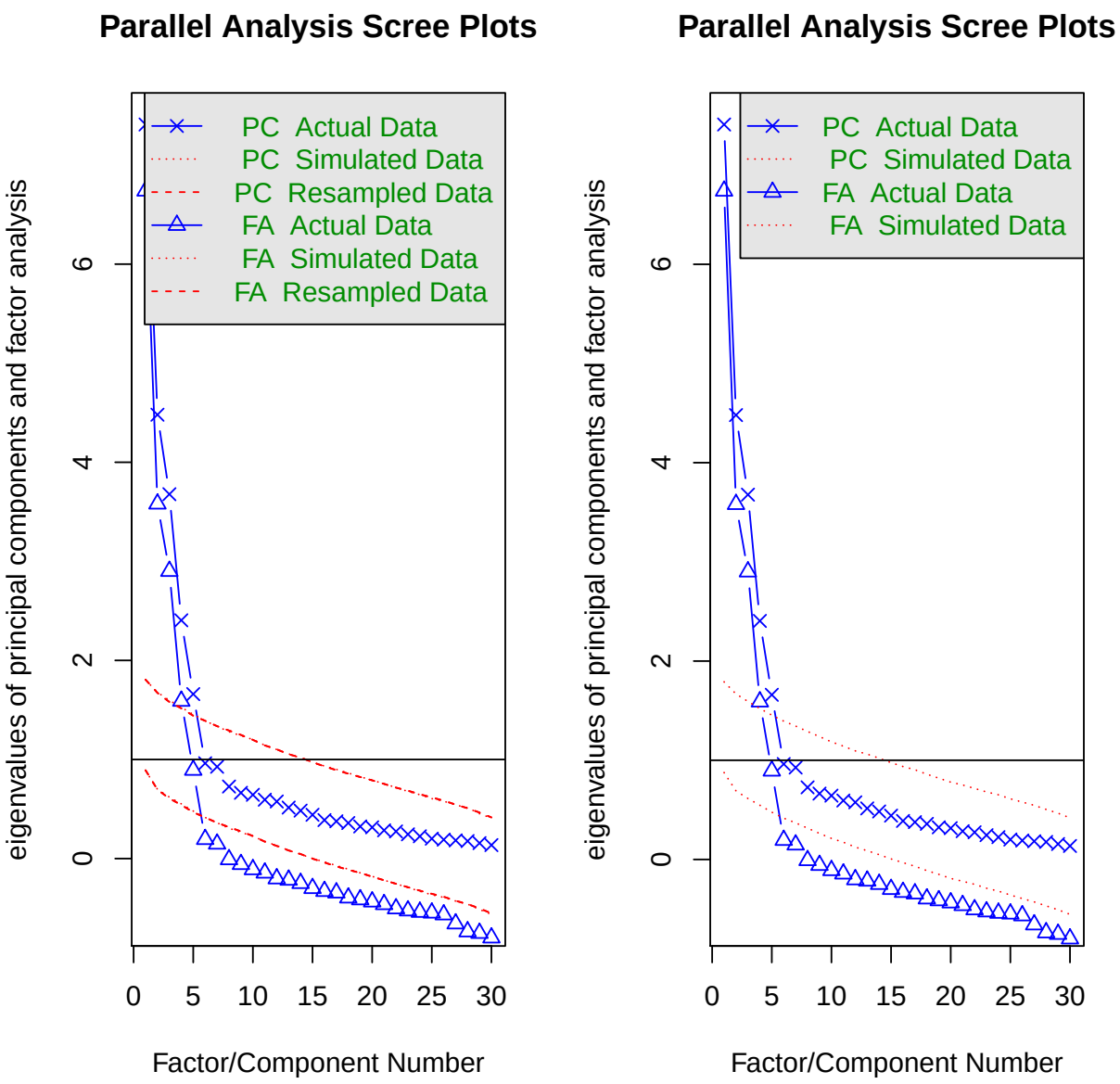
Now that we have seen evidence suggesting that we should conduct a CFA or PCA, we need to determine how many factors we should extract.

2.2.1 Parallel Analysis (Scree Test)

```
par(mfrow=c(1,2))
scree_1 <- fa.parallel(dat %>% select(-ID), fa="both")

## Parallel analysis suggests that the number of factors =  5  and the number of components =  5

scree_2 <- fa.parallel(r, fa = "both", n.obs = nrow(dat))
```

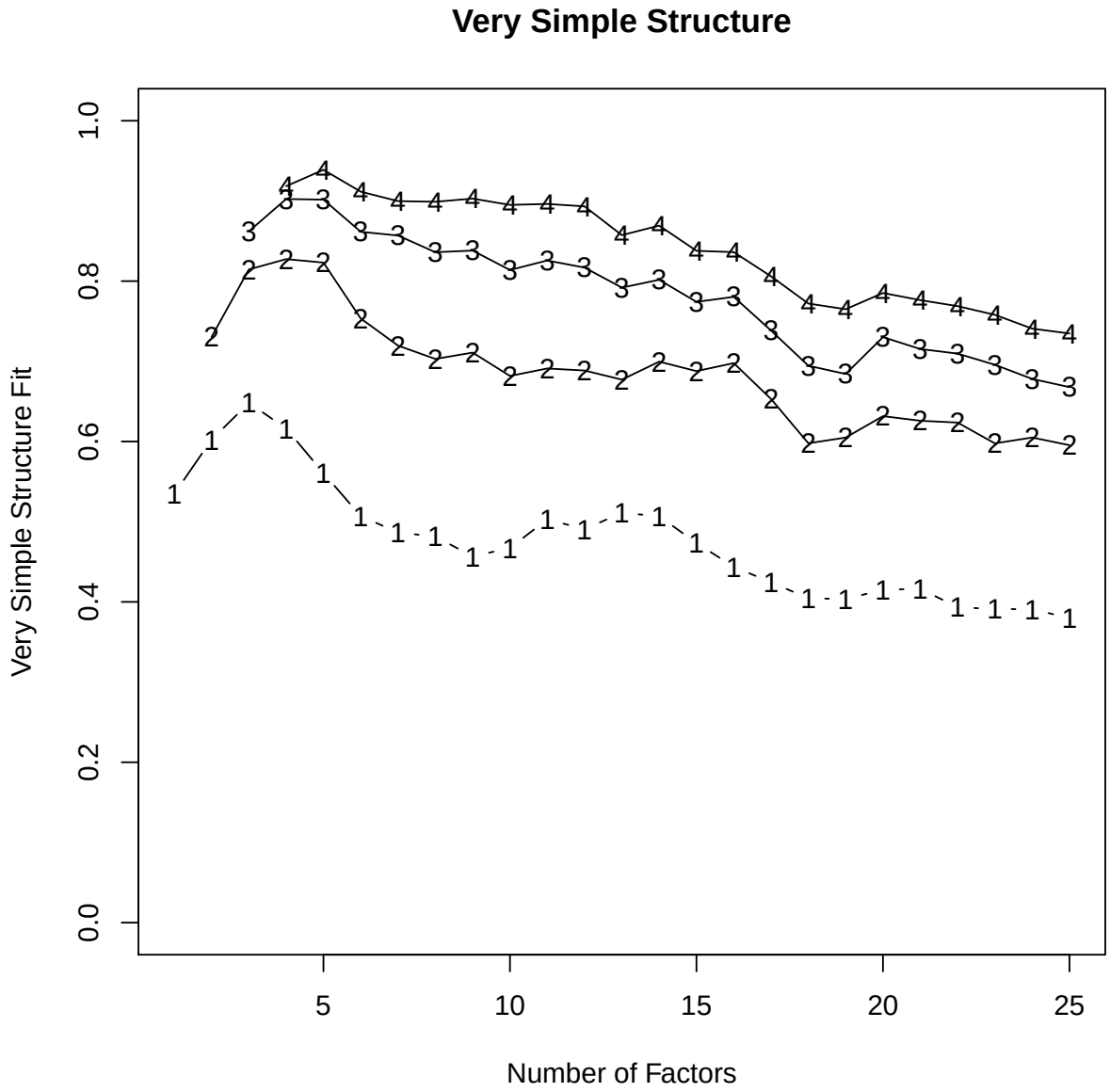



```
## Parallel analysis suggests that the number of factors =  5  and the number of components =  5
```

Parallel analysis suggests 5 principal components and 5 factors.

2.2.2 VSS

```
par(mfrow = c(1,1))
vss_1 <- vss(dat %>% select(-ID), n = 25, rotate = "none", fm = "pc")
```



VSS also suggests 5 factors.

2.3 Exploratory Factor Analysis

```
fa_1 <- fa(dat %>% select(-ID), nfactors = 5, rotate = "none", scores = T)
fa_2 <- fa(dat %>% select(-ID), nfactors = 5, rotate = "varimax", scores = T)
fa_3 <- fa(dat %>% select(-ID), nfactors = 5, rotate = "oblimin", scores = T)

scores_1 <- fa_1$scores
scores_2 <- fa_2$scores
scores_3 <- fa_3$scores

# unrotated
cor(scores_1) %>% round(., 2)
```

```
##       MR1  MR2  MR3  MR4   MR5
## MR1  1.00 0.00 0.01 0.00 -0.01
## MR2  0.00 1.00 0.00 0.01  0.00
## MR3  0.01 0.00 1.00 0.01  0.02
## MR4  0.00 0.01 0.01 1.00  0.00
## MR5 -0.01 0.00 0.02 0.00  1.00

# varimax rotation
cor(scores_2) %>% round(., 2)

##       MR3   MR2   MR1   MR5  MR4
## MR3  1.00  0.00  0.04 -0.01 0.02
## MR2  0.00  1.00 -0.01  0.02 0.01
## MR1  0.04 -0.01  1.00  0.08 0.02
## MR5 -0.01  0.02  0.08  1.00 0.04
## MR4  0.02  0.01  0.02  0.04 1.00

# oblimin rotation
cor(scores_3) %>% round(., 2)

##      MR3  MR2  MR1  MR5  MR4
## MR3 1.00 0.02 0.32 0.11 0.09
## MR2 0.02 1.00 0.00 0.11 0.04
## MR1 0.32 0.00 1.00 0.46 0.07
## MR5 0.11 0.11 0.46 1.00 0.11
## MR4 0.09 0.04 0.07 0.11 1.00
```

The two models fit the data relatively well ($RMSEA_{unrotated} = 0.07$, $RMSEA_{varimax} = 0.07$, $RMSEA_{oblimin} = 0.07$, $TLI_{unrotated} = 0.89$; $TLI_{varimax} = 0.89$; $TLI_{oblimin} = 0.89$).

We can also look at the communalities:

```
tibble(Facet = names(fa_1$communalities),
       Unrotated = fa_1$communalities,
       Varimax = fa_2$communalities,
       Oblimin = fa_3$communalities) %>%
  mutate(Facet = str_replace_all(Facet, "_", " ")) %>%
  kable(., "latex", booktabs = T, escape = F, digits = 2,
        caption = "Communalities") %>%
  kable_styling(full_width = F)
```

THe communalities are identical across models but suggest that the latent factors explain a considerable amount of the variance in most variables.

How much variance is explained?

```
fa_1$Vaccounted %>% data.frame %>% mutate(Measure = rownames(.), Rotate = "Unrotated") %>%
  full_join(
    fa_1$Vaccounted %>% data.frame %>% mutate(Measure = rownames(.), Rotate = "Varimax")
  ) %>%
  full_join(
    fa_1$Vaccounted %>% data.frame %>% mutate(Measure = rownames(.), Rotate = "Oblimin")
  ) %>%
  select(Measure, everything(), -Rotate) %>%
  kable(., "latex", escape = F, booktabs = T, digits = 2,
        caption = "Variance Explained") %>%
  group_rows("Unrotated", 1,5) %>%
```

Table 1: Communalities

Facet	Unrotated	Varimax	Oblimin
Anxiety	0.74	0.74	0.74
Angry Hostility	0.71	0.71	0.71
Depression	0.77	0.77	0.77
Self Consciousness	0.64	0.64	0.64
Impulsiveness	0.45	0.45	0.45
Vulnerability	0.69	0.69	0.69
Warmth	0.76	0.76	0.76
Gregariousness	0.54	0.54	0.54
Assertiveness	0.56	0.56	0.56
Activity	0.57	0.57	0.57
Excitement Seeking	0.35	0.35	0.35
Positive Emotions	0.68	0.68	0.68
Fantasy	0.53	0.53	0.53
Aesthetics	0.54	0.54	0.54
Feelings	0.60	0.60	0.60
Actions	0.49	0.49	0.49
Ideas	0.51	0.51	0.51
Values	0.47	0.47	0.47
Trust	0.47	0.47	0.47
Straightforwardness	0.46	0.46	0.46
Altruism	0.71	0.71	0.71
Compliance	0.66	0.66	0.66
Modesty	0.40	0.40	0.40
Tender Mindedness	0.45	0.45	0.45
Competence	0.69	0.69	0.69
Order	0.50	0.50	0.50
Dutifulness	0.65	0.65	0.65
Achievement Striving	0.73	0.73	0.73
Self Discipline	0.75	0.75	0.75
Deliberation	0.56	0.56	0.56

Table 2: Variance Explained

Measure	MR1	MR2	MR3	MR4	MR5
Unrotated					
SS loadings	7.01	4.14	3.26	2.00	1.22
Proportion Var	0.23	0.14	0.11	0.07	0.04
Cumulative Var	0.23	0.37	0.48	0.55	0.59
Proportion Explained	0.40	0.23	0.18	0.11	0.07
Cumulative Proportion	0.40	0.63	0.82	0.93	1.00
Varimax					
SS loadings	7.01	4.14	3.26	2.00	1.22
Proportion Var	0.23	0.14	0.11	0.07	0.04
Cumulative Var	0.23	0.37	0.48	0.55	0.59
Proportion Explained	0.40	0.23	0.18	0.11	0.07
Cumulative Proportion	0.40	0.63	0.82	0.93	1.00
Oblimin					
SS loadings	7.01	4.14	3.26	2.00	1.22
Proportion Var	0.23	0.14	0.11	0.07	0.04
Cumulative Var	0.23	0.37	0.48	0.55	0.59
Proportion Explained	0.40	0.23	0.18	0.11	0.07
Cumulative Proportion	0.40	0.63	0.82	0.93	1.00

```
  group_rows("Varimax", 6, 10) %>%
  group_rows("Oblimin", 11, 15)
```

But we aren't just concerned with model fit. We are also generally interested in naming the factors.

There's no way for me to pretend I don't have expectations for how the data should come out. So let's look at the rotated and unrotated solutions and see if we managed to recover the Big 5.

```
fa_1$Structure %>% unclass %>%
  data.frame %>%
  mutate(Facet = rownames(.)) %>%
  full_join(source) %>%
  select(Factor, Facet, MR1, MR2, MR3, MR4, MR5) %>%
  mutate_at(vars(MR1:MR5), funs(round(., 2))) %>%
  mutate_at(vars(MR1:MR5), funs(cell_spec(., "latex",
        background = ifelse((.) > .5, "yellow", "white")))) %>%
  mutate(Facet = str_replace_all(Facet, "_", " ")) %>%
  kable(., "latex", escape = F, booktabs = T,
        caption = "Unrotated Solution") %>%
  kable_styling(full_width = F)
```

```
fa_2$Structure %>% unclass %>%
  data.frame %>%
  mutate(Facet = rownames(.)) %>%
  full_join(source) %>%
  select(Factor, Facet, MR1, MR2, MR3, MR4, MR5) %>%
  mutate_at(vars(MR1:MR5), funs(round(., 2))) %>%
  mutate_at(vars(MR1:MR5), funs(cell_spec(., "latex",
        background = ifelse(abs(.) > .5, "yellow", "white")))) %>%
```

Table 3: Unrotated Solution

Factor	Facet	MR1	MR2	MR3	MR4	MR5
Neuroticism	Anxiety	0.26	0.78	0.25	0.09	0
Neuroticism	Angry Hostility	0.03	0.47	0.12	0.69	0.02
Neuroticism	Depression	0.08	0.87	0.05	0.12	-0.05
Neuroticism	Self Consciousness	0.17	0.72	0.28	-0.04	0.03
Neuroticism	Impulsiveness	0.29	0.43	-0.22	0.31	-0.18
Neuroticism	Vulnerability	0.05	0.81	0.12	0.07	-0.11
Extraversion	Warmth	0.73	-0.14	-0.24	-0.01	-0.38
Extraversion	Gregariousness	0.53	-0.2	-0.27	0.19	-0.34
Extraversion	Assertiveness	0.47	-0.42	-0.04	0.38	-0.12
Extraversion	Activity	0.62	-0.21	0.02	0.38	-0.02
Extraversion	Excitement Seeking	0.42	-0.07	-0.35	0.22	-0.01
Extraversion	Positive Emotions	0.7	-0.3	-0.32	-0.01	-0.08
Openness	Fantasy	0.41	0.1	-0.55	0	0.24
Openness	Aesthetics	0.37	0.3	-0.3	-0.1	0.46
Openness	Feelings	0.66	0.19	-0.22	0.27	0.07
Openness	Actions	0.38	0.01	-0.57	-0.09	0.12
Openness	Ideas	0.35	-0.09	-0.23	0.02	0.57
Openness	Values	0.47	0.24	-0.35	-0.05	0.27
Agreeableness	Trust	0.57	-0.06	-0.12	-0.31	-0.2
Agreeableness	Straightforwardness	0.43	0.19	0.26	-0.4	-0.1
Agreeableness	Altruism	0.78	0.03	-0.04	-0.21	-0.24
Agreeableness	Compliance	0.42	0.17	-0.06	-0.67	-0.05
Agreeableness	Modesty	0.36	0.43	0.15	-0.24	-0.09
Agreeableness	Tender Mindedness	0.55	0.29	-0.19	-0.13	0
Conscientiousness	Competence	0.6	-0.42	0.35	0.07	0.15
Conscientiousness	Order	0.39	-0.08	0.59	0.03	0.05
Conscientiousness	Dutifulness	0.61	-0.11	0.52	0.04	0.03
Conscientiousness	Achievement Striving	0.6	-0.14	0.52	0.25	0.11
Conscientiousness	Self Discipline	0.57	-0.28	0.57	0	0.14
Conscientiousness	Deliberation	0.46	-0.06	0.52	-0.2	0.19

```
  mutate(Facet = str_replace_all(Facet, "_", " "))
```

```
    Factor Facet MR1 1 Neuroticism Anxiety
cellcolorwhite-0.05 2 Neuroticism Angry Hostility
cellcolorwhite0.14 3 Neuroticism Depression
cellcolorwhite-0.07 4 Neuroticism Self Consciousness
cellcolorwhite-0.18 5 Neuroticism Impulsiveness
cellcolorwhite0.4 6 Neuroticism Vulnerability
cellcolorwhite-0.09 7 Extraversion Warmth
cellcoloryellow0.77 8 Extraversion Gregariousness
cellcoloryellow0.72 9 Extraversion Assertiveness
cellcoloryellow0.6 10 Extraversion Activity
cellcoloryellow0.57 11 Extraversion Excitement Seeking
cellcolorwhite0.5 12 Extraversion Positive Emotions
cellcoloryellow0.65 13 Openness Fantasy
cellcolorwhite0.32 14 Openness Aesthetics
cellcolorwhite0.01 15 Openness Feelings
cellcoloryellow0.53 16 Openness Actions
cellcolorwhite0.36 17 Openness Ideas
cellcolorwhite0.04 18 Openness Values
cellcolorwhite0.22 19 Agreeableness Trust
cellcolorwhite0.39 20 Agreeableness Straightforwardness
cellcolorwhite0.03 21 Agreeableness Altruism
cellcoloryellow0.53 22 Agreeableness Compliance
cellcolorwhite0.01 23 Agreeableness Modesty
cellcolorwhite0.03 24 Agreeableness Tender Mindedness
cellcolorwhite0.31 25 Conscientiousness Competence
cellcolorwhite0.27 26 Conscientiousness Order
cellcolorwhite0.02 27 Conscientiousness Dutifulness
cellcolorwhite0.2 28 Conscientiousness Achievement Striving
cellcolorwhite0.24 29 Conscientiousness Self Discipline
cellcolorwhite0.12 30 Conscientiousness Deliberation
cellcolorwhite-0.08 MR2 MR3 1
cellcoloryellow0.84
cellcolorwhite0.16 2
cellcoloryellow0.62
cellcolorwhite0.07 3
cellcoloryellow0.86
cellcolorwhite-0.13 4
cellcoloryellow0.74
cellcolorwhite0.14 5
cellcolorwhite0.5
cellcolorwhite-0.12 6
cellcoloryellow0.82
cellcolorwhite-0.1 7
cellcolorwhite0
cellcolorwhite0.15 8
cellcolorwhite-0.06
cellcolorwhite0.07 9
cellcolorwhite-0.22
cellcolorwhite0.34 10
cellcolorwhite0
cellcolorwhite0.44 11
cellcolorwhite-0.01
```

cellcolorwhite0.01 12
cellcolorwhite-0.21
cellcolorwhite0.19 13
cellcolorwhite0.03
cellcolorwhite-0.15 14
cellcolorwhite0.21
cellcolorwhite0.02 15
cellcolorwhite0.3
cellcolorwhite0.2 16
cellcolorwhite-0.07
cellcolorwhite-0.2 17
cellcolorwhite-0.13
cellcolorwhite0.19 18
cellcolorwhite0.19
cellcolorwhite0 19
cellcolorwhite-0.02
cellcolorwhite0.15 20
cellcolorwhite0.22
cellcolorwhite0.32 21
cellcolorwhite0.13
cellcolorwhite0.3 22
cellcolorwhite0.07
cellcolorwhite0.07 23
cellcolorwhite0.44
cellcolorwhite0.16 24
cellcolorwhite0.3
cellcolorwhite0.08 25
cellcolorwhite-0.24
cellcoloryellow0.74 26
cellcolorwhite0.1
cellcoloryellow0.69 27
cellcolorwhite0.1
cellcoloryellow0.76 28
cellcolorwhite0.11
cellcoloryellow0.81 29
cellcolorwhite-0.08
cellcoloryellow0.84 30
cellcolorwhite0.05
cellcoloryellow0.68 MR4 MR5 1
cellcolorwhite0.1
cellcolorwhite0.07 2
cellcoloryellow-0.55
cellcolorwhite0 3
cellcolorwhite0.03
cellcolorwhite0.08 4
cellcolorwhite0.17
cellcolorwhite0.05 5
cellcolorwhite-0.07
cellcolorwhite0.13 6
cellcolorwhite0.08
cellcolorwhite-0.02 7
cellcolorwhite0.37
cellcolorwhite0.1 8
cellcolorwhite0.09

cellcolorwhite0.05 9
cellcolorwhite-0.18
cellcolorwhite0.04 10
cellcolorwhite-0.13
cellcolorwhite0.17 11
cellcolorwhite-0.04
cellcolorwhite0.31 12
cellcolorwhite0.25
cellcolorwhite0.33 13
cellcolorwhite0.1
cellcoloryellow0.63 14
cellcolorwhite0.14
cellcoloryellow0.69 15
cellcolorwhite0
cellcolorwhite0.43 16
cellcolorwhite0.19
cellcoloryellow0.53 17
cellcolorwhite-0.05
cellcoloryellow0.67 18
cellcolorwhite0.17
cellcoloryellow0.6 19
cellcoloryellow0.53
cellcolorwhite0.14 20
cellcoloryellow0.55
cellcolorwhite0 21
cellcoloryellow0.54
cellcolorwhite0.16 22
cellcoloryellow0.78
cellcolorwhite0.21 23
cellcolorwhite0.41
cellcolorwhite0.07 24
cellcolorwhite0.36
cellcolorwhite0.36 25
cellcolorwhite0.06
cellcolorwhite0.12 26
cellcolorwhite0.09
cellcolorwhite-0.11 27
cellcolorwhite0.16
cellcolorwhite-0.02 28
cellcolorwhite-0.05
cellcolorwhite0.03 29
cellcolorwhite0.13
cellcolorwhite0.01 30
cellcolorwhite0.28
cellcolorwhite0.07

```
  kable(., "latex", escape = F, booktabs = T,
        caption = "Varimax Rotated Solution") %>%
  kable_styling(full_width = F)
```

```
## Error in seq_len(m):  argument must be coercible to non-negative integer
```

```
fa_3$Structure %>% unclass %>%
  data.frame %>%
  mutate(Facet = rownames(.)) %>%
```

```
  full_join(source) %>%
  select(Factor, Facet, MR1, MR2, MR3, MR4, MR5) %>%
  mutate_at(vars(MR1:MR5), funs(round(., 2))) %>%
  mutate_at(vars(MR1:MR5), funs(cell_spec(., "latex",
        background = ifelse(abs(.) > .5, "yellow", "white")))) %>%
  mutate(Facet = str_replace_all(Facet, "_", " "))
```

Factor Facet MR1 1 Neuroticism Anxiety
cellcolorwhite0.02 2 Neuroticism Angry Hostility
cellcolorwhite0.01 3 Neuroticism Depression
cellcolorwhite-0.05 4 Neuroticism Self Consciousness
cellcolorwhite-0.08 5 Neuroticism Impulsiveness
cellcolorwhite0.37 6 Neuroticism Vulnerability
cellcolorwhite-0.06 7 Extraversion Warmth
cellcoloryellow0.86 8 Extraversion Gregariousness
cellcoloryellow0.72 9 Extraversion Assertiveness
cellcoloryellow0.57 10 Extraversion Activity
cellcoloryellow0.58 11 Extraversion Excitement Seeking
cellcolorwhite0.5 12 Extraversion Positive Emotions
cellcoloryellow0.75 13 Openness Fantasy
cellcolorwhite0.4 14 Openness Aesthetics
cellcolorwhite0.14 15 Openness Feelings
cellcoloryellow0.59 16 Openness Actions
cellcolorwhite0.43 17 Openness Ideas
cellcolorwhite0.13 18 Openness Values
cellcolorwhite0.34 19 Agreeableness Trust
cellcoloryellow0.54 20 Agreeableness Straightforwardness
cellcolorwhite0.22 21 Agreeableness Altruism
cellcoloryellow0.71 22 Agreeableness Compliance
cellcolorwhite0.25 23 Agreeableness Modesty
cellcolorwhite0.17 24 Agreeableness Tender Mindedness
cellcolorwhite0.45 25 Conscientiousness Competence
cellcolorwhite0.37 26 Conscientiousness Order
cellcolorwhite0.11 27 Conscientiousness Dutifulness
cellcolorwhite0.32 28 Conscientiousness Achievement Striving
cellcolorwhite0.31 29 Conscientiousness Self Discipline
cellcolorwhite0.25 30 Conscientiousness Deliberation
cellcolorwhite0.09 MR2 MR3 1
cellcoloryellow0.85
cellcolorwhite0.16 2
cellcoloryellow0.55
cellcolorwhite0.04 3
cellcoloryellow0.87
cellcolorwhite-0.12 4
cellcoloryellow0.77
cellcolorwhite0.14 5
cellcolorwhite0.48
cellcolorwhite-0.07 6
cellcoloryellow0.82
cellcolorwhite-0.1 7
cellcolorwhite0
cellcolorwhite0.3 8
cellcolorwhite-0.09
cellcolorwhite0.18 9

cellcolorwhite-0.26
cellcolorwhite0.4 10
cellcolorwhite-0.03
cellcolorwhite0.5 11
cellcolorwhite-0.02
cellcolorwhite0.08 12
cellcolorwhite-0.2
cellcolorwhite0.31 13
cellcolorwhite0.05
cellcolorwhite-0.08 14
cellcolorwhite0.25
cellcolorwhite0.05 15
cellcolorwhite0.3
cellcolorwhite0.28 16
cellcolorwhite-0.05
cellcolorwhite-0.12 17
cellcolorwhite-0.1
cellcolorwhite0.2 18
cellcolorwhite0.22
cellcolorwhite0.06 19
cellcolorwhite0.01
cellcolorwhite0.26 20
cellcolorwhite0.27
cellcolorwhite0.38 21
cellcolorwhite0.16
cellcolorwhite0.44 22
cellcolorwhite0.16
cellcolorwhite0.15 23
cellcolorwhite0.48
cellcolorwhite0.21 24
cellcolorwhite0.33
cellcolorwhite0.16 25
cellcolorwhite-0.23
cellcoloryellow0.77 26
cellcolorwhite0.11
cellcoloryellow0.69 27
cellcolorwhite0.11
cellcoloryellow0.8 28
cellcolorwhite0.1
cellcoloryellow0.83 29
cellcolorwhite-0.06
cellcoloryellow0.86 30
cellcolorwhite0.09
cellcoloryellow0.69 MR4 MR5 1
cellcolorwhite0.05
cellcolorwhite0.12 2
cellcoloryellow-0.61
cellcolorwhite0.02 3
cellcolorwhite-0.01
cellcolorwhite0.1 4
cellcolorwhite0.16
cellcolorwhite0.06 5
cellcolorwhite-0.18
cellcolorwhite0.24 6

cellcolorwhite0.04
cellcolorwhite0.01 7
cellcolorwhite0.19
cellcolorwhite0.32 8
cellcolorwhite-0.06
cellcolorwhite0.23 9
cellcolorwhite-0.28
cellcolorwhite0.17 10
cellcolorwhite-0.24
cellcolorwhite0.31 11
cellcolorwhite-0.13
cellcolorwhite0.42 12
cellcolorwhite0.14
cellcolorwhite0.5 13
cellcolorwhite0.06
cellcoloryellow0.69 14
cellcolorwhite0.16
cellcoloryellow0.69 15
cellcolorwhite-0.11
cellcoloryellow0.57 16
cellcolorwhite0.14
cellcoloryellow0.61 17
cellcolorwhite-0.01
cellcoloryellow0.66 18
cellcolorwhite0.14
cellcoloryellow0.65 19
cellcolorwhite0.44
cellcolorwhite0.28 20
cellcoloryellow0.52
cellcolorwhite0.08 21
cellcolorwhite0.41
cellcolorwhite0.35 22
cellcoloryellow0.76
cellcolorwhite0.28 23
cellcolorwhite0.37
cellcolorwhite0.14 24
cellcolorwhite0.28
cellcolorwhite0.47 25
cellcolorwhite0.03
cellcolorwhite0.2 26
cellcolorwhite0.08
cellcolorwhite-0.06 27
cellcolorwhite0.11
cellcolorwhite0.09 28
cellcolorwhite-0.1
cellcolorwhite0.12 29
cellcolorwhite0.12
cellcolorwhite0.08 30
cellcolorwhite0.29
cellcolorwhite0.1

```
  kable(., "latex", escape = F, booktabs = T,
        caption = "Oblimin Rotated Solution") %>%
  kable_styling(full_width = F)
```

```
## Error in seq_len(m):  argument must be coercible to non-negative integer
```

With the exception of the 2nd and 3rd factors, the unrotated solution doesn't resemble the expected solution. However, the indicators for each factor in the varimax rotated solution can clearly be identified as the Big 5 by content. Finally, in the oblimin rotated solution, we see that the factors can be fairly readily identified by content.

Another fun test is the order of extraction, which is typically Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to Experience.

In this case, the order of extraction for the rotated solutions appears to be Extraversion, Neuroticism, Conscientiousness, Agreeableness, Openness.