Assignment 2 STAT 315-463: Multivariable Statistical Methods and Applications

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Due date: Friday 24 March 2023

- Your assignment needs to show the R code you used, and your well discussed answers to the questions.
- Submit your assignments on Learn.

Background

In the dataset, `USJudgeRatings.csv`, you are presented with ratings of State Judges on the Superior Court on 12 variables provided by 43 Lawyers in 1977.

CONT	Number of contacts of lawyer with judge	INTG	Judicial integrity	DMNR	Demeanour
DILG	Diligence	CFMG	Case flow managing	DECI	Prompt decisions
PREP	Preparation for trial	FAMI	Familiarity with law	ORAL	Sound oral rulings
WRIT	Sound written rulings	PHYS	Physical ability	RTEN	Worthy of retention

```
# Read in the data
dataset <- read.csv("USJudgeRatings.csv")
```

Principal Component Analysis of the Rating Data.

Perform a PCA on the standardised ratings. Note, you will need to standardise the ratings yourself. Then answer the following questions.

```
# Standardise the ratings
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
dataset %>% mutate(across(where(is.numeric),scale))
```

```
##             Lawyer        CONT        INTG        DMNR        DILG        CFMG
## 1    AARONSON,L.H. -1.84637275 -0.15702273  0.16063659 -0.436257319 -0.44072232
## 2   ALEXANDER,J.M. -0.67725051  1.14143449  1.12242274  0.895747277  0.37312687
## 3   ARMENTANO,A.J. -0.25211515  0.10266871  0.24807169  0.118744596  0.02433436
## 4      BERDON,R.I. -0.67725051  1.01158876  0.86011742  1.228748425  0.95444771
## 5     BRACKEN,J.J. -0.14583132 -2.10470856 -2.81215696 -1.324260383 -1.71962817
## 6       BURNS,E.B. -1.31495355  1.01158876  1.03498763  0.895747277  0.48939104
## 7    CALLAHAN,R.J.  3.36153540  1.27128021  1.20985784  1.117748042  1.18697605
## 8       COHEN,S.S. -0.46468283 -2.75393717 -2.28754634 -2.878265744 -2.41721319
## 9        DALY,J.J. -0.14583132  1.14143449  1.20985784  1.117748042  1.30324022
## 10    DANNEHY,J.F.  0.81072324 -0.15702273 -0.71371446  0.451745745  0.48939104
## 11       DEAN,H.H. -0.46468283 -0.02717701  0.07320148 -0.325256936 -0.20819398
## 12     DEVITA,H.J. -0.99610203 -0.02717701  0.07320148 -0.547257702 -0.55698648
## 13   DRISCOLL,P.J. -0.78353435  0.75189732  0.59781211 -0.991259234 -0.67325065
## 14     GRILLO,A.E. -0.46468283 -0.67640562 -0.97601977 -0.991259234 -1.13830733
## 15  HADDEN,W.L.JR. -0.99610203  0.10266871  0.42294190  0.340745362  0.48939104
## 16     HAMILL,E.C. -0.14583132 -0.02717701 -0.10166873  0.007744213 -0.20819398
## 17     HEALEY.A.H.  0.59815556 -0.54655990 -0.80114956 -0.547257702 -1.13830733
## 18       HULL,T.C.  0.27930404 -0.41671418 -0.71371446 -0.214256553 -0.09192981
## 19       LEVINE,I.  0.91700708  0.23251443 -0.10166873  0.118744596  0.25686270
## 20   LEVISTER,R.L.  2.29869700 -1.45547995 -1.58806550 -1.213260000 -0.67325065
## 21     MARTIN,L.F. -0.35839899  0.23251443  0.16063659 -0.658258085 -1.02204316
## 22    MCGRATH,J.F.  0.17302020 -0.93609706 -0.53884425 -0.991259234 -0.90577899
## 23    MIGNONE,A.F. -0.88981819 -0.80625134 -1.15088998 -1.657261532 -2.41721319
## 24     MISSAL,H.M. -1.31495355  0.36236015  0.51037700  0.007744213 -0.09192981
## 25     MULVEY,H.M.  0.06673636  0.88174304  0.86011742  1.006747659  1.18697605
## 26      NARUK,H.J.  0.38558788  1.14143449  1.03498763  1.339748808  1.41950439
## 27    O'BRIEN,F.J. -0.35839899  0.62205160  0.68524721  0.340745362  0.48939104
## 28 O'SULLIVAN,T.J.  0.06673636  1.27128021  1.20985784  1.117748042  1.07071188
## 29       PASKEY,L.  0.06673636  0.10266871  0.16063659  0.562746128  0.60565521
## 30    RUBINOW,J.E. -0.35839899  1.53097165  1.29729294  1.450749191  1.07071188
## 31      SADEN.G.A. -0.88981819 -0.80625134 -0.53884425  0.784746894  0.60565521
## 32 SATANIELLO,A.G.  1.02329092 -0.02717701  0.33550680  0.229744979  0.37312687
## 33       SHEA,D.M. -0.57096667  0.62205160  0.24807169  0.895747277  0.72191938
## 34    SHEA,J.F.JR. -0.14583132  1.14143449  1.12242274  1.117748042  1.07071188
## 35      SIDOR,W.J.  0.27930404 -2.36440001 -2.11267613 -2.323263830 -2.18468485
## 36   SPEZIALE,J.A.  1.12957476  0.36236015  0.51037700  0.673746511  1.07071188
## 37     SPONZO,M.J. -0.57096667  0.36236015  0.42294190  0.451745745  0.48939104
## 38  STAPLETON,J.F. -0.99610203  0.23251443  0.16063659  0.118744596  0.14059853
## 39      TESTO,R.J.  0.91700708 -0.93609706 -0.45140914 -0.991259234 -0.55698648
## 40 TIERNEY,W.L.JR.  0.91700708  0.23251443  0.24807169  0.673746511  1.07071188
## 41       WALL,R.A.  1.66099396 -1.32563423 -1.41319529 -0.769258468 -0.55698648
## 42     WRIGHT,D.B. -0.35839899  0.49220588  0.77268232  0.007744213  0.02433436
## 43   ZARRILLI,K.J.  1.23585860 -0.80625134 -0.45140914 -0.214256553  0.02433436
##          DECI        PREP        FAMI         ORAL        WRIT        PHYS
## 1  -0.2056406 -0.38541362 -0.40924922 -0.191103867 -0.39923819  0.38859714
## 2   0.6661597  0.55860582  0.53913072  0.501935459  0.53715684  0.60145927
## 3   0.0434452  0.03415057  0.01225297  0.006907369  0.01693738 -0.03712712
## 4   1.1643313  1.29284316  1.27675956  1.095969167  1.16142020  0.92075246
## 5  -1.7001554 -1.85388831 -1.88450691 -2.171216227 -2.16798436 -2.59147264
## 6   0.5416168  0.66349687  0.53913072  0.699946695  0.64120073  0.70789033
## 7   1.1643313  1.08306107  1.06600846  1.293980403  1.05737630  1.24004565
## 8  -2.0737841 -2.79790775 -2.51676020 -2.567238699 -2.58415993 -1.20786881
## 9   1.1643313  0.97817002  0.96063291  1.095969167  1.16142020  0.92075246
```

```
## 10  0.5416168  0.45371477  0.64450626  0.402929841  0.43311295  0.60145927
## 11 -0.0810977 -0.38541362 -0.30387368 -0.191103867 -0.19115041  0.49502820
## 12 -0.5792693 -0.59519572 -0.51462477 -0.290109485 -0.29519430 -1.10143775
## 13 -1.2019838 -0.38541362 -0.19849813 -0.092098249 -0.19115041  0.17573501
## 14 -0.7038122 -0.90986887 -0.72537587 -0.983148811 -0.81541376 -1.84645520
## 15  0.5416168  0.45371477  0.32837962  0.501935459  0.43311295  0.49502820
## 16 -0.3301835 -0.17563152 -0.30387368 -0.191103867 -0.19115041  0.06930395
## 17 -1.3265267 -0.70008677 -0.83075142 -0.884143193 -0.91945765 -1.10143775
## 18 -0.0810977 -0.38541362 -0.19849813 -0.191103867 -0.08710651  0.17573501
## 19  0.1679881  0.24393267  0.32837962  0.204918605  0.22502516  0.06930395
## 20 -1.2019838 -1.32943307 -1.56838026 -1.478176901 -1.64776490 -0.78214456
## 21 -1.2019838 -0.80497782 -0.83075142 -0.488120721 -0.60732598 -0.46285137
## 22 -0.9528980 -1.11965097 -1.25225362 -0.983148811 -1.12754544 -0.56928243
## 23 -2.3228698 -1.74899726 -1.67375581 -2.072210609 -1.64776490 -3.44292115
## 24 -0.3301835 -0.17563152 -0.19849813 -0.092098249 -0.08710651 -0.14355818
## 25  1.0397884  1.08306107  1.06600846  1.095969167  1.05737630  0.81432139
## 26  1.5379600  1.50262526  1.59288620  1.491991639  1.57759577  1.13361458
## 27  0.4170739  0.34882372  0.32837962  0.501935459  0.32906906  0.38859714
## 28  1.1643313  0.97817002  0.85525736  0.996963549  0.95333241  0.92075246
## 29  0.6661597  0.76838792  0.96063291  0.699946695  0.74524463  0.49502820
## 30  1.2888742  1.71240736  1.69826175  1.590997257  1.68163966  1.02718352
## 31  0.4170739  0.76838792  0.96063291  0.402929841  0.53715684  0.49502820
## 32  0.2925310  0.13904162 -0.09312258  0.105912987  0.01693738  0.17573501
## 33  0.7907026  0.97817002  1.06600846  0.798952313  0.95333241  0.81432139
## 34  1.1643313  1.08306107  1.06600846  1.095969167  1.05737630  0.92075246
## 35 -2.0737841 -1.95877936 -1.98988246 -1.973204991 -1.95989658 -1.74002413
## 36  0.7907026  0.76838792  0.64450626  0.600941077  0.64120073  0.06930395
## 37  0.4170739  0.45371477  0.22300407  0.303924223  0.32906906  0.17573501
## 38  0.1679881  0.24393267  0.22300407  0.204918605  0.22502516  0.60145927
## 39 -0.5792693 -0.80497782 -0.83075142 -0.587126339 -0.71136987  0.06930395
## 40  0.9152455  0.24393267  0.11762852  0.204918605  0.32906906  0.17573501
## 41 -0.4547264 -0.59519572 -0.62000032 -0.785137575 -0.81541376 -0.35642031
## 42  0.1679881  0.34882372  0.74988181  0.699946695  0.74524463  0.38859714
## 43  0.1679881 -0.07074048 -0.30387368 -0.389115103 -0.39923819 -0.14355818
##           RTEN
## 1   0.17954551
## 2   0.99700568
## 3   0.17954551
## 4   0.99700568
## 5  -2.54532170
## 6   0.90617677
## 7   1.26949240
## 8  -2.36366389
## 9   1.08783459
## 10  0.27037442
## 11  0.08871661
## 12 -0.36542793
## 13  0.08871661
## 14 -1.00123028
## 15  0.36120333
## 16 -0.00211230
## 17 -0.81957246
## 18 -0.18377011
## 19  0.36120333
```

```
## 20 -1.45537481
## 21 -0.27459902
## 22 -0.91040137
## 23 -2.18200607
## 24 -0.00211230
## 25  0.99700568
## 26  1.26949240
## 27  0.54286114
## 28  0.99700568
## 29  0.45203224
## 30  1.45115021
## 31 -0.09294121
## 32  0.27037442
## 33  0.63369005
## 34  1.08783459
## 35 -2.09117716
## 36  0.54286114
## 37  0.36120333
## 38  0.08871661
## 39 -0.54708574
## 40  0.27037442
## 41 -0.91040137
## 42  0.45203224
## 43 -0.45625684
```

1. How many principal components do you believe should be retained. Justify your answer by looking at the variation in the data explained by each component.
2. In your own words, describe what you believe the first principal component is measuring.
3. What do you think the second principal component represents?
4. You are told *Judicial Integrity* and *Demeanour* are particularly important traits, and should be given 5 times the weight of the other variables. Re-run the Principal Component Analysis such that Integrity and Demeanour is given 5 times the weight of all other variables. What impact does this have?

Factor Analysis for the Rating Data

Perform Factor Analysis on the standardised Ratings Data.

1. What happens when you try to fit a 3 and a 4 factor solution with no rotation. Hint: For the three factor solution, you may need to add `control=list(nstart=100)` as an additional argument in the `factanal` function.
2. Which variables are grouped by the first two factors? (e.g. threshold |loading| ≥ 0.25)
3. Compare the factor loadings for the first two factors to the first two principal components of the standardised data found in the previous section. Comment on any similarities and/or differences.
4. Comment on the observed variable specific variances (the uniquenesses). Do you believe all observed variables are explained by the factors discovered.
5. Re-fit the 3 factor solution with a varimax rotation. How does this change the interpretation of the factors? In this case, do you find the rotated or non-rotated solution easier to interpret. Explain why or why not?