

Canonical Correlation Analysis I

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1 Preliminaries

The RStudio workspace and console panes are cleared of old output, variables, and other miscellaneous debris. Then some packages are loaded and the required data files are input.

1.1 Clear the Console Panes and Load Packages

```
options(replace.assign = TRUE, width = 65, digits = 4, scipen = 4, fig.width = 4,
        fig.height = 4)
# Clear the workspace and console.
rm(list = ls(all = TRUE))
cat("\f")
```

```
# Turn off showing of significance asterisks.
options(show.signif.stars = F)
# Set the contrast option; important for ANOVAs.
options(contrasts = c("contr.sum", "contr.poly"))
how_long <- Sys.time()
set.seed(123)
library(knitr)
```

```
library(psych)

## Warning: package 'psych' was built under R version 3.5.1

library(ggplot2)

## Warning: package 'ggplot2' was built under R version 3.5.1
##
## Attaching package: 'ggplot2'
## The following objects are masked from 'package:psych':
##
##    %+%, alpha

library(MASS)

## Warning: package 'MASS' was built under R version 3.5.1

library(sciplot)
library(dplyr)
```

```

## Warning: package 'dplyr' was built under R version 3.5.1
##
## Attaching package: 'dplyr'
## The following object is masked from 'package:MASS':
##
## select
## The following objects are masked from 'package:stats':
##
## filter, lag
## The following objects are masked from 'package:base':
##
## intersect, setdiff, setequal, union

library(aod)
library(MVN)

## sROC 0.1-2 loaded

library(boot)

##
## Attaching package: 'boot'
## The following object is masked from 'package:psych':
##
## logit

library(car)

## Warning: package 'car' was built under R version 3.5.1
## Loading required package: carData
## Warning: package 'carData' was built under R version 3.5.1
##
## Attaching package: 'car'
## The following object is masked from 'package:boot':
##
## logit
## The following object is masked from 'package:dplyr':
##
## recode
## The following object is masked from 'package:psych':
##
## logit

library(LogisticDx)
library(biotools)

## Loading required package: rpanel
## Loading required package: tcltk
## Package 'rpanel', version 1.1-4: type help(rpanel) for summary information
##
## Attaching package: 'rpanel'
## The following object is masked from 'package:boot':
##
## poisons
## Loading required package: tkrplot
## Warning: package 'tkrplot' was built under R version 3.5.1
## Loading required package: lattice

```

```

## Warning: package 'lattice' was built under R version 3.5.1
##
## Attaching package: 'lattice'
## The following object is masked from 'package:boot':
##
##     melanoma
## Loading required package: SpatialEpi
## Loading required package: sp
## ---
## biotools version 3.1
##

library(multcomp)

## Loading required package: mvtnorm
## Loading required package: survival
## Warning: package 'survival' was built under R version 3.5.1
##
## Attaching package: 'survival'
## The following object is masked from 'package:boot':
##
##     aml
## The following object is masked from 'package:aod':
##
##     rats
## Loading required package: TH.data
## Warning: package 'TH.data' was built under R version 3.5.1
##
## Attaching package: 'TH.data'
## The following object is masked from 'package:MASS':
##
##     geyser

library(candisc)

## Loading required package: heplots
##
## Attaching package: 'heplots'
## The following object is masked from 'package:biotools':
##
##     boxM
##
## Attaching package: 'candisc'
## The following object is masked from 'package:stats':
##
##     cancel

library(ez)
library(GGally)

##
## Attaching package: 'GGally'
## The following object is masked from 'package:dplyr':
##
##     nasa

```

```

library(qqplotr)

## Warning: package 'qqplotr' was built under R version 3.5.1
##
## Attaching package: 'qqplotr'
## The following objects are masked from 'package:ggplot2':
##
##   stat_qq_line, StatQqLine

library(gridExtra)

##
## Attaching package: 'gridExtra'
## The following object is masked from 'package:dplyr':
##
##   combine

library(reshape)

## Warning: package 'reshape' was built under R version 3.5.1
##
## Attaching package: 'reshape'
## The following object is masked from 'package:dplyr':
##
##   rename

library(emmeans)

## Warning: package 'emmeans' was built under R version 3.5.1
##
## Attaching package: 'emmeans'
## The following object is masked from 'package:GGally':
##
##   pigs
## The following object is masked from 'package:multcomp':
##
##   cld

library(profileR)

## Warning: package 'profileR' was built under R version 3.5.1
## Loading required package: RColorBrewer
## Loading required package: lavaan
## Warning: package 'lavaan' was built under R version 3.5.1
## This is lavaan 0.6-3
## lavaan is BETA software! Please report any bugs.
##
## Attaching package: 'lavaan'
## The following object is masked from 'package:psych':
##
##   cor2cov

library(Rmisc)

## Loading required package: plyr
## -----
## You have loaded plyr after dplyr - this is likely to cause problems.
## If you need functions from both plyr and dplyr, please load plyr first, then dplyr:
## library(plyr); library(dplyr)

```

```
## -----
##
## Attaching package: 'plyr'
## The following objects are masked from 'package:reshape':
##
##   rename, round_any
## The following objects are masked from 'package:dplyr':
##
##   arrange, count, desc, failwith, id, mutate, rename,
##   summarise, summarize
```

1.2 Data

```
setwd("C:\\Courses\\Psychology 516\\PowerPoint\\2018")

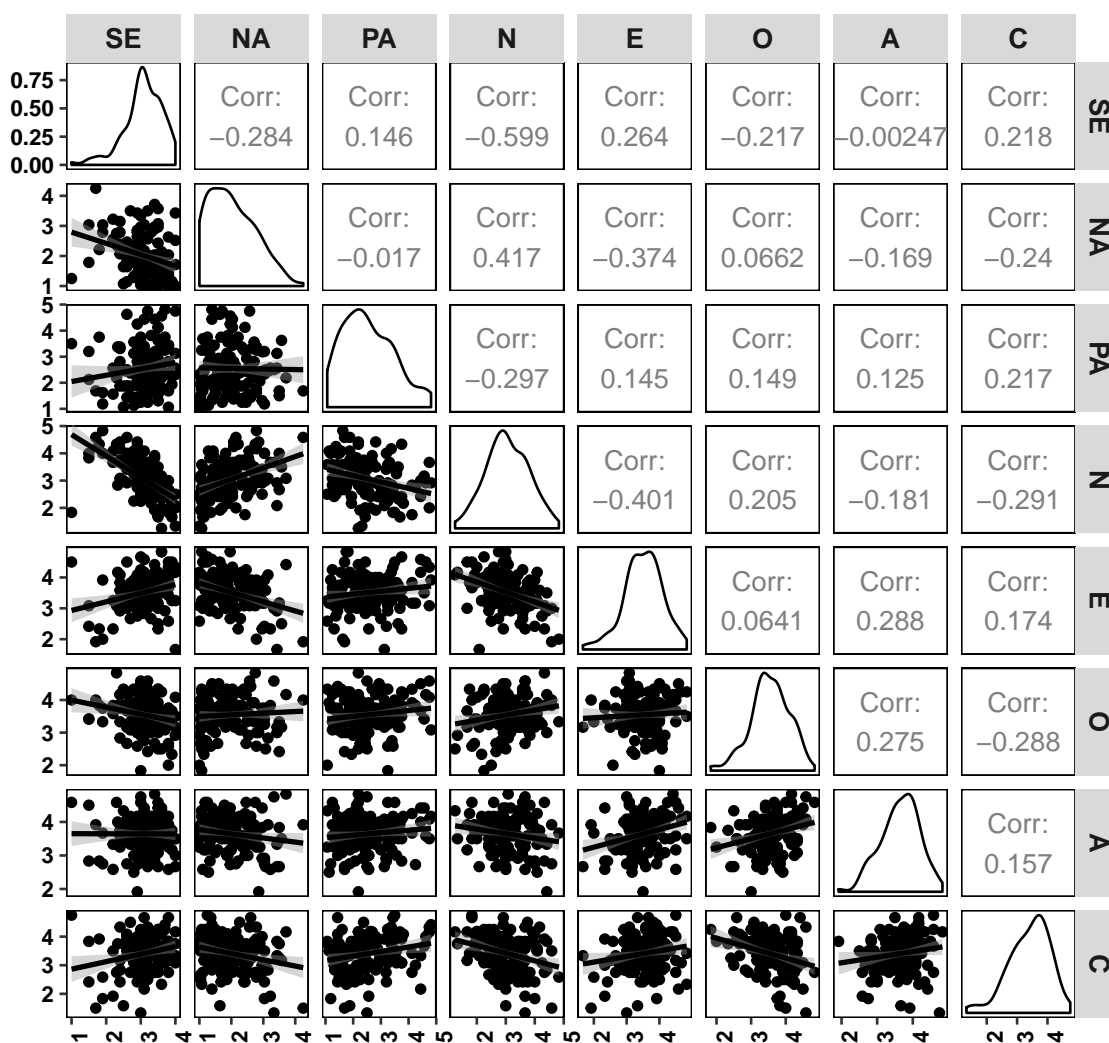
# Get the data for the main MANOVA examples.
CCA <- read.table("cancorr_neo.csv", sep = ",", header = TRUE)
CCA <- as.data.frame(CCA)
```

1.3 Basic Visualization

The basic nature of the data is easily viewed with some simple graphics.

```
ggpairs(CCA[2:9], lower = list(continuous = "smooth"), upper = list(continuous = "cor"),
  columnLabels = c("SE", "NA", "PA", "N", "E", "O", "A", "C")) +
  theme(text = element_text(size = 14, family = "sans", color = "black",
    face = "bold"), axis.text.y = element_text(colour = "black",
    size = 9, face = "bold"), axis.text.x = element_text(colour = "black",
    size = 9, face = "bold", angle = 90), axis.title.x = element_text(margin = margin(15,
    0, 0, 0), size = 16), axis.title.y = element_text(margin = margin(0,
    15, 0, 0), size = 16), axis.line.x = element_blank(), axis.line.y = element_blank(),
    plot.title = element_text(size = 16, face = "bold", margin = margin(0,
    0, 20, 0), hjust = 0.5), panel.background = element_rect(fill = "white",
    linetype = 1, color = "black"), panel.grid.major = element_blank(),
    panel.grid.minor = element_blank(), plot.background = element_rect(fill = "white"),
    plot.margin = unit(c(1, 1, 1, 1), "cm"), legend.position = "bottom",
    legend.title = element_blank()) + ggtitle("Correlations Among Measures")
```

Correlations Among Measures



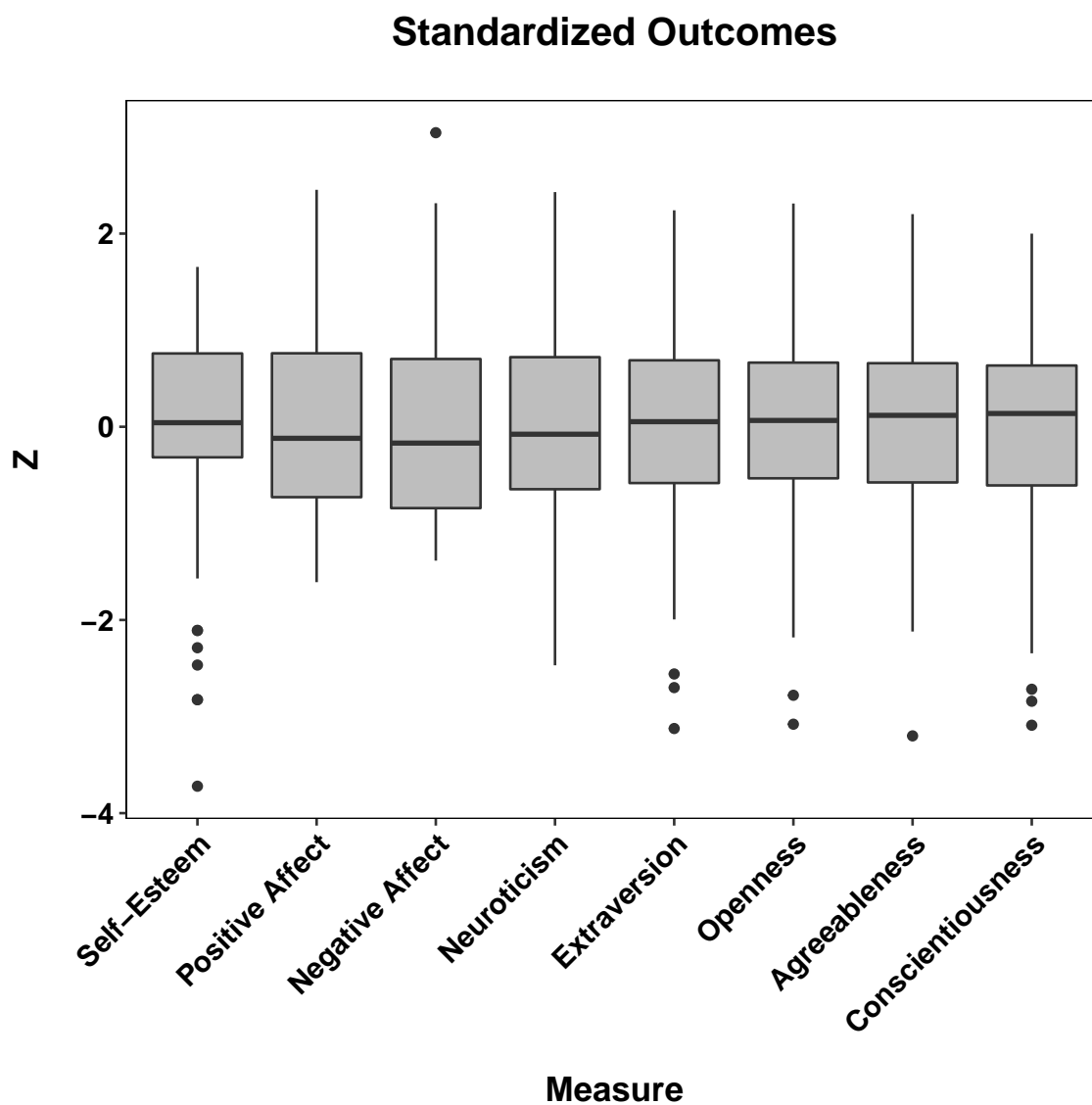
```
CCA_Z <- scale(CCA[-1])
plot_data <- melt(CCA_Z)
plot_data <- as.data.frame(plot_data)
names(plot_data) <- c("Case", "Measure", "Z")
plot_data$Measure_F <- factor(plot_data$Measure, levels = c("rosen_se",
  "panas_p", "panas_n", "neo_n", "neo_e", "neo_o", "neo_a", "neo_c"),
  labels = c("Self-Esteem", "Positive Affect", "Negative Affect",
    "Neuroticism", "Extraversion", "Openness", "Agreeableness",
    "Conscientiousness"))

ggplot(plot_data, aes(x = Measure_F, y = Z)) + geom_boxplot(fill = "gray") +
  ylab("Z") + xlab("Measure") + theme(text = element_text(size = 14,
    family = "sans", color = "black", face = "bold"), axis.text.y = element_text(colour = "black",
    size = 12, face = "bold"), axis.text.x = element_text(colour = "black",
```

```

size = 12, face = "bold", angle = 45, hjust = 1), axis.title.x = element_text(margin = margin(15,
0, 0, 0), size = 14), axis.title.y = element_text(margin = margin(0,
15, 0, 0), size = 14), axis.line.x = element_blank(), axis.line.y = element_blank(),
plot.title = element_text(size = 16, face = "bold", margin = margin(0,
0, 20, 0), hjust = 0.5), panel.background = element_rect(fill = "white",
linetype = 1, color = "black"), panel.grid.major = element_blank(),
panel.grid.minor = element_blank(), plot.background = element_rect(fill = "white"),
plot.margin = unit(c(1, 1, 1, 1), "cm"), legend.position = "bottom",
legend.title = element_blank()) + ggtitle("Standardized Outcomes")

```



2 Multivariate Normality Assumption

2.1 Full Sample

```
mvn(CCA[, 2:9], mvnTest = "mardia")

## $multivariateNormality
##           Test           Statistic           p value Result
## 1 Mardia Skewness 299.119034297691 2.71647280885726e-17    NO
## 2 Mardia Kurtosis  7.1931311285724 6.33271213246189e-13    NO
## 3              MVN              <NA>              <NA>    NO
##
## $univariateNormality
##           Test Variable Statistic    p value Normality
## 1 Shapiro-Wilk rosen_se      0.9457    0.0001      NO
## 2 Shapiro-Wilk panas_n      0.9529    0.0002      NO
## 3 Shapiro-Wilk panas_p      0.9617    0.0013      NO
## 4 Shapiro-Wilk neo_n        0.9934    0.8261      YES
## 5 Shapiro-Wilk neo_e        0.9848    0.1705      YES
## 6 Shapiro-Wilk neo_o        0.9853    0.1906      YES
## 7 Shapiro-Wilk neo_a        0.9859    0.2162      YES
## 8 Shapiro-Wilk neo_c        0.9712    0.0085      NO
##
## $Descriptives
##           n Mean Std.Dev Median   Min   Max 25th 75th
## rosen_se 126 3.076  0.5580  3.100 1.000 4.000 2.900 3.500
## panas_n  126 2.017  0.7336  1.893 1.000 4.250 1.399 2.531
## panas_p  126 2.548  0.9232  2.438 1.062 4.812 1.875 3.250
## neo_n    126 3.056  0.7314  3.000 1.250 4.833 2.583 3.583
## neo_e    126 3.510  0.5902  3.542 1.667 4.833 3.167 3.917
## neo_o    126 3.547  0.5565  3.583 1.833 4.833 3.250 3.917
## neo_a    126 3.645  0.5399  3.708 1.917 4.833 3.333 4.000
## neo_c    126 3.408  0.6713  3.500 1.333 4.750 3.000 3.833
##
##           Skew Kurtosis
## rosen_se -0.89779  1.25663
## panas_n   0.55904 -0.42080
## panas_p   0.51108 -0.46035
## neo_n     0.01739 -0.38834
## neo_e     -0.35119  0.39208
## neo_o     -0.33584  0.14004
## neo_a     -0.34782 -0.08027
## neo_c     -0.61659  0.31163

CV <- cov(CCA[, 2:9])
D2_1 <- mahalanobis(CCA[, 2:9], center = colMeans(CCA[, 2:9]), cov = CV)
D2_1 <- as.data.frame(D2_1)
ggplot(D2_1, aes(sample = D2_1)) + stat_qq_band(distribution = "chisq",
  dparams = list(df = 8)) + stat_qq_line(distribution = "chisq",
  dparams = list(df = 8)) + stat_qq(distribution = "qchisq", dparams = list(df = 8)) +
  scale_y_continuous(breaks = seq(0, 45, 5)) + scale_x_continuous(breaks = seq(0,
  25, 5)) + coord_cartesian(xlim = c(0, 25), ylim = c(0, 45)) +
  xlab(expression("Expected Values from" * ~chi[8]^2)) + ylab(expression("Mahalanobis " *
  ~D^2)) + theme(text = element_text(size = 14, family = "sans",
```

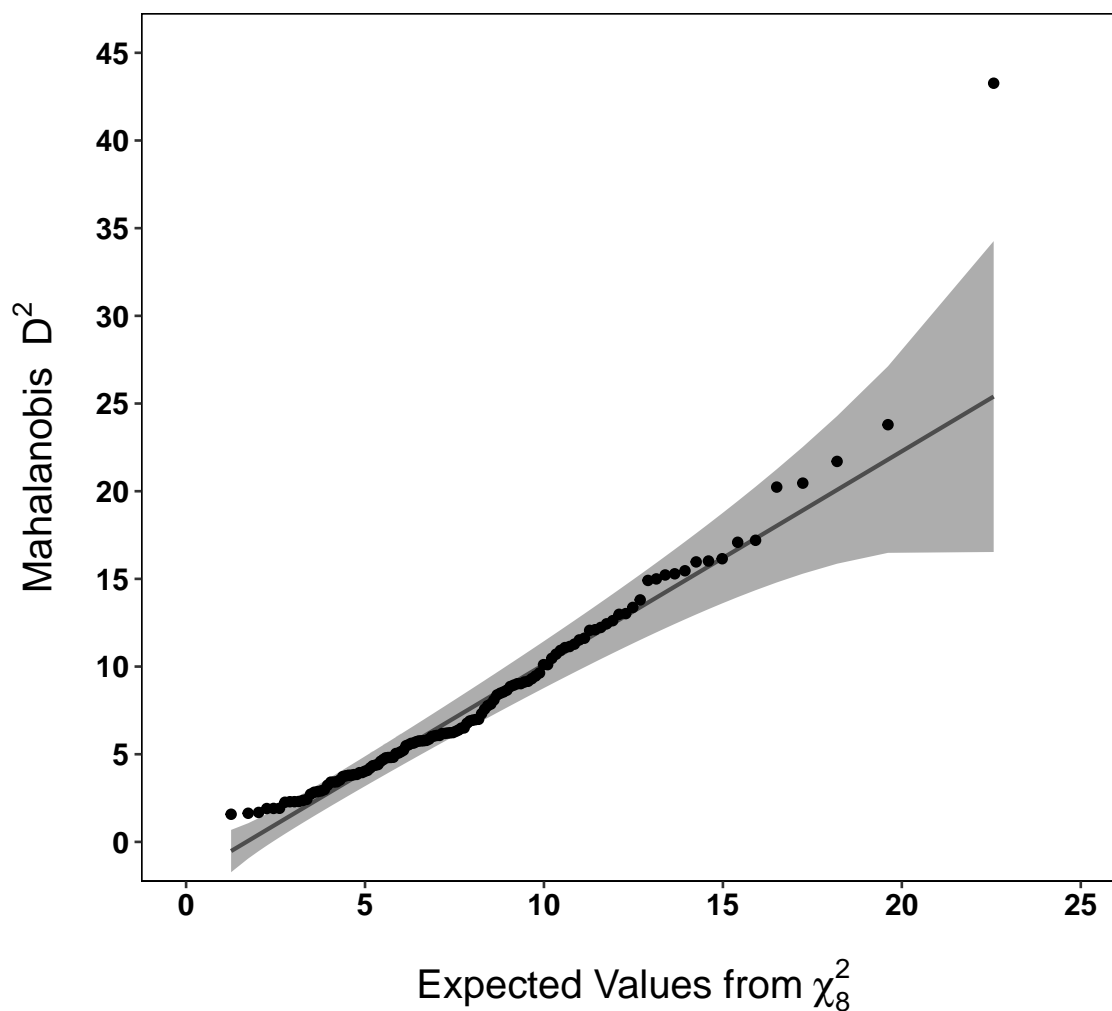


```

color = "black", face = "bold"), axis.text.y = element_text(colour = "black",
size = 12, face = "bold"), axis.text.x = element_text(colour = "black",
size = 12, face = "bold", angle = 0), axis.title.x = element_text(margin = margin(15,
0, 0, 0), size = 16), axis.title.y = element_text(margin = margin(0,
15, 0, 0), size = 16), axis.line.x = element_blank(), axis.line.y = element_blank(),
plot.title = element_text(size = 16, face = "bold", margin = margin(0,
0, 20, 0), hjust = 0.5), panel.background = element_rect(fill = "white",
linetype = 1, color = "black"), panel.grid.major = element_blank(),
panel.grid.minor = element_blank(), plot.background = element_rect(fill = "white"),
plot.margin = unit(c(1, 1, 1, 1), "cm"), legend.position = "bottom",
legend.title = element_blank()) + ggtitle(expression("Q-Q Plot of Mahalanobis" *
~D^2 * " vs. Quantiles of" * ~chi[8]^2))

```

Q-Q Plot of Mahalanobis D^2 vs. Quantiles of χ_8^2



2.2 Outlier Excluded

```
CCA$D2_1 <- D2_1
CCA_Trimmed <- CCA[which(CCA$D2_1 != max(CCA$D2_1)), ]

mvn(CCA_Trimmed[, 2:9], mvnTest = "mardia")

## $multivariateNormality
##           Test           Statistic           p value Result
## 1 Mardia Skewness 205.806610974633 0.0000018153144861216    NO
## 2 Mardia Kurtosis 3.33221975072556 0.000861561958803936    NO
## 3           MVN           <NA>           <NA>    NO
##
## $univariateNormality
##           Test Variable Statistic   p value Normality
## 1 Shapiro-Wilk rosen_se      0.9589   0.0008    NO
## 2 Shapiro-Wilk panas_n      0.9543   0.0003    NO
## 3 Shapiro-Wilk panas_p      0.9606   0.0011    NO
## 4 Shapiro-Wilk neo_n       0.9935   0.8380    YES
## 5 Shapiro-Wilk neo_e       0.9844   0.1612    YES
## 6 Shapiro-Wilk neo_o       0.9853   0.1948    YES
## 7 Shapiro-Wilk neo_a       0.9855   0.2042    YES
## 8 Shapiro-Wilk neo_c       0.9669   0.0037    NO
##
## $Descriptives
##           n Mean Std.Dev Median   Min   Max 25th 75th
## rosen_se 125 3.093  0.5280  3.100 1.500 4.000 2.900 3.500
## panas_n  125 2.023  0.7333  1.893 1.000 4.250 1.417 2.536
## panas_p  125 2.540  0.9229  2.438 1.062 4.812 1.875 3.250
## neo_n    125 3.066  0.7261  3.000 1.250 4.833 2.583 3.583
## neo_e    125 3.503  0.5858  3.500 1.667 4.833 3.167 3.917
## neo_o    125 3.543  0.5573  3.583 1.833 4.833 3.250 3.917
## neo_a    125 3.637  0.5355  3.667 1.917 4.833 3.333 4.000
## neo_c    125 3.397  0.6631  3.500 1.333 4.667 3.000 3.833
##
##           Skew Kurtosis
## rosen_se -0.67507  0.51642
## panas_n   0.54845 -0.42426
## panas_p   0.53140 -0.42896
## neo_n     0.01604 -0.35486
## neo_e    -0.36034  0.43692
## neo_o    -0.32212  0.13615
## neo_a    -0.36084 -0.05427
## neo_c    -0.66322  0.32854

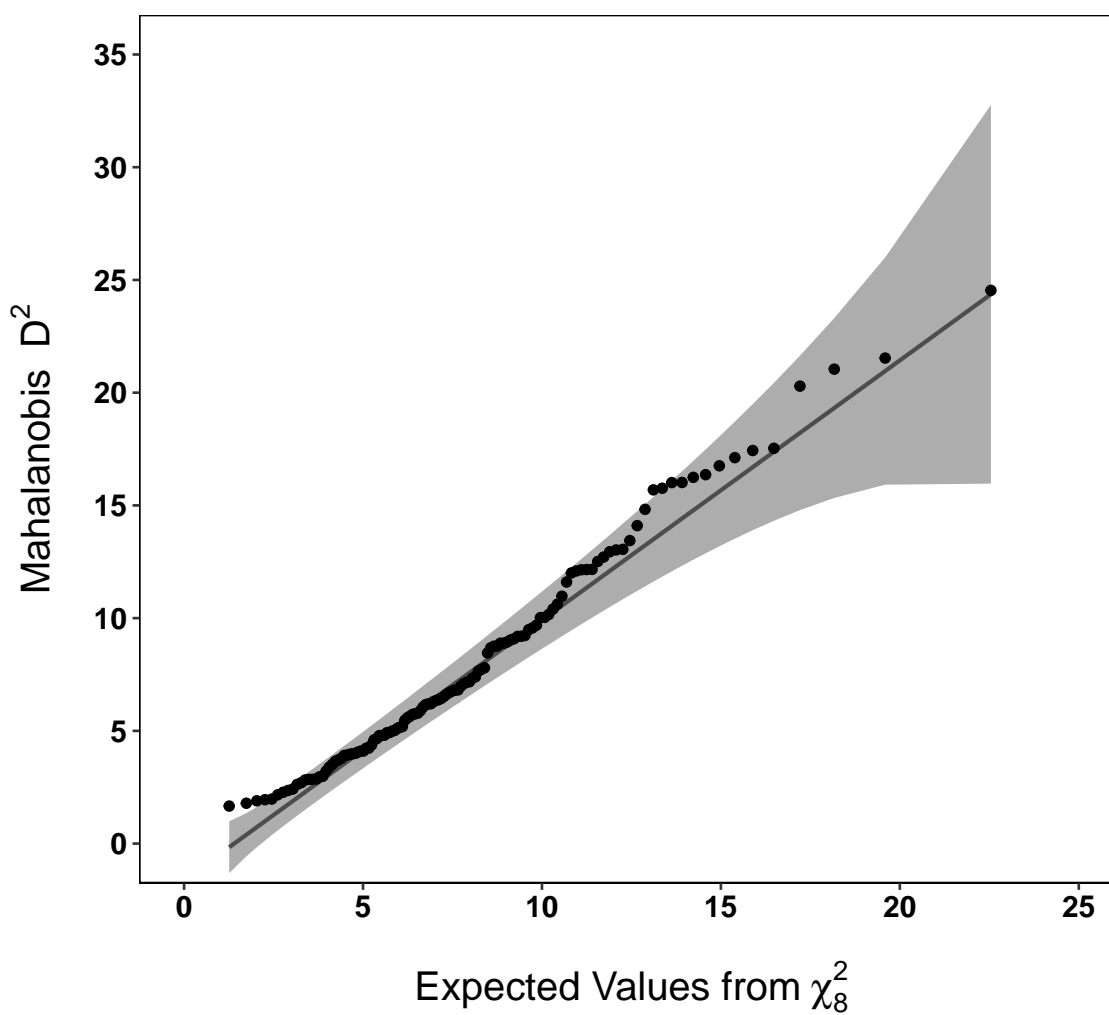
CV <- cov(CCA_Trimmed[, 2:9])
D2_1 <- mahalanobis(CCA_Trimmed[, 2:9], center = colMeans(CCA_Trimmed[,
2:9]), cov = CV)
D2_1 <- as.data.frame(D2_1)
ggplot(D2_1, aes(sample = D2_1)) + stat_qq_band(distribution = "chisq",
dparams = list(df = 8)) + stat_qq_line(distribution = "chisq",
dparams = list(df = 8)) + stat_qq(distribution = "qchisq", dparams = list(df = 8)) +
scale_y_continuous(breaks = seq(0, 35, 5)) + scale_x_continuous(breaks = seq(0,
25, 5)) + coord_cartesian(xlim = c(0, 25), ylim = c(0, 35)) +
```

```

xlab(expression("Expected Values from" * ~chi[8]^2)) + ylab(expression("Mahalanobis " *
~D^2)) + theme(text = element_text(size = 14, family = "sans",
color = "black", face = "bold"), axis.text.y = element_text(colour = "black",
size = 12, face = "bold"), axis.text.x = element_text(colour = "black",
size = 12, face = "bold", angle = 0), axis.title.x = element_text(margin = margin(15,
0, 0, 0), size = 16), axis.title.y = element_text(margin = margin(0,
15, 0, 0), size = 16), axis.line.x = element_blank(), axis.line.y = element_blank(),
plot.title = element_text(size = 16, face = "bold", margin = margin(0,
0, 20, 0), hjust = 0.5), panel.background = element_rect(fill = "white",
linetype = 1, color = "black"), panel.grid.major = element_blank(),
panel.grid.minor = element_blank(), plot.background = element_rect(fill = "white"),
plot.margin = unit(c(1, 1, 1, 1), "cm"), legend.position = "bottom",
legend.title = element_blank()) + ggtitle(expression("Q-Q Plot of Mahalanobis" *
~D^2 * " vs. Quantiles of" * ~chi[8]^2))

```

Q-Q Plot of Mahalanobis D^2 vs. Quantiles of χ_8^2



```

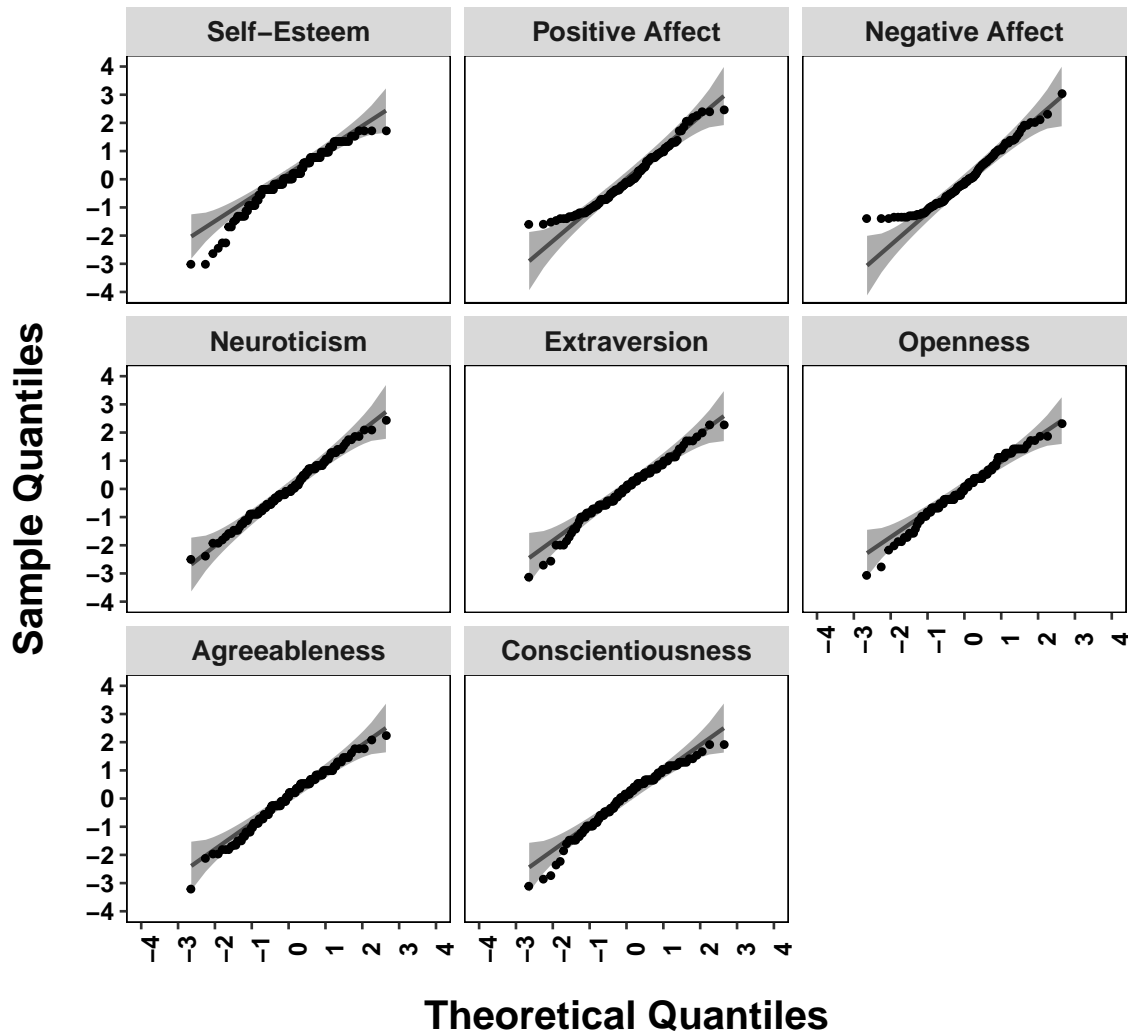
CCA_Trimmed_QQ <- scale(CCA_Trimmed[, 2:9])
plot_data <- melt(CCA_Trimmed_QQ)

names(plot_data) <- c("Case", "Measure", "Z")
plot_data$Measure_F <- factor(plot_data$Measure, levels = c("rosen_se",
  "panas_p", "panas_n", "neo_n", "neo_e", "neo_o", "neo_a", "neo_c"),
  labels = c("Self-Esteem", "Positive Affect", "Negative Affect",
    "Neuroticism", "Extraversion", "Openness", "Agreeableness",
    "Conscientiousness"))

p <- ggplot(plot_data, aes(sample = Z)) + stat_qq_band() + stat_qq_line() +
  stat_qq(distribution = qnorm, size = 1) + scale_y_continuous(breaks = seq(-4,
  4, 1)) + scale_x_continuous(breaks = seq(-4, 4, 1)) + coord_cartesian(xlim = c(-4,
  4), ylim = c(-4, 4)) + xlab("Theoretical Quantiles") + ylab("Sample Quantiles") +
  theme(text = element_text(size = 14, family = "sans", color = "black",
    face = "bold"), axis.text.y = element_text(colour = "black",
    size = 10, face = "bold"), axis.text.x = element_text(colour = "black",
    size = 10, face = "bold", angle = 90), axis.title.x = element_text(margin = margin(15,
    0, 0, 0), size = 16), axis.title.y = element_text(margin = margin(0,
    15, 0, 0), size = 16), axis.line.x = element_blank(), axis.line.y = element_blank(),
    plot.title = element_text(size = 16, face = "bold", margin = margin(0,
    0, 20, 0), hjust = 0.5), panel.background = element_rect(fill = "white",
    linetype = 1, color = "black"), panel.grid.major = element_blank(),
    panel.grid.minor = element_blank(), plot.background = element_rect(fill = "white"),
    plot.margin = unit(c(1, 1, 1, 1), "cm"), legend.position = "bottom",
    legend.title = element_blank()) + ggtitle("Q-Q Plots for Measures")
p + facet_wrap(~Measure_F)

```

Q-Q Plots for Measures



The QQ-plot looks good but we still violate multivariate normality. It would probably be prudent to verify any claims about significance with a bootstrap or permutation test.

3 Correlations

The correlations among the variables can be examined to detect simple patterns and to get a sense of the relations across sets.

```
cor(CCA_Trimmed[, 5:9])
```

	neo_n	neo_e	neo_o	neo_a	neo_c
neo_n	1.0000	-0.38685	0.21904	-0.1611	-0.2719
neo_e	-0.3869	1.00000	0.05385	0.2711	0.1508
neo_o	0.2190	0.05385	1.00000	0.2680	-0.3069

```
## neo_a -0.1611  0.27112  0.26800  1.0000  0.1331
## neo_c -0.2719  0.15075 -0.30690  0.1331  1.0000

cor(CCA_Trimmed[, 2:4])

##          rosen_se  panas_n  panas_p
## rosen_se    1.0000 -0.336316  0.188864
## panas_n    -0.3363  1.000000 -0.008335
## panas_p     0.1889 -0.008335  1.000000

cor(CCA_Trimmed[, 2:4], CCA_Trimmed[, 5:9])

##          neo_n  neo_e  neo_o  neo_a  neo_c
## rosen_se -0.6966  0.3371 -0.20468  0.05339  0.2999
## panas_n   0.4093 -0.3656  0.07355 -0.15647 -0.2283
## panas_p  -0.2875  0.1332  0.14284  0.11280  0.2043
```

4 Canonical Correlation Analysis

A simple canonical correlation analysis can be conducted using the `cancor()` function from the `candisc` package.

```
CCA_1 <- cancor(cbind(rosen_se, panas_n, panas_p) ~ neo_n + neo_e +
  neo_o + neo_a + neo_c, data = CCA_Trimmed, prefix = c("NEO", "Well-Being"),
  standardize = TRUE)
CCA_2 <- cancor(cbind(neo_n, neo_e, neo_o, neo_a, neo_c) ~ rosen_se +
  panas_n + panas_p, data = CCA_Trimmed, prefix = c("Well-Being",
  "NEO"), standardize = TRUE)
CCA_1

##
## Canonical correlation analysis of:
## 5 X variables: neo_n, neo_e, neo_o, neo_a, neo_c
## with 3 Y variables: rosen_se, panas_n, panas_p
##
##      CanR  CanRSQ  Eigen percent  cum
## 1 0.7715 0.59514 1.46997 91.875 91.87
## 2 0.2851 0.08127 0.08846 5.529 97.40
## 3 0.1997 0.03989 0.04155 2.597 100.00
##
##              scree
## 1 *****
## 2 **
## 3 *
##
## Test of H0: The canonical correlations in the
## current row and all that follow are zero
##
##      CanR LR test stat approx F numDF denDF Pr(> F)
## 1 0.771      0.357    9.75    15    323 <2e-16
## 2 0.285      0.882    1.91     8    236  0.059
## 3 0.200      0.960    1.65     3    119  0.182

CCA_1$coef
```

```

## $X
##          NEO1      NEO2      NEO3
## neo_n -1.1781  0.09616  0.85933
## neo_e  0.3142 -0.11932  1.56070
## neo_o  0.1703  1.74253 -0.66598
## neo_a -0.1608  0.18465  0.80840
## neo_c  0.3678  0.85769 -0.08445
##
## $Y
##          Well_Being1 Well_Being2 Well_Being3
## rosen_se          1.4263      -1.1365      -0.9394
## panas_n          -0.4516      -0.3591      -1.3310
## panas_p           0.2981       1.0199      -0.3044

CCA_1$structure

## $X.xscores
##          NEO1      NEO2      NEO3
## neo_n -0.9582  0.13900  0.13441
## neo_e  0.5335  0.06792  0.76190
## neo_o -0.1804  0.83456 -0.05204
## neo_a  0.1595  0.40462  0.47332
## neo_c  0.4636  0.25432  0.08372
##
## $Y.xscores
##          NEO1      NEO2      NEO3
## rosen_se  0.7070 -0.09514 -0.04411
## panas_n  -0.4526 -0.01978 -0.16115
## panas_p   0.3241  0.23666 -0.07320
##
## $X.yscores
##          Well_Being1 Well_Being2 Well_Being3
## neo_n      -0.7392      0.03963      0.02685
## neo_e       0.4116      0.01936      0.15217
## neo_o      -0.1392      0.23791     -0.01039
## neo_a       0.1230      0.11535      0.09454
## neo_c       0.3576      0.07250      0.01672
##
## $Y.yscores
##          Well_Being1 Well_Being2 Well_Being3
## rosen_se       0.9164     -0.33373     -0.2209
## panas_n      -0.5867     -0.06938     -0.8068
## panas_p       0.4201      0.83018     -0.3665

coef(CCA_1, type = "both", standardize = TRUE)

## [[1]]
##          NEO1      NEO2      NEO3
## neo_n -0.85535  0.06982  0.6239
## neo_e  0.18407 -0.06990  0.9143
## neo_o  0.09491  0.97106 -0.3711
## neo_a -0.08610  0.09887  0.4329
## neo_c  0.24388  0.56869 -0.0560
##
## [[2]]

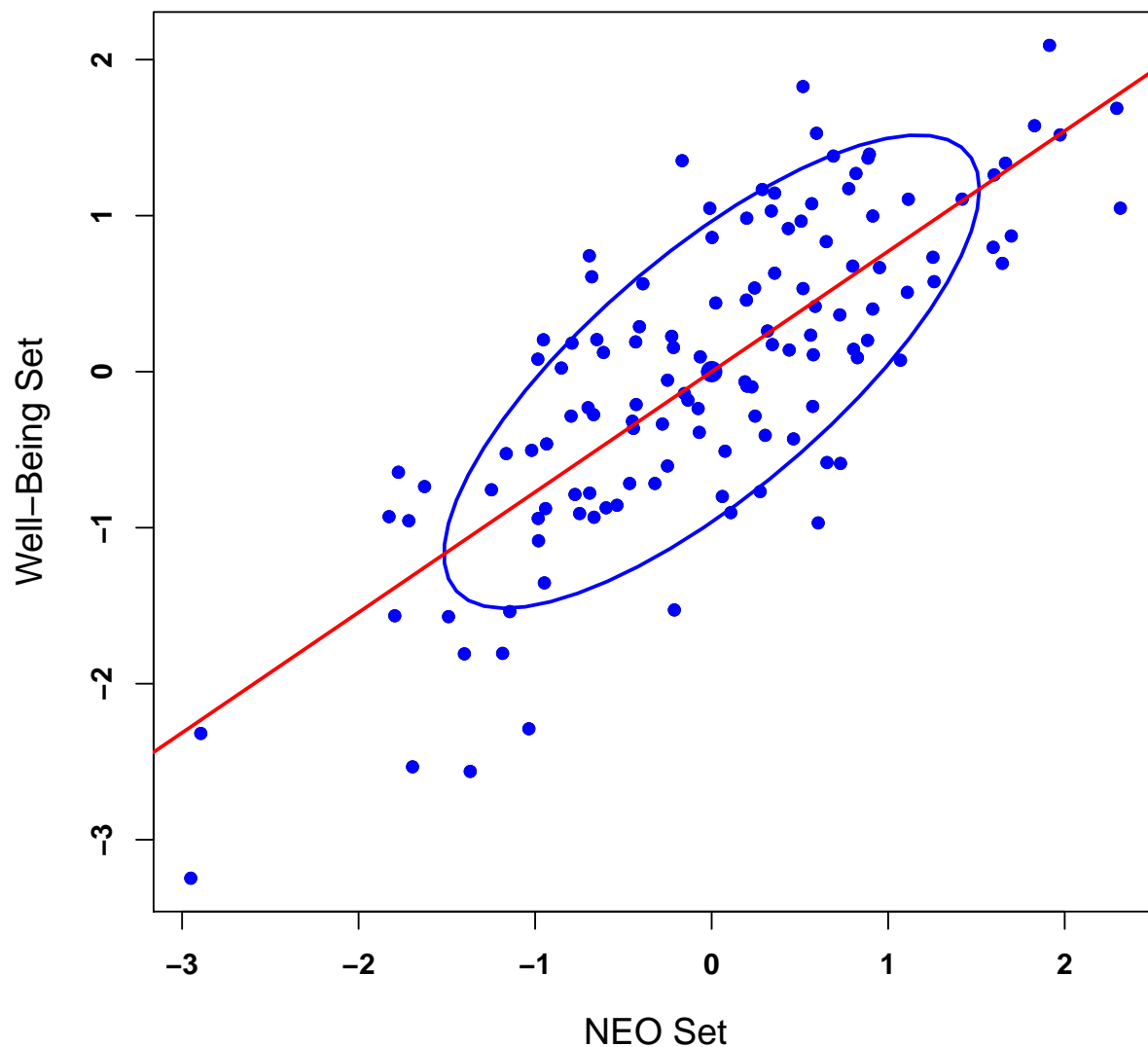
```

```
##          Well_Being1 Well_Being2 Well_Being3
## rosen_se      0.7531     -0.6001     -0.496
## panas_n       -0.3311     -0.2633     -0.976
## panas_p        0.2751      0.9413     -0.281

CCA_1_Scores <- cbind(CCA_1$scores$X, CCA_1$scores$Y)

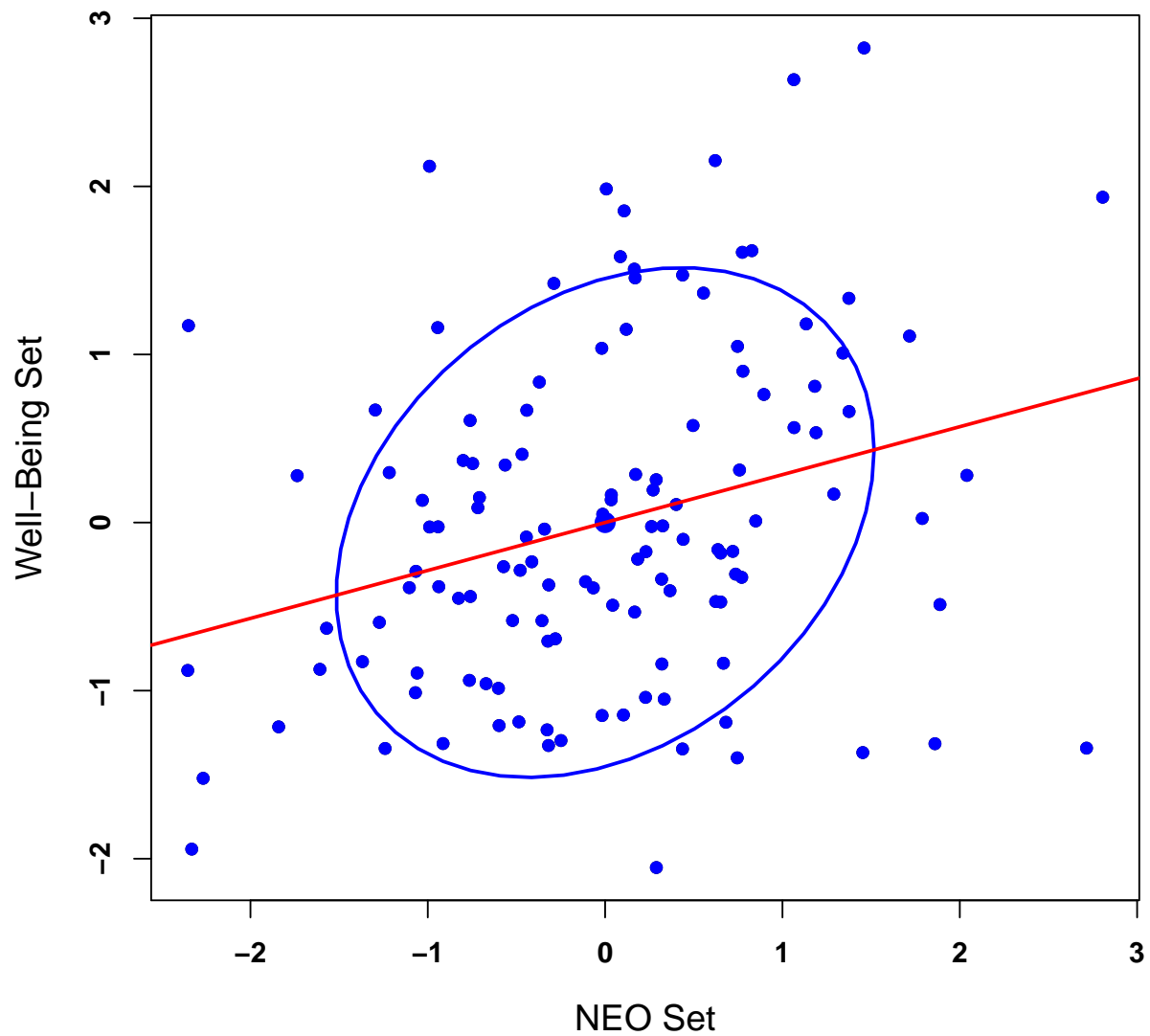
plot(CCA_1, which = 1, main = list("First Canonical Functions", cex = 1.5),
     xlab = list("NEO Set", cex = 1.25), ylab = list("Well-Being Set",
     cex = 1.25), font.axis = 2, pch = 16, col = "blue")
```

First Canonical Functions



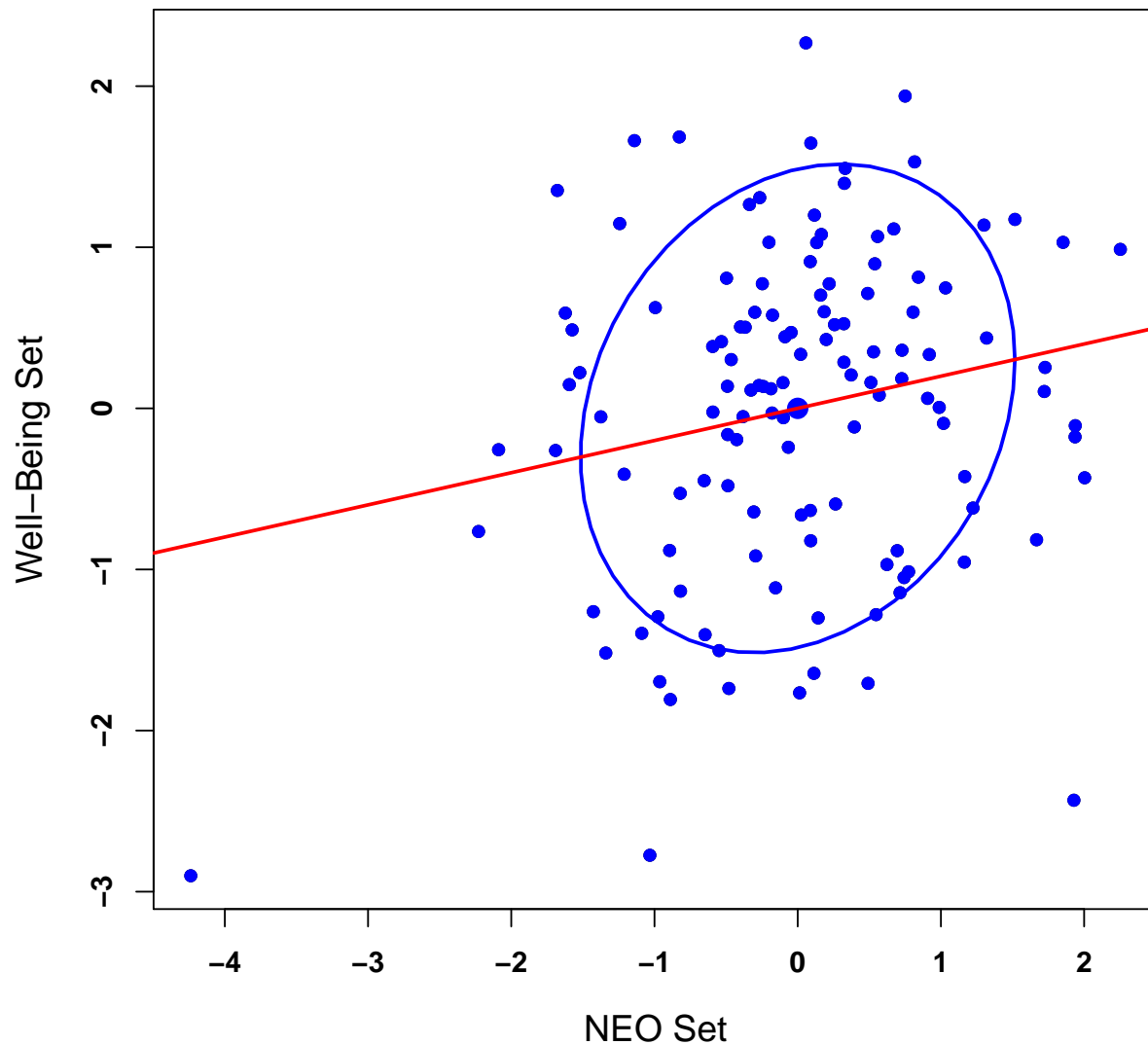
```
plot(CCA_1, which = 2, main = list("Second Canonical Functions", cex = 1.5),
     xlab = list("NEO Set", cex = 1.25), ylab = list("Well-Being Set",
     cex = 1.25), font.axis = 2, pch = 16, col = "blue")
```


Second Canonical Functions



```
plot(CCA_1, which = 3, main = list("Third Canonical Functions", cex = 1.5),  
      xlab = list("NEO Set", cex = 1.25), ylab = list("Well-Being Set",  
      cex = 1.25), font.axis = 2, pch = 16, col = "blue")
```

Third Canonical Functions



```
Well_Being_Loadings <- CCA_1$structure$Y.scores
NEO_Loadings <- CCA_1$structure$X.scores

(Well_Being_Communalities <- rowSums((Well_Being_Loadings)^2))

## rosen_se panas_n panas_p
##      1      1      1

(NEO_Communalities <- rowSums((NEO_Loadings)^2))

## neo_n neo_e neo_o neo_a neo_c
## 0.9555 0.8697 0.7318 0.4132 0.2866

(Well_Being_Adequacy <- colSums((Well_Being_Loadings)^2)/length(Well_Being_Loadings[,
1]))
```

```

## Well_Being1 Well_Being2 Well_Being3
##      0.4535      0.2685      0.2780

(NEO_Adequacy <- colSums((NEO_Loadings)^2)/length(NEO_Loadings[, 1]))

##      NEO1      NEO2      NEO3
## 0.2951 0.1898 0.1665

(Well_Being_Redundancy <- Well_Being_Adequacy * (CCA_1$cancor)^2)

## Well_Being1 Well_Being2 Well_Being3
##      0.26990      0.02182      0.01109

(NEO_Redundancy <- NEO_Adequacy * (CCA_1$cancor)^2)

##      NEO1      NEO2      NEO3
## 0.17565 0.01542 0.00664

redundancy(CCA_1)

##
## Redundancies for the X variables & total X canonical redundancy
##
##      NEO1      NEO2      NEO3 total X|Y
## 0.17565 0.01542 0.00664 0.19771
##
## Redundancies for the Y variables & total Y canonical redundancy
##
## Well_Being1 Well_Being2 Well_Being3 total Y|X
##      0.2699      0.0218      0.0111      0.3028

# Including the outlier.
CCA_3 <- cancort(cbind(rosen_se, panas_n, panas_p) ~ neo_n + neo_e +
  neo_o + neo_a + neo_c, data = CCA, prefix = c("NEO", "Well-Being"),
  standardize = TRUE)
CCA_3

##
## Canonical correlation analysis of:
## 5 X variables: neo_n, neo_e, neo_o, neo_a, neo_c
## with 3 Y variables: rosen_se, panas_n, panas_p
##
##      CanR CanRSQ Eigen percent cum
## 1 0.7130 0.50835 1.03395 86.536 86.54
## 2 0.3223 0.10391 0.11596 9.705 96.24
## 3 0.2073 0.04298 0.04491 3.759 100.00
##
##      scree
## 1 *****
## 2 ***
## 3 *
##
## Test of H0: The canonical correlations in the
## current row and all that follow are zero
##
##      CanR LR test stat approx F numDF denDF Pr(> F)
## 1 0.713      0.422      7.99      15      326 2.3e-15
## 2 0.322      0.858      2.38       8      238 0.018
## 3 0.207      0.957      1.80       3      120 0.152

```

```

plot_data <- as.data.frame(CCA_1_Scores)
ggpairs(plot_data, lower = list(continuous = "smooth"), upper = list(continuous = "cor"),
  columnLabels = c("NEO 1", "NEO 2", "NEO 3", "Well- \nBeing 1",
    "Well- \nBeing 2", "Well- \nBeing 3")) + theme(text = element_text(size = 14,
  family = "sans", color = "black", face = "bold"), axis.text.y = element_text(colour = "black",
  size = 9, face = "bold"), axis.text.x = element_text(colour = "black",
  size = 9, face = "bold", angle = 90), axis.title.x = element_text(margin = margin(15,
  0, 0, 0), size = 16), axis.title.y = element_text(margin = margin(0,
  15, 0, 0), size = 16), axis.line.x = element_blank(), axis.line.y = element_blank(),
  plot.title = element_text(size = 16, face = "bold", margin = margin(0,
  0, 20, 0), hjust = 0.5), panel.background = element_rect(fill = "white",
  linetype = 1, color = "black"), panel.grid.major = element_blank(),
  panel.grid.minor = element_blank(), plot.background = element_rect(fill = "white"),
  plot.margin = unit(c(1, 1, 1, 1), "cm"), legend.position = "bottom",
  legend.title = element_blank()) + ggtitle("Correlations Among Measures")

```

Correlations Among Measures

