THE HIERARCHICAL STRUCTURE OF AFFECT

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Contents

1 Environment Setup

```
if (!require("pacman")) {
  install.packages("pacman")
}
```

```
## Carregando pacotes exigidos: pacman
```

```
# Step 2: Use pacman's p_load() function to install (if necessary) and load all packages.
# You only need to list the package names without quotes.
pacman::p_load(
  # Data Reading and Manipulation
  readr, readxl, dplyr, tidyr, janitor, stringi, stringr, tidytext,

  # Factor Analysis and Psychometrics
  psych, EFA.dimensions, GPArotation, MVN,

  # Structural Equation Modeling
  lavaan, semTools, seminr, cSEM,

  # Network Analysis
  EGAnet,

  # Data Visualization
  ggplot2, patchwork, ggrepel, GGally, semPlot, plotly
)

# Confirmation message
cat("All necessary packages have been verified and loaded successfully.")
```

```
## All necessary packages have been verified and loaded successfully.
```

2 Estimates with embeddings

2.1 Load embeddings and transpose matrix to 768 x 45

```
data <- read_csv("embeddings_circumplex.csv")
```

```
## Rows: 45 Columns: 769
## -- Column specification --------------------------------------------------------
```

```
## Delimiter: ","
## chr   (1): palavra
## dbl (768): dim_1, dim_2, dim_3, dim_4, dim_5, dim_6, dim_7, dim_8, dim_9, di...
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```r
cat("Original file dimensions (Rows x Columns):", dim(data), "\n")
```

```
## Original file dimensions (Rows x Columns): 45 769
```

```r
print("First rows of the original file:")
```

```
## [1] "First rows of the original file:"
```

```r
print(head(data))
```

```
## # A tibble: 6 x 769
##   palavra    dim_1  dim_2   dim_3     dim_4  dim_5    dim_6    dim_7   dim_8
##   <chr>      <dbl>  <dbl>   <dbl>     <dbl>  <dbl>    <dbl>    <dbl>   <dbl>
## 1 foda     -0.0177 0.0514 -0.0165  0.0392   0.0824  0.0450  -0.00317 -0.0190
## 2 grande   -0.0474 0.0904 -0.0152  0.0436   0.102  -0.00491 -0.0896  -0.0344
## 3 saudade  -0.0177 0.125  -0.0155 -0.00331  0.105   0.0108  -0.0563  -0.0258
## 4 merda     0.0104 0.0927 -0.0157  0.0430   0.0844  0.0552   0.0201  -0.0119
## 5 bons     -0.0502 0.109  -0.0152  0.000375 0.0937 -0.00222 -0.0901  -0.0242
## 6 descanse -0.0687 0.179  -0.0157  0.0744   0.103  -0.0347  -0.0802   0.0179
## # i 760 more variables: dim_9 <dbl>, dim_10 <dbl>, dim_11 <dbl>, dim_12 <dbl>,
## #   dim_13 <dbl>, dim_14 <dbl>, dim_15 <dbl>, dim_16 <dbl>, dim_17 <dbl>,
## #   dim_18 <dbl>, dim_19 <dbl>, dim_20 <dbl>, dim_21 <dbl>, dim_22 <dbl>,
## #   dim_23 <dbl>, dim_24 <dbl>, dim_25 <dbl>, dim_26 <dbl>, dim_27 <dbl>,
## #   dim_28 <dbl>, dim_29 <dbl>, dim_30 <dbl>, dim_31 <dbl>, dim_32 <dbl>,
## #   dim_33 <dbl>, dim_34 <dbl>, dim_35 <dbl>, dim_36 <dbl>, dim_37 <dbl>,
## #   dim_38 <dbl>, dim_39 <dbl>, dim_40 <dbl>, dim_41 <dbl>, dim_42 <dbl>, ...
```

```r
# --- Step 3: Prepare DataFrame for Analysis ---
# Select all columns EXCEPT the first column 'palavra' (word)
# dplyr's select() function is more explicit and safer for this
embeddings_matrix <- data %>%
  select(-palavra)

print("\nLast rows of the embedding matrix ready for analysis:")
```

```
## [1] "\nLast rows of the embedding matrix ready for analysis:"
```

```r
print(tail(embeddings_matrix))
```

```
## # A tibble: 6 x 768
##      dim_1  dim_2   dim_3  dim_4  dim_5  dim_6    dim_7    dim_8    dim_9 dim_10
##      <dbl>  <dbl>   <dbl>  <dbl>  <dbl>  <dbl>    <dbl>    <dbl>    <dbl>  <dbl>
## 1  0.0132   0.139  -0.0165 0.0440 0.0908 0.0228 -0.00486 -0.0215  -0.0283  0.0853
```

```
## 2 -0.0365  0.0471 -0.0175 0.0156 0.0795 0.0494 -0.129   -0.0490   0.00369 0.110
## 3 -0.00446 0.0765 -0.0176 0.0571 0.0892 0.0183  0.00473 -0.00311 -0.0192  0.0863
## 4 -0.00477 0.151  -0.0158 0.0310 0.0590 0.0623 -0.0435  -0.0371   0.00316 0.0854
## 5 -0.0233  0.0185 -0.0179 0.0351 0.0735 0.0101 -0.0373  -0.0110  -0.00532 0.0934
## 6 -0.0211  0.162  -0.0154 0.0256 0.0544 0.0554 -0.0346  -0.0209   0.00552 0.0771
## # i 758 more variables: dim_11 <dbl>, dim_12 <dbl>, dim_13 <dbl>, dim_14 <dbl>,
## #   dim_15 <dbl>, dim_16 <dbl>, dim_17 <dbl>, dim_18 <dbl>, dim_19 <dbl>,
## #   dim_20 <dbl>, dim_21 <dbl>, dim_22 <dbl>, dim_23 <dbl>, dim_24 <dbl>,
## #   dim_25 <dbl>, dim_26 <dbl>, dim_27 <dbl>, dim_28 <dbl>, dim_29 <dbl>,
## #   dim_30 <dbl>, dim_31 <dbl>, dim_32 <dbl>, dim_33 <dbl>, dim_34 <dbl>,
## #   dim_35 <dbl>, dim_36 <dbl>, dim_37 <dbl>, dim_38 <dbl>, dim_39 <dbl>,
## #   dim_40 <dbl>, dim_41 <dbl>, dim_42 <dbl>, dim_43 <dbl>, dim_44 <dbl>, ...
```

```r
# --- Step 1: Transpose the Embedding Matrix ---
transposed_matrix <- t(embeddings_matrix)


# --- Step 2: Assign Word Names as Column Names ---
colnames(transposed_matrix) <- data$palavra

english_words <- c(
  "Fuck", "Great", "Longing", "Shit", "Good", "Rest", "Delight", "Sad",
  "Alone", "Sadness", "Wonder", "Crazy", "Dancing", "Charming", "Chic",
  "Beautiful", "Peace", "Happy", "Vibe", "Wonderful", "Cry", "Crying",
  "Gentle", "Relax", "Tranquility", "Loves", "Loved", "Love", "Like",
  "Heart", "Remember", "Grace", "Triggers", "Think", "Calm", "Top", "Perfect",
  "Bad", "Liked", "Trash", "Addicted", "Banger", "Hell", "Hit", "Memories"
)
data$palavra <- english_words
colnames(transposed_matrix) <- data$palavra
```

2.2 Verify if the matrix is factorable

```r
cat("--- STEP 1: Bartlett's Test of Sphericity ---\n")
```

```
## --- STEP 1: Bartlett's Test of Sphericity ---
```

```r
cor_matrix <- cor(transposed_matrix, use = "pairwise.complete.obs")
bartlett_test <- cortest.bartlett(cor_matrix, n = nrow(transposed_matrix))
print(bartlett_test)
```

```
## $chisq
## [1] 82501.89
##
## $p.value
## [1] 0
##
## $df
## [1] 990
```

```r
cat("\n\n--- STEP 2: Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy ---\n")
```

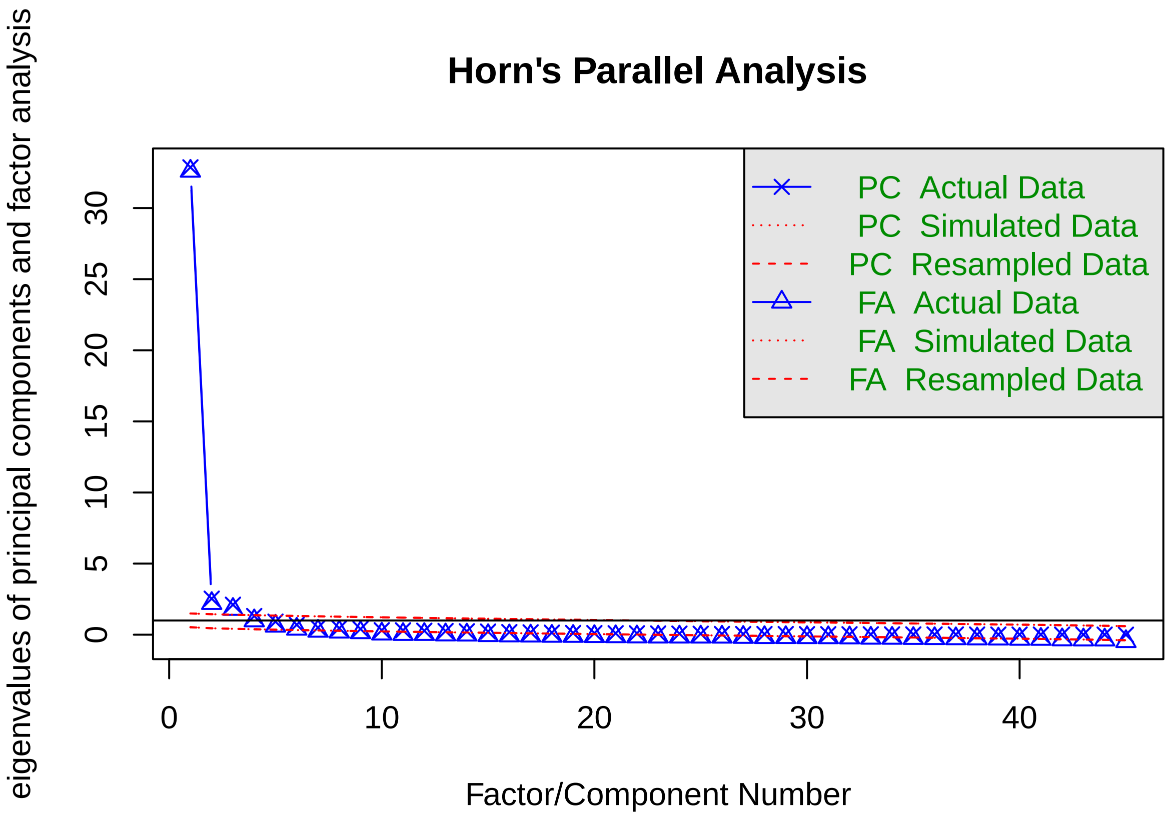
```
##
##
## --- STEP 2: Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy ---
```

```r
kmo_test <- KMO(cor_matrix)
print(kmo_test)
```

```
## Kaiser-Meyer-Olkin factor adequacy
## Call: KMO(r = cor_matrix)
## Overall MSA =  0.96
## MSA for each item =
##        Fuck       Great     Longing        Shit        Good        Rest
##        0.96        0.98        0.97        0.95        0.97        0.93
##     Delight         Sad       Alone     Sadness      Wonder       Crazy
##        0.98        0.95        0.98        0.95        0.96        0.99
##     Dancing    Charming        Chic   Beautiful       Peace       Happy
##        0.96        0.92        0.91        0.97        0.94        0.97
##        Vibe   Wonderful         Cry      Crying      Gentle       Relax
##        0.97        0.95        0.96        0.96        0.97        0.95
## Tranquility       Loves       Loved        Love        Like       Heart
##        0.94        0.93        0.96        0.97        0.93        0.96
##    Remember       Grace    Triggers       Think        Calm         Top
##        0.96        0.96        0.95        0.95        0.95        0.98
##     Perfect         Bad       Liked       Trash    Addicted      Banger
##        0.98        0.97        0.93        0.98        0.98        0.96
##        Hell         Hit    Memories
##        0.94        0.97        0.94
```

2.3 Horn's Parallel Analysis for Principal Components and Factor Analysis

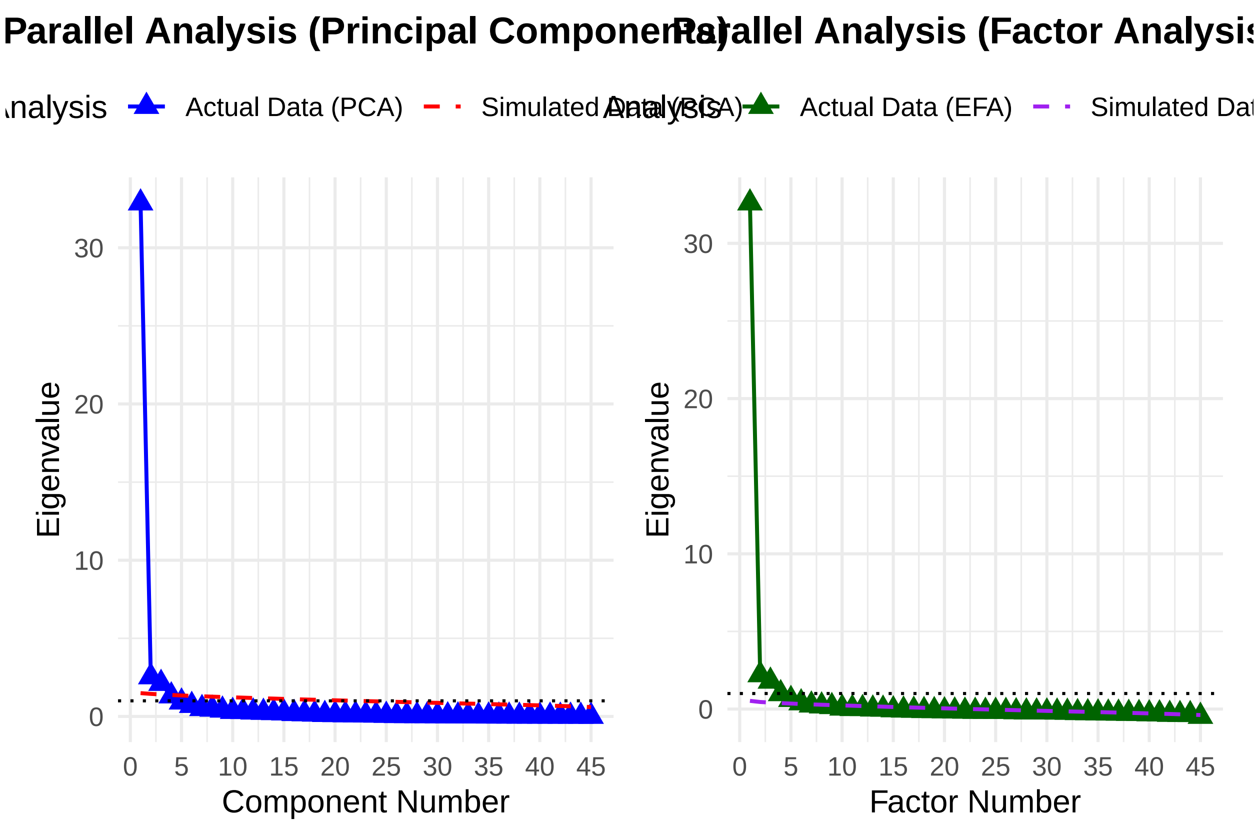
```r
# --- STEP 1: Run Horn's Parallel Analysis ---
parallel_analysis <- fa.parallel(
  transposed_matrix,
  fa = "both",      # "both" runs the analysis for PCA and Factor Analysis (EFA)
  n.iter = 100,
  show.legend = TRUE,
  main = "Horn's Parallel Analysis"
)
```




```
## Parallel analysis suggests that the number of factors =  6  and the number of components =  3
```

```
# Output message analysis:
# "Parallel analysis suggests that the number of factors = 6 and the number of components = 3"


# --- STEP 2: Prepare data frames for ggplot with English variable names ---

# Data frame for the PCA plot
df_plot_pca <- data.frame(
  Number = 1:length(parallel_analysis$pc.values),
  Actual_Eigenvalue = parallel_analysis$pc.values,
  Simulated_Eigenvalue = parallel_analysis$pc.sim
)

# Data frame for the EFA (Exploratory Factor Analysis) plot
df_plot_efa <- data.frame(
  Number = 1:length(parallel_analysis$fa.values),
  Actual_Eigenvalue = parallel_analysis$fa.values,
  Simulated_Eigenvalue = parallel_analysis$fa.sim
)


# --- STEP 3: Create the PCA plot ---
plot_pca <- ggplot(df_plot_pca, aes(x = Number)) +
```

```r
  geom_line(aes(y = Actual_Eigenvalue, color = "Actual Data (PCA)"), linewidth = 0.7) +
  geom_point(aes(y = Actual_Eigenvalue, color = "Actual Data (PCA)"), shape = 17, size = 3) +
  geom_line(aes(y = Simulated_Eigenvalue, color = "Simulated Data (PCA)"), linetype = "dashed", linewid

  geom_hline(yintercept = 1, linetype = "dotted", color = "black") +

  scale_color_manual(
    name = "Analysis",
    values = c("Actual Data (PCA)" = "blue", "Simulated Data (PCA)" = "red")
  ) +
  labs(
    title = "Parallel Analysis (Principal Components)",
    x = "Component Number",
    y = "Eigenvalue"
  ) +
  theme_minimal(base_size = 12) +
  theme(legend.position = "top", plot.title = element_text(hjust = 0.5, face = "bold")) +
  scale_x_continuous(breaks = seq(0, 45, by = 5))


# --- STEP 4: Create the EFA plot ---
plot_efa <- ggplot(df_plot_efa, aes(x = Number)) +
  geom_line(aes(y = Actual_Eigenvalue, color = "Actual Data (EFA)"), linewidth = 0.7) +
  geom_point(aes(y = Actual_Eigenvalue, color = "Actual Data (EFA)"), shape = 17, size = 3) +
  geom_line(aes(y = Simulated_Eigenvalue, color = "Simulated Data (EFA)"), linetype = "dashed", linewid

  geom_hline(yintercept = 1, linetype = "dotted", color = "black") +

  scale_color_manual(
    name = "Analysis",
    values = c("Actual Data (EFA)" = "darkgreen", "Simulated Data (EFA)" = "purple")
  ) +
  labs(
    title = "Parallel Analysis (Factor Analysis)",
    x = "Factor Number",
    y = "Eigenvalue"
  ) +
  theme_minimal(base_size = 12) +
  theme(legend.position = "top", plot.title = element_text(hjust = 0.5, face = "bold")) +
  scale_x_continuous(breaks = seq(0, 45, by = 5))


# --- STEP 5: Combine both plots side-by-side ---
combined_plot <- plot_pca + plot_efa
print(combined_plot)
```




```
# Now, save the plot to a file
#ggsave("parallel_analysis.png",width = 12, height = 8, dpi = 300)
```

2.4 PCA - General Factor Identification

1st dimension where all words load positively

```
cat("\n--- Running PCA to extract 3 components ---\n")
```

```
##
## --- Running PCA to extract 3 components ---
```

```
pca_results_psych <- principal(
  r = transposed_matrix,
  nfactors = 3,
  rotate = "none" # No rotation to see the raw structure
)
print(pca_results_psych$loadings, cutoff = 0.3, sort = TRUE)
```

```
##
## Loadings:
##                PC1    PC2    PC3
## Fuck           0.816  0.399  0.301
```

```
## Great        0.946
## Longing      0.873
## Shit         0.785  0.351  0.416
## Good         0.925
## Rest         0.767
## Delight      0.869
## Sad          0.865
## Alone        0.840
## Sadness      0.837 -0.387
## Wonder       0.903
## Crazy        0.846  0.413
## Dancing      0.822  0.396
## Charming     0.740  0.425
## Chic         0.721  0.445
## Beautiful    0.912
## Peace        0.854 -0.363
## Happy        0.870
## Vibe         0.932
## Wonderful    0.896
## Cry          0.841
## Crying       0.796
## Gentle       0.887
## Relax        0.790 -0.305
## Tranquility  0.830 -0.376
## Loves        0.886
## Loved        0.896
## Love         0.893
## Like         0.910
## Heart        0.916
## Remember     0.833
## Grace        0.934
## Triggers     0.863
## Think        0.874
## Calm         0.904
## Top          0.817
## Perfect      0.841
## Bad          0.808         0.398
## Liked        0.852
## Trash        0.755  0.333  0.385
## Addicted     0.861
## Banger       0.852         0.307
## Hell         0.798         0.423
## Hit          0.920
## Memories     0.801         0.376
##
##                   PC1   PC2   PC3
## SS loadings    32.863 2.532 2.108
## Proportion Var  0.730 0.056 0.047
## Cumulative Var  0.730 0.787 0.833
```

```
pca_results_psych$fit.off
```

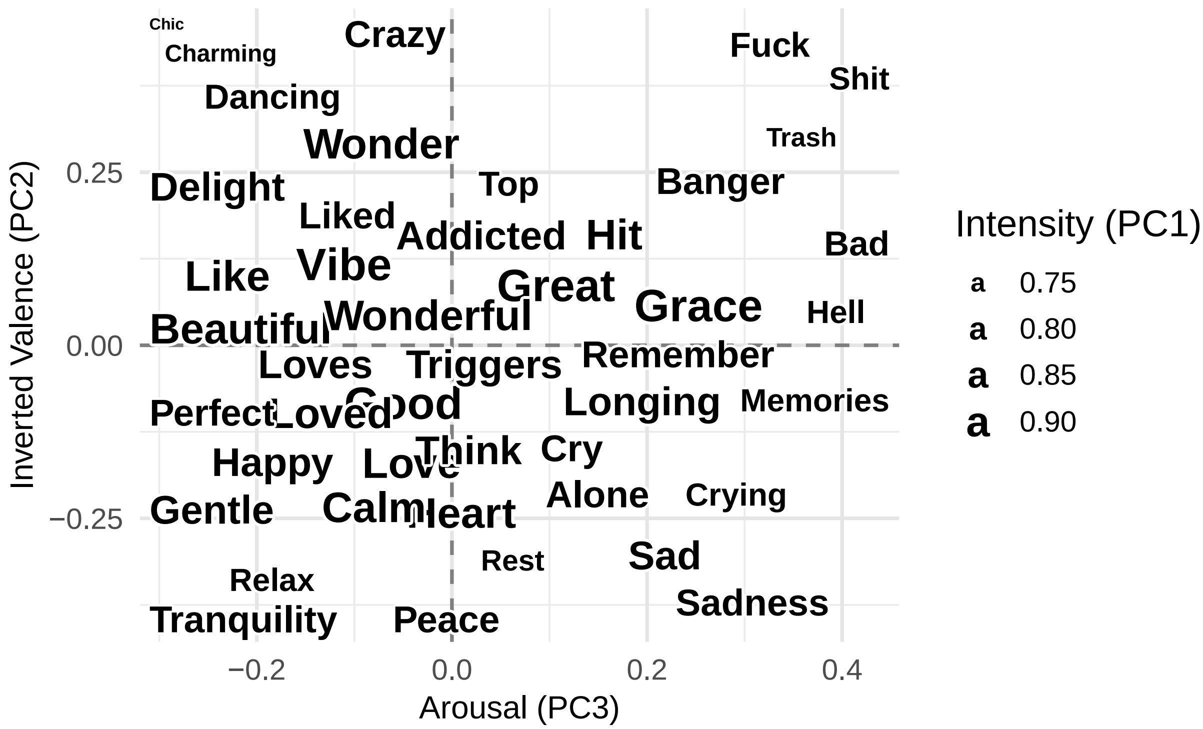
```
## [1] 0.9972998
```

```r
pc_scores_df <- as.data.frame(pca_results_psych$scores)
```

2.5 General factor extraction reveals the circumplex model

```r
loadings_df <- as.data.frame(unclass(pca_results_psych$loadings))
loadings_df$palavra <- rownames(loadings_df)


grafico_pca_intensidade_final <- ggplot(
  data = loadings_df,
  aes(x = PC3, y = PC2, label = palavra, size = PC1)
) +

  # Quadrant reference lines
  geom_hline(yintercept = 0, linetype = "dashed", color = "gray50") +
  geom_vline(xintercept = 0, linetype = "dashed", color = "gray50") +

  # Text layer with repulsion
  geom_text_repel(
    fontface = "bold",
    color = "black",
    bg.color = "white",
    bg.r = 0.1,
    segment.color = "transparent",
    max.overlaps = Inf
  ) +

  # Size scale customization
  scale_size_continuous(
    range = c(2, 6),
    name = "Intensity (PC1)"
  ) +
  labs(
    title = "",
    subtitle = "",
    x = "Arousal (PC3)",
    y = "Inverted Valence (PC2)"
  ) +

  # Clean visual theme
  theme_minimal(base_size = 14) +
  theme(
    panel.grid.major = element_line(color = "gray90"),
    plot.title = element_text(hjust = 0.5, face = "bold", size = 18),
    plot.subtitle = element_text(hjust = 0.5, size = 11),
    legend.position = "right",

    axis.title = element_text(size = 12)
  )

# Display final plot
```

```r
print(grafico_pca_intensidade_final)
```




```r
#ggsave("Figure 2.png",width = 12, height = 8, dpi = 300, bg = "white")
```

2.6 PCA with Varimax to better identify words representing PCs

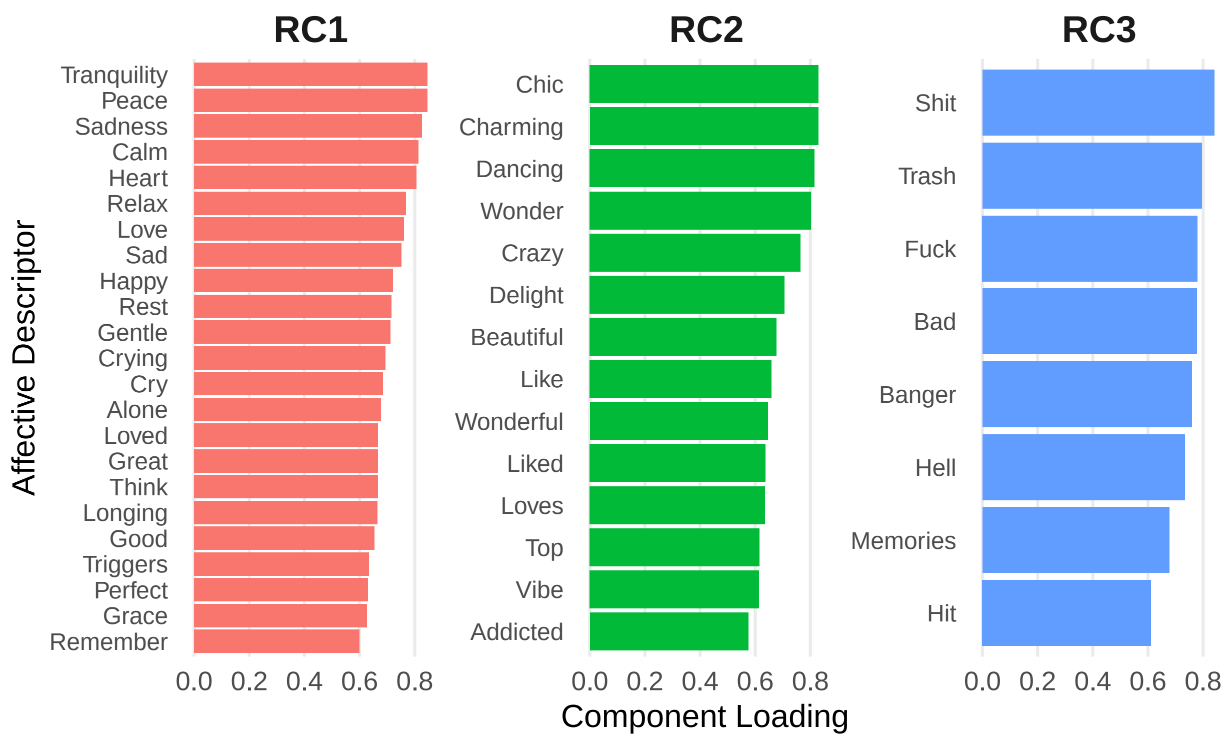
```r
cat("\n--- Running PCA to extract 3 components with rotation ---\n")
```

```
##
## --- Running PCA to extract 3 components with rotation ---
```

```r
pca_results_psych <- principal(
  r = transposed_matrix,
  nfactors = 3,
  rotate = "none"
)
#print(pca_results_psych$loadings, cutoff = 0.3, sort = TRUE)
pca_results_psych$fit.off
```

```
## [1] 0.9972998
```

```r
# Run PCA with Varimax rotation
pca_results_varimax <- principal(
  r = transposed_matrix,
  nfactors = 3,
  rotate = "varimax"
)

# Extract loadings and convert to dataframe
loadings_df_unique <- as.data.frame(unclass(pca_results_varimax$loadings))

loadings_df_unique <- loadings_df_unique %>%
  mutate(palavra = rownames(.)) %>%
  # Transform to long format
  pivot_longer(
    cols = c("RC1", "RC2", "RC3"),
    names_to = "Component",
    values_to = "Loading"
  ) %>%
  # Group by word
  group_by(palavra) %>%
  filter(abs(Loading) == max(abs(Loading))) %>%
  ungroup() %>%
  # Optional: Filter out low loadings to clean plot
  filter(abs(Loading) > 0.4) %>%
  # Sort words within each component
  group_by(Component) %>%
  mutate(palavra = reorder_within(palavra, Loading, Component))

# Create plot using the unique loadings dataframe
loadings_plot_unique <- ggplot(loadings_df_unique, aes(x = Loading, y = palavra, fill = Component)) +
  geom_col() +
  facet_wrap(~ Component, scales = "free_y") +
  scale_y_reordered() +

  # Aesthetics and Labels
  labs(
    title = "",
    subtitle = "",
    x = "Component Loading",
    y = "Affective Descriptor"
  ) +
  theme_minimal(base_size = 12) +
  theme(
    legend.position = "none",
    strip.text = element_text(face = "bold", size = 14),
    panel.grid.major.y = element_blank(),
    panel.grid.minor.x = element_blank(),
    axis.text.y = element_text(size = 9)
  )

# Display plot
print(loadings_plot_unique)
```




```
# Save in high quality:
#ggsave("Figure 3.png", plot = loadings_plot_unique, bg = "white", width = 12,
#       height = 8, dpi = 300)
```

2.7 Formative vs. Reflective

Using PLS-SEM to test if the general factor in this model is formative or reflective

```
# --- PART 1: First-Order Model (to extract scores) ---

# Convert transposed matrix to data frame and clean names
data_df <- as.data.frame(transposed_matrix)
clean_data <- clean_names(data_df)

# Define first-order measurement model
first_order_mm <- constructs(
  composite("HighValence",
            c("remember", "chic", "charming", "dancing", "wonder", "crazy",
              "delight", "beautiful", "like", "wonderful", "liked", "love",
              "top", "vibe"),
            weights = mode_A),

  composite("LowValence",
            c("addicted", "shit", "trash", "fuck", "bad", "banger",
              "hell", "memories", "hit"),
```

```
           weights = mode_A)
)

# Define first-order structural model
first_order_sm <- relationships(
  paths(from = "HighValence", to = "LowValence")
)

# Estimate first-order PLS model
first_order_pls_model <- estimate_pls(
  data = clean_data,
  measurement_model = first_order_mm,
  structural_model = first_order_sm
)
```

```
## Generating the seminr model
```

```
## All 768 observations are valid.
```

```
# Extract scores
construct_scores <- first_order_pls_model$construct_scores
data_with_scores <- cbind(as.data.frame(clean_data), construct_scores)
```

2.8 Formative second-order

To validate a formative construct, it needs to POINT towards something. As we lack an external variable, we use an "anchor construct". We create a reflective anchor construct with RC1 items.

```
# --- PART 2: Second-Order Formative Model ---

# Define measurement model with second-order construct
full_mm_formative <- constructs(
  composite("HighValence", "HighValence"),
  composite("LowValence", "LowValence"),

  # Second-order FORMATIVE construct
  composite("GeneralFactor",
           c("HighValence", "LowValence"),
           weights = mode_B), # mode_B for formative

  # Anchor construct
  composite("Anchor", c("peace", "calm", "sadness", "love"), weights = mode_A)
)

# Define structural model
final_sm <- relationships(
  paths(from = "GeneralFactor", to = "Anchor")
)

# Estimate formative model
final_pls_formative <- estimate_pls(
```

```r
  data = data_with_scores,
  measurement_model = full_mm_formative,
  structural_model = final_sm
)
```

```
## Generating the seminr model

## All 768 observations are valid.
```

```r
# Results Analysis
summary_final_formative <- summary(final_pls_formative)
print(summary_final_formative$reliability)
```

```
##               alpha  rhoC   AVE  rhoA
## GeneralFactor 0.920 0.950 0.904 1.000
## Anchor        0.954 0.967 0.879 0.957
##
## Alpha, rhoC, and rhoA should exceed 0.7 while AVE should exceed 0.5
```

```r
print(summary_final_formative$validity$vif_items)
```

```
## GeneralFactor :
## HighValence  LowValence
##       3.649       3.649
##
## Anchor :
##   peace    calm sadness    love
##   5.034   5.701   4.272   4.434
```

```r
# Bootstrapping for weight significance
boot_results_formative <- bootstrap_model(final_pls_formative, nboot = 5000)
```

```
## Bootstrapping model using seminr...

## SEMinR Model successfully bootstrapped
```

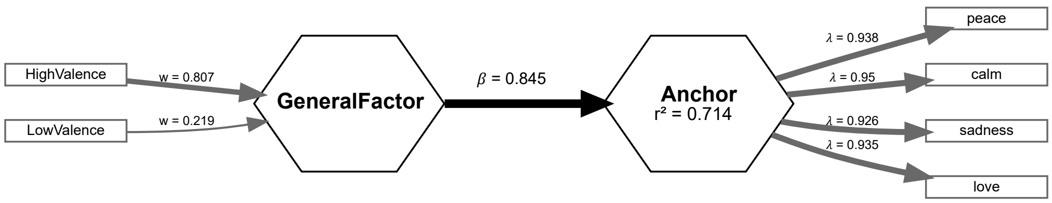
```r
summary_boot_formative <- summary(boot_results_formative)

# Check p-values:
print(summary_boot_formative$bootstrapped_weights)
```

```
##                                 Original Est. Bootstrap Mean Bootstrap SD
## HighValence  ->  GeneralFactor          0.807          0.808        0.043
## LowValence  ->  GeneralFactor           0.219          0.218        0.047
## peace  ->  Anchor                       0.258          0.258        0.003
## calm  ->  Anchor                        0.282          0.282        0.004
## sadness  ->  Anchor                     0.246          0.246        0.003
## love  ->  Anchor                        0.281          0.281        0.003
##                                 T Stat. 2.5% CI 97.5% CI
## HighValence  ->  GeneralFactor  18.733   0.722    0.891
```

```
## LowValence  ->  GeneralFactor    4.651   0.126    0.310
## peace  ->  Anchor              87.386   0.253    0.264
## calm  ->  Anchor               67.103   0.274    0.290
## sadness  ->  Anchor            79.178   0.239    0.252
## love  ->  Anchor               83.687   0.275    0.288
```

```r
plot(final_pls_formative)
```

```
## file:///C:/Users/vinic/AppData/Local/Temp/Rtmp2p5UKb/file37ec2a015a89/widget37ec577318a0.html screens
```




```r
# Extract formative scores
scores_pls_formative <- as.data.frame(final_pls_formative$construct_scores)
```

```r
general_factor_formative_scores <- scores_pls_formative$GeneralFactor
```

```r
if (!require("DiagrammeR")) install.packages("DiagrammeR")
```

```
## Carregando pacotes exigidos: DiagrammeR
```

```r
if (!require("magick")) install.packages("magick")
```

```
## Carregando pacotes exigidos: magick
```

```
## Warning: pacote 'magick' foi compilado no R versão 4.5.2
```

```
## Linking to ImageMagick 6.9.13.29
## Enabled features: cairo, freetype, fftw, ghostscript, heic, lcms, pango, raw, rsvg, webp
## Disabled features: fontconfig, x11
```

```r
if (!require("DiagrammeRsvg")) install.packages("DiagrammeRsvg")
```

```
## Carregando pacotes exigidos: DiagrammeRsvg
```

```r
plot_formative <- plot(final_pls_formative, title = "")

#temp_svg_file_formative <- tempfile(fileext = ".svg")
#export_svg(plot_formative) %>%
#  charToRaw() %>%
#  writeBin(temp_svg_file_formative)

#image_read_svg(temp_svg_file_formative) %>%
#  image_write(
#    path = "Figure4.png",
#    format = "png",
#    density = 300
#  )
```

2.9 Reflective second-order

```r
full_mm_reflective <- constructs(
  # First-order constructs
  composite("HighValence", "HighValence"),
  composite("LowValence", "LowValence"),

  # Second-order REFLECTIVE construct
  composite("GeneralFactor",
            c("HighValence", "LowValence"),
            weights = mode_A), # mode_A for reflective

  # Anchor construct
  composite("Anchor", c("peace", "calm", "sadness", "love"), weights = mode_A)
```

```r
)

# Structural model
final_sm_reflective <- relationships(
  paths(from = "GeneralFactor", to = "Anchor")
)

# Estimate reflective model
final_pls_reflective <- estimate_pls(
  data = data_with_scores,
  measurement_model = full_mm_reflective,
  structural_model = final_sm_reflective
)
```

```
## Generating the seminr model

## All 768 observations are valid.
```

```r
# Results analysis
summary_final_reflective <- summary(final_pls_reflective)
print(summary_final_reflective$reliability)
```

```
##               alpha  rhoC   AVE  rhoA
## GeneralFactor 0.920 0.962 0.926 0.926
## Anchor        0.954 0.967 0.879 0.956
##
## Alpha, rhoC, and rhoA should exceed 0.7 while AVE should exceed 0.5
```

```r
# Bootstrapping
boot_results_reflective <- bootstrap_model(final_pls_reflective, nboot = 5000)
```

```
## Bootstrapping model using seminr...

## SEMinR Model successfully bootstrapped
```

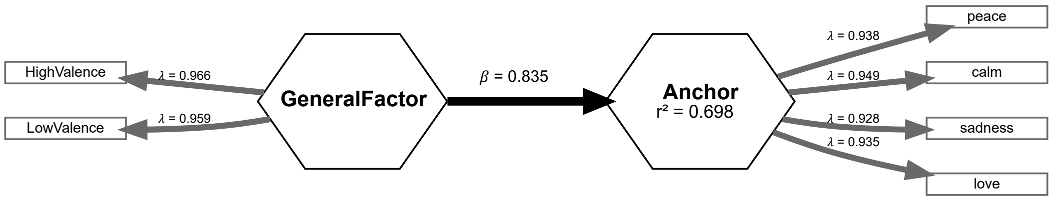
```r
summary_boot_reflective <- summary(boot_results_reflective)

# Check p-values for loadings:
print(summary_boot_reflective$bootstrapped_loadings)
```

```
##                                 Original Est. Bootstrap Mean Bootstrap SD
## HighValence  ->  GeneralFactor          0.966          0.966        0.003
## LowValence  ->  GeneralFactor           0.959          0.958        0.005
## peace  ->  Anchor                       0.938          0.937        0.006
## calm  ->  Anchor                        0.949          0.949        0.004
## sadness  ->  Anchor                     0.928          0.927        0.007
## love  ->  Anchor                        0.935          0.935        0.006
##                                 T Stat. 2.5% CI 97.5% CI
## HighValence  ->  GeneralFactor 311.907   0.959    0.971
## LowValence  ->  GeneralFactor  207.084   0.949    0.967
```

```
## peace  ->  Anchor              154.081   0.925    0.949
## calm  ->  Anchor               216.154   0.940    0.957
## sadness  ->  Anchor            135.129   0.913    0.940
## love  ->  Anchor               157.286   0.923    0.946
```

```
plot(final_pls_reflective)
```

```
## file:///C:/Users/vinic/AppData/Local/Temp/Rtmp2p5UKb/file37ec703810d/widget37ec4771310d.html screensh
```




```
# Extract scores
scores_pls_reflective <- as.data.frame(final_pls_reflective$construct_scores)
```

```r
general_factor_reflective_scores <- scores_pls_reflective$GeneralFactor
```

```r
plot_reflexive <- plot(final_pls_reflective)

# Save plot to temp SVG
#temp_svg_file2 <- tempfile(fileext = ".svg")
#export_svg(plot_reflexive) %>%
#  charToRaw() %>%
#  writeBin(temp_svg_file2)

# Save as PNG
#image_read_svg(temp_svg_file2) %>%
#  image_write("Figure5.png")
```

2.10 Reflective via lavaan

Model does not fit even with excellent reliability

```r
semantic_model <- '
  HighV    =~ remember + chic + charming + dancing + wonder + crazy +
                delight + beautiful + like + wonderful + liked + love + top + vibe
  LowV     =~ addicted + shit + trash + fuck + bad + hit + hell + memories + banger
'

fit_semantic <- cfa(semantic_model, data = clean_data, estimator = "MLR", orthogonal = F)
fitmeasures(fit_semantic, c("chisq", "df", "pvalue", "cfi", "rmsea",
                             "rmsea.ci.lower", "rmsea.ci.upper"))
```

```
##          chisq             df         pvalue            cfi          rmsea
##      15568.181        229.000          0.000          0.610          0.295
## rmsea.ci.lower rmsea.ci.upper
##          0.291          0.299
```

```r
summary(fit_semantic, fit.measures = TRUE, standardized = TRUE)
```

```
## lavaan 0.6-20 ended normally after 269 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        47
##
##   Number of observations                           768
##
## Model Test User Model:
##                                               Standard      Scaled
##   Test Statistic                             15568.181   12774.108
##   Degrees of freedom                               229         229
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.219
##     Yuan-Bentler correction (Mplus variant)
##
```

```
## Model Test Baseline Model:
##
##   Test statistic                             39589.355   32948.102
##   Degrees of freedom                               253         253
##   P-value                                        0.000       0.000
##   Scaling correction factor                                  1.202
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.610       0.616
##   Tucker-Lewis Index (TLI)                       0.569       0.576
##
##   Robust Comparative Fit Index (CFI)                         0.611
##   Robust Tucker-Lewis Index (TLI)                            0.570
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              36121.193   36121.193
##   Scaling correction factor                                  1.814
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)      43905.283   43905.283
##   Scaling correction factor                                  1.320
##       for the MLR correction
##
##   Akaike (AIC)                              -72148.385  -72148.385
##   Bayesian (BIC)                            -71930.127  -71930.127
##   Sample-size adjusted Bayesian (SABIC)     -72079.373  -72079.373
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.295       0.267
##   90 Percent confidence interval - lower         0.291       0.264
##   90 Percent confidence interval - upper         0.299       0.271
##   P-value H_0: RMSEA <= 0.050                    0.000       0.000
##   P-value H_0: RMSEA >= 0.080                    1.000       1.000
##
##   Robust RMSEA                                               0.295
##   90 Percent confidence interval - lower                     0.291
##   90 Percent confidence interval - upper                     0.299
##   P-value H_0: Robust RMSEA <= 0.050                         0.000
##   P-value H_0: Robust RMSEA >= 0.080                         1.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.080       0.080
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
```

```
##   HighV =~
##     remember          1.000                               0.047    0.770
##     chic              1.321    0.120   10.973    0.000    0.062    0.831
##     charming          1.309    0.114   11.492    0.000    0.061    0.844
##     dancing           1.261    0.089   14.178    0.000    0.059    0.904
##     wonder            1.281    0.068   18.758    0.000    0.060    0.966
##     crazy             1.198    0.081   14.721    0.000    0.056    0.905
##     delight           1.221    0.047   26.159    0.000    0.057    0.903
##     beautiful         1.341    0.046   29.241    0.000    0.063    0.929
##     like              1.153    0.039   29.449    0.000    0.054    0.914
##     wonderful         1.347    0.049   27.474    0.000    0.063    0.907
##     liked             1.178    0.042   28.227    0.000    0.055    0.867
##     love              0.985    0.034   29.385    0.000    0.046    0.805
##     top               1.064    0.051   21.024    0.000    0.050    0.829
##     vibe              1.215    0.035   34.672    0.000    0.057    0.923
##   LowV =~
##     addicted          1.000                               0.056    0.839
##     shit              0.990    0.033   29.892    0.000    0.055    0.959
##     trash             0.931    0.035   26.332    0.000    0.052    0.910
##     fuck              0.991    0.029   33.974    0.000    0.055    0.963
##     bad               0.892    0.028   32.080    0.000    0.050    0.897
##     hit               0.878    0.026   34.042    0.000    0.049    0.925
##     hell              0.885    0.032   27.739    0.000    0.049    0.818
##     memories          0.876    0.034   26.108    0.000    0.049    0.780
##     banger            0.947    0.029   33.115    0.000    0.053    0.955
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   HighV ~~
##     LowV              0.002    0.000    7.721    0.000    0.835    0.835
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .remember          0.002    0.000   11.587    0.000    0.002    0.406
##    .chic              0.002    0.000    4.625    0.000    0.002    0.310
##    .charming          0.002    0.000    4.506    0.000    0.002    0.287
##    .dancing           0.001    0.000    3.824    0.000    0.001    0.183
##    .wonder            0.000    0.000    2.592    0.010    0.000    0.066
##    .crazy             0.001    0.000    3.918    0.000    0.001    0.180
##    .delight           0.001    0.000    8.357    0.000    0.001    0.184
##    .beautiful         0.001    0.000    4.572    0.000    0.001    0.137
##    .like              0.001    0.000    6.587    0.000    0.001    0.166
##    .wonderful         0.001    0.000    5.042    0.000    0.001    0.177
##    .liked             0.001    0.000    8.643    0.000    0.001    0.249
##    .love              0.001    0.000   10.789    0.000    0.001    0.351
##    .top               0.001    0.000   13.629    0.000    0.001    0.313
##    .vibe              0.001    0.000    4.850    0.000    0.001    0.148
##    .addicted          0.001    0.000   15.509    0.000    0.001    0.295
##    .shit              0.000    0.000   10.746    0.000    0.000    0.080
##    .trash             0.001    0.000   13.254    0.000    0.001    0.172
##    .fuck              0.000    0.000    9.699    0.000    0.000    0.073
##    .bad               0.001    0.000   15.535    0.000    0.001    0.195
##    .hit               0.000    0.000   12.757    0.000    0.000    0.144
##    .hell              0.001    0.000   14.883    0.000    0.001    0.330
```

```
##    .memories           0.002    0.000   15.315    0.000    0.002    0.392
##    .banger             0.000    0.000   11.808    0.000    0.000    0.087
##     HighV              0.002    0.000    7.826    0.000    1.000    1.000
##     LowV               0.003    0.000    9.473    0.000    1.000    1.000
```

```
semTools::compRelSEM(fit_semantic)
```

```
## HighV  LowV
## 0.982 0.964
```

2.11 Study 1 Correlations

```
## GENERAL FACTOR
matriz <- cbind(scores_pls_reflective[1], scores_pls_formative[1], pca_results_psych$scores[,1])
colnames(matriz) <- c("GF_Reflective", "GF_Formative", "PC1")
#mvn(matriz, univariateTest = "SW")
corCi(matriz,method = "spearman", plot = F)
```

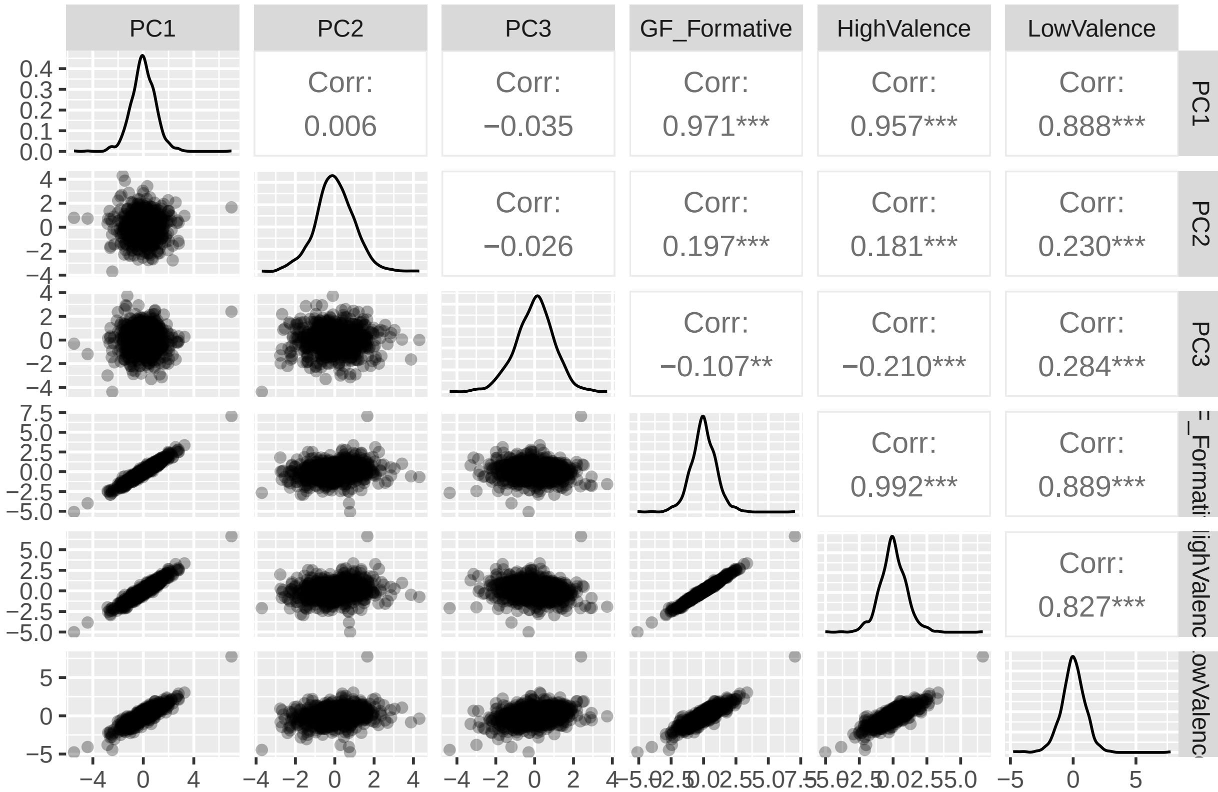
```
## Call:corCi(x = matriz, method = "spearman", plot = F)
##
##  Coefficients and bootstrapped confidence intervals
##               GF_Rf GF_Fr PC1
## GF_Reflective 1.00
## GF_Formative  0.99  1.00
## PC1           0.97  0.97  1.00
##
##  scale correlations and bootstrapped confidence intervals
##             lower.emp lower.norm estimate upper.norm upper.emp p
## GF_Rf-GF_Fr      0.98       0.98     0.99       0.99      0.99 0
## GF_Rf-PC1        0.96       0.96     0.97       0.97      0.97 0
## GF_Fr-PC1        0.97       0.97     0.97       0.98      0.97 0
```

```
# SPECIFIC FACTORS
especificos <- as.data.frame(construct_scores)
matriz_especificos <- cbind(especificos, pc_scores_df[2:3])
#mvn(matriz_especificos, univariateTest = "SW")
corCi(matriz_especificos,method = "spearman", plot = F)
```

```
## Call:corCi(x = matriz_especificos, method = "spearman", plot = F)
##
##  Coefficients and bootstrapped confidence intervals
##             HghVl LwVln PC2   PC3
## HighValence  1.00
## LowValence   0.83  1.00
## PC2          0.18  0.23  1.00
## PC3         -0.21  0.28 -0.03  1.00
##
##  scale correlations and bootstrapped confidence intervals
##             lower.emp lower.norm estimate upper.norm upper.emp    p
## HghVl-LwVln      0.80       0.80     0.83       0.85      0.85 0.00
```

```
## HghVl-PC2         0.11       0.10     0.18       0.25      0.25 0.00
## HghVl-PC3        -0.27      -0.27    -0.21      -0.15     -0.15 0.00
## LwVln-PC2         0.16       0.15     0.23       0.30      0.30 0.00
## LwVln-PC3         0.22       0.22     0.28       0.35      0.36 0.00
## PC2-PC3          -0.09      -0.10    -0.03       0.04      0.03 0.39
```

```r
pc_scores_df <- as.data.frame(pca_results_psych$scores)

# Create dataframe for convergence analysis
convergence_study1_df <- data.frame(
  PC1 = pc_scores_df$PC1,
  PC2 = pc_scores_df$PC2,
  PC3 = pc_scores_df$PC3,
  GF_Formative = general_factor_formative_scores,
  HighValence = especificos$HighValence,
  LowValence = especificos$LowValence
)


# GGpairs visualization
cor_plot <- GGally::ggpairs(
  convergence_study1_df,
  title = "",
  upper = list(continuous = wrap("cor", method = "spearman", size = 4)),
  lower = list(continuous = wrap("points", alpha = 0.3))
)
print(cor_plot)
```




```
#ggsave("Figure6.png", plot = cor_plot, bg = "white", width = 10,
#       height = 6, dpi = 300)
```

3 Estimates with PANAS

```
load("data.RData")
panas_data <- as.data.frame(data[97:116])
str(panas_data)
```

```
## 'data.frame':    457 obs. of  20 variables:
##  $ PN1ativo   : num  5 4 4 5 4 4 4 2 5 4 ...
##  $ PN2envergo : num  1 1 4 3 2 2 2 1 2 2 ...
##  $ PN3atento  : num  4 4 4 4 4 3 4 4 4 3 ...
##  $ PN4aflit   : num  2 5 3 4 5 3 2 2 2 4 ...
##  $ PN5determ  : num  4 3 4 4 4 4 4 3 5 4 ...
##  $ PN6culpado : num  1 4 4 2 2 3 2 1 2 2 ...
##  $ PN7empol   : num  2 2 4 2 4 3 4 3 5 5 ...
##  $ PN8irrit   : num  1 4 2 5 4 3 2 1 3 4 ...
##  $ PN9interes : num  5 2 4 1 5 4 4 3 5 5 ...
##  $ PN10medo   : num  1 4 1 5 4 1 3 2 2 4 ...
##  $ PN11orgul  : num  4 1 5 1 2 4 3 4 5 4 ...
##  $ PN12hostil : num  1 4 4 5 1 3 3 1 2 2 ...
```

```
##  $ PN13alerta : num  4 4 4 5 3 4 3 1 5 3 ...
##  $ PN14inquie : num  4 4 3 5 4 4 3 2 3 3 ...
##  $ PN15entusia: num  4 1 4 1 4 4 4 3 5 4 ...
##  $ PN16nervo  : num  1 4 3 5 4 4 2 1 3 4 ...
##  $ PN17forte  : num  4 1 5 1 5 3 3 4 5 4 ...
##  $ PN18apavo  : num  1 4 4 3 3 1 2 1 2 2 ...
##  $ PN19inspi  : num  4 1 5 1 5 3 4 5 5 4 ...
##  $ PN20chate  : num  1 4 4 5 2 4 2 1 2 2 ...
```

3.1 Factorability

```
cat("--- Bartlett's Test of Sphericity ---\n")
```

```
## --- Bartlett's Test of Sphericity ---
```

```
poly <- polychoric(panas_data)
cor_poly <- poly$rho
bartlett_results_correto <- cortest.bartlett(cor_poly)
```

```
## Warning in cortest.bartlett(cor_poly): n not specified, 100 used
```

```
print(bartlett_results_correto)
```

```
## $chisq
## [1] 1179.216
##
## $p.value
## [1] 2.56106e-142
##
## $df
## [1] 190
```

```
cat("\n--- Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy ---\n")
```

```
##
## --- Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy ---
```

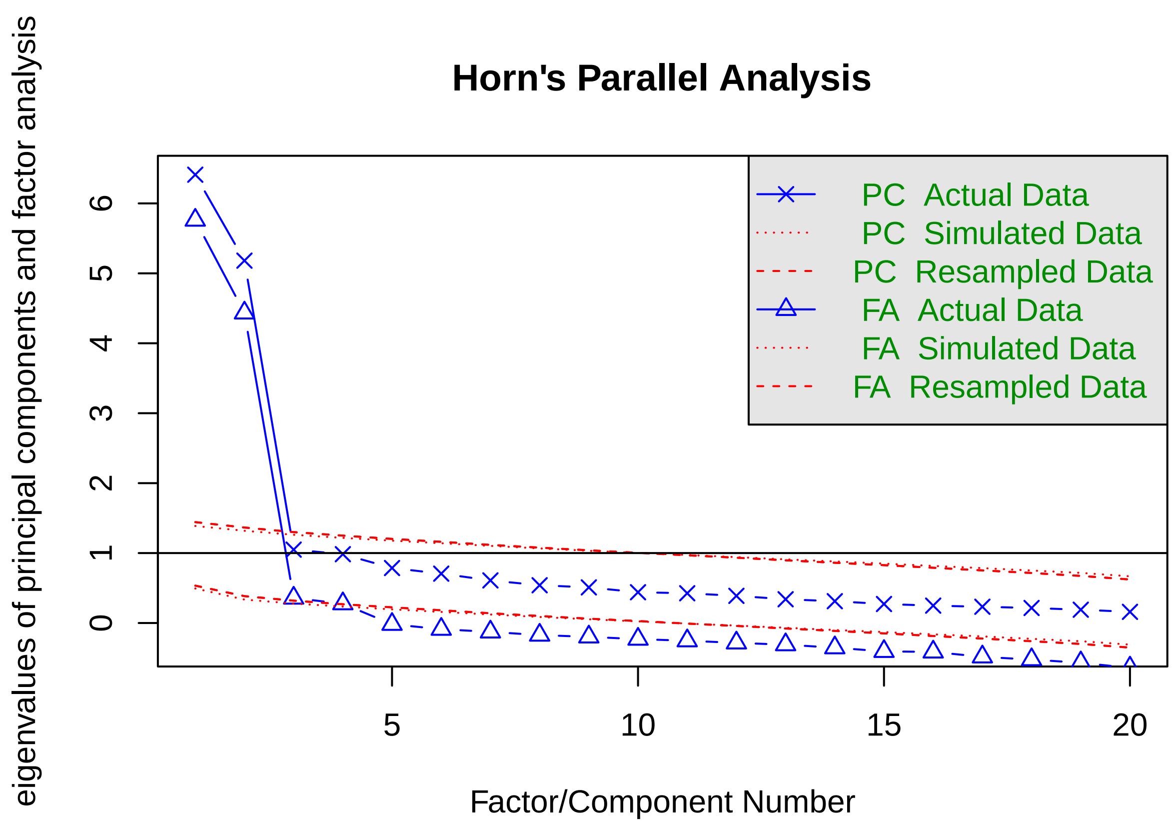
```
kmo_results_correto <- KMO(cor_poly)
print(kmo_results_correto)
```

```
## Kaiser-Meyer-Olkin factor adequacy
## Call: KMO(r = cor_poly)
## Overall MSA =  0.89
## MSA for each item =
##    PN1ativo  PN2envergo   PN3atento    PN4aflit   PN5determ  PN6culpado
##        0.89        0.91        0.86        0.87        0.92        0.87
##     PN7empol     PN8irrit  PN9interes    PN10medo   PN11orgul  PN12hostil
##        0.91        0.89        0.91        0.90        0.93        0.85
##   PN13alerta   PN14inquie PN15entusia    PN16nervo   PN17forte   PN18apavo
##        0.82        0.88        0.91        0.85        0.91        0.89
##    PN19inspi   PN20chate
##        0.89        0.91
```

3.2 Horn's Parallel Analysis

```
parallel_analysis_results <- fa.parallel(
  panas_data,
  fa = "both",
  n.iter = 100,
  show.legend = TRUE,
  cor="poly",
  main = "Horn's Parallel Analysis"
)
```

```
## Warning in fa.stats(r = r, f = f, phi = phi, n.obs = n.obs, np.obs = np.obs, :
## The estimated weights for the factor scores are probably incorrect.  Try a
## different factor score estimation method.
## Warning in fa.stats(r = r, f = f, phi = phi, n.obs = n.obs, np.obs = np.obs, :
## The estimated weights for the factor scores are probably incorrect.  Try a
## different factor score estimation method.
## Warning in fa.stats(r = r, f = f, phi = phi, n.obs = n.obs, np.obs = np.obs, :
## The estimated weights for the factor scores are probably incorrect.  Try a
## different factor score estimation method.
```

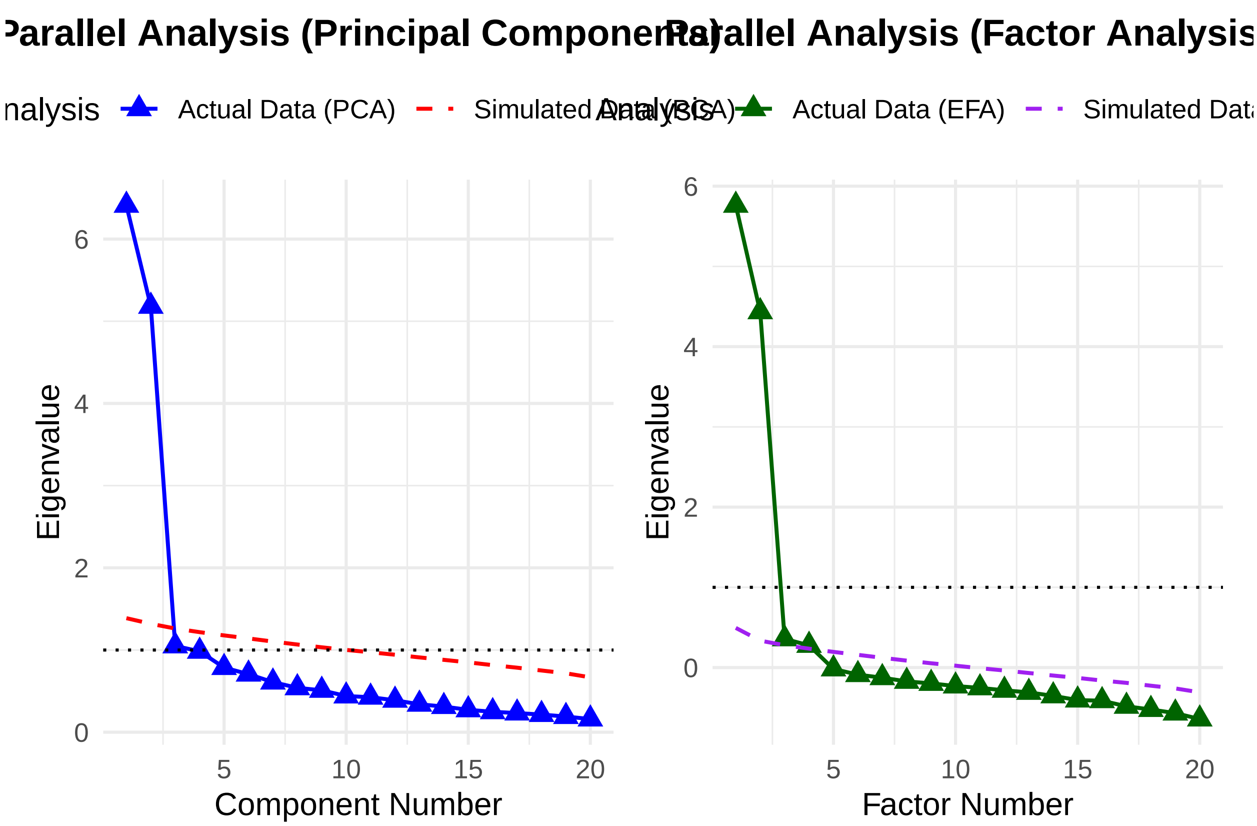



```
## Parallel analysis suggests that the number of factors =  4  and the number of components =  2
```

3.3 Parallel Analysis Plot

```
# --- STEP 1: Prepare data frames for plotting ---

# Data frame for PCA plot
df_plot_pca <- data.frame(
  Number = 1:length(parallel_analysis_results$pc.values),
  Actual_Eigenvalue = parallel_analysis_results$pc.values,
  Simulated_Eigenvalue = parallel_analysis_results$pc.sim
)

# Data frame for EFA plot
df_plot_efa <- data.frame(
  Number = 1:length(parallel_analysis_results$fa.values),
  Actual_Eigenvalue = parallel_analysis_results$fa.values,
  Simulated_Eigenvalue = parallel_analysis_results$fa.sim
)


# --- STEP 2: Create PCA plot ---
plot_pca <- ggplot(df_plot_pca, aes(x = Number)) +
  geom_line(aes(y = Actual_Eigenvalue, color = "Actual Data (PCA)"), linewidth = 0.7) +
  geom_point(aes(y = Actual_Eigenvalue, color = "Actual Data (PCA)"), shape = 17, size = 3) +
  geom_line(aes(y = Simulated_Eigenvalue, color = "Simulated Data (PCA)"), linetype = "dashed", linewid

  geom_hline(yintercept = 1, linetype = "dotted", color = "black") +

  scale_color_manual(
    name = "Analysis",
    values = c("Actual Data (PCA)" = "blue", "Simulated Data (PCA)" = "red")
  ) +
  labs(
    title = "Parallel Analysis (Principal Components)",
    x = "Component Number",
    y = "Eigenvalue"
  ) +
  theme_minimal(base_size = 12) +
  theme(legend.position = "top", plot.title = element_text(hjust = 0.5, face = "bold")) +
  scale_x_continuous(breaks = seq(0, 45, by = 5))


# --- STEP 3: Create EFA plot ---
plot_efa <- ggplot(df_plot_efa, aes(x = Number)) +
  geom_line(aes(y = Actual_Eigenvalue, color = "Actual Data (EFA)"), linewidth = 0.7) +
  geom_point(aes(y = Actual_Eigenvalue, color = "Actual Data (EFA)"), shape = 17, size = 3) +
  geom_line(aes(y = Simulated_Eigenvalue, color = "Simulated Data (EFA)"), linetype = "dashed", linewid

  geom_hline(yintercept = 1, linetype = "dotted", color = "black") +

  scale_color_manual(
    name = "Analysis",
    values = c("Actual Data (EFA)" = "darkgreen", "Simulated Data (EFA)" = "purple")
  ) +
```

```
  labs(
    title = "Parallel Analysis (Factor Analysis)",
    x = "Factor Number",
    y = "Eigenvalue"
  ) +
  theme_minimal(base_size = 12) +
  theme(legend.position = "top", plot.title = element_text(hjust = 0.5, face = "bold")) +
  scale_x_continuous(breaks = seq(0, 45, by = 5))


# --- STEP 4: Combine plots ---
combined_plot <- plot_pca + plot_efa

print(combined_plot)
```




```
ggsave("Figure7.png", plot = combined_plot, width = 12, height = 5, dpi = 300,
       bg = "white")
```

3.4 PANAS PCA

The first component represents valence, while the second represents Intensity/Salience, with all words loading positively.

```r
library(dplyr)

# Standard PANAS items (Watson et al., 1988)
panas_english_names <- c(
  "PN1ativo"    = "Active",
  "PN2envergo"  = "Ashamed",
  "PN3atento"   = "Attentive",
  "PN4aflit"    = "Distressed",
  "PN5determ"   = "Determined",
  "PN6culpado"  = "Guilty",
  "PN7empol"    = "Excited",
  "PN8irrit"    = "Irritable",
  "PN9interes"  = "Interested",
  "PN10medo"    = "Scared",
  "PN11orgul"   = "Proud",
  "PN12hostil"  = "Hostile",
  "PN13alerta"  = "Alert",
  "PN14inquie"  = "Jittery",
  "PN15entusia" = "Enthusiastic",
  "PN16nervo"   = "Nervous",
  "PN17forte"   = "Strong",
  "PN18apavo"   = "Afraid",
  "PN19inspi"   = "Inspired",
  "PN20chate"   = "Upset"
)

panas_data <- panas_data %>%
  rename(any_of(setNames(names(panas_english_names), panas_english_names)))


# Run PCA with English names
pca_results_psych <- principal(
  r = panas_data,
  nfactors = 2,
  rotate = "none"
)

# Print loadings
print(pca_results_psych$loadings, cutoff = 0.30, sort = TRUE)
```

```
##
## Loadings:
##                PC1    PC2
## Active         0.637  0.363
## Attentive      0.592  0.405
## Determined     0.653  0.415
## Guilty        -0.503  0.474
## Excited        0.695  0.384
## Interested     0.596  0.494
## Proud          0.668  0.380
## Enthusiastic   0.692  0.426
## Strong         0.574  0.432
## Afraid        -0.580  0.407
```

```
## Inspired      0.610  0.378
## Distressed   -0.527  0.570
## Irritable    -0.366  0.619
## Scared       -0.496  0.590
## Alert                0.560
## Jittery      -0.373  0.599
## Nervous      -0.457  0.699
## Upset        -0.540  0.550
## Ashamed      -0.345  0.412
## Hostile      -0.325  0.482
##
##                  PC1   PC2
## SS loadings    5.791 4.826
## Proportion Var 0.290 0.241
## Cumulative Var 0.290 0.531
```

```r
cat("\n--- Running PCA to extract 2 components ---\n")
```

```
##
## --- Running PCA to extract 2 components ---
```

```r
pca_results_psych <- principal(
  r = panas_data,
  nfactors = 2,
  rotate = "none"
)

print(pca_results_psych$loadings, cutoff = 0.30, sort = TRUE)
```

```
##
## Loadings:
##              PC1    PC2
## Active        0.637  0.363
## Attentive     0.592  0.405
## Determined    0.653  0.415
## Guilty       -0.503  0.474
## Excited       0.695  0.384
## Interested    0.596  0.494
## Proud         0.668  0.380
## Enthusiastic  0.692  0.426
## Strong        0.574  0.432
## Afraid       -0.580  0.407
## Inspired      0.610  0.378
## Distressed   -0.527  0.570
## Irritable    -0.366  0.619
## Scared       -0.496  0.590
## Alert                0.560
## Jittery      -0.373  0.599
## Nervous      -0.457  0.699
## Upset        -0.540  0.550
## Ashamed      -0.345  0.412
## Hostile      -0.325  0.482
##
```

```
##                   PC1   PC2
## SS loadings    5.791 4.826
## Proportion Var 0.290 0.241
## Cumulative Var 0.290 0.531
```

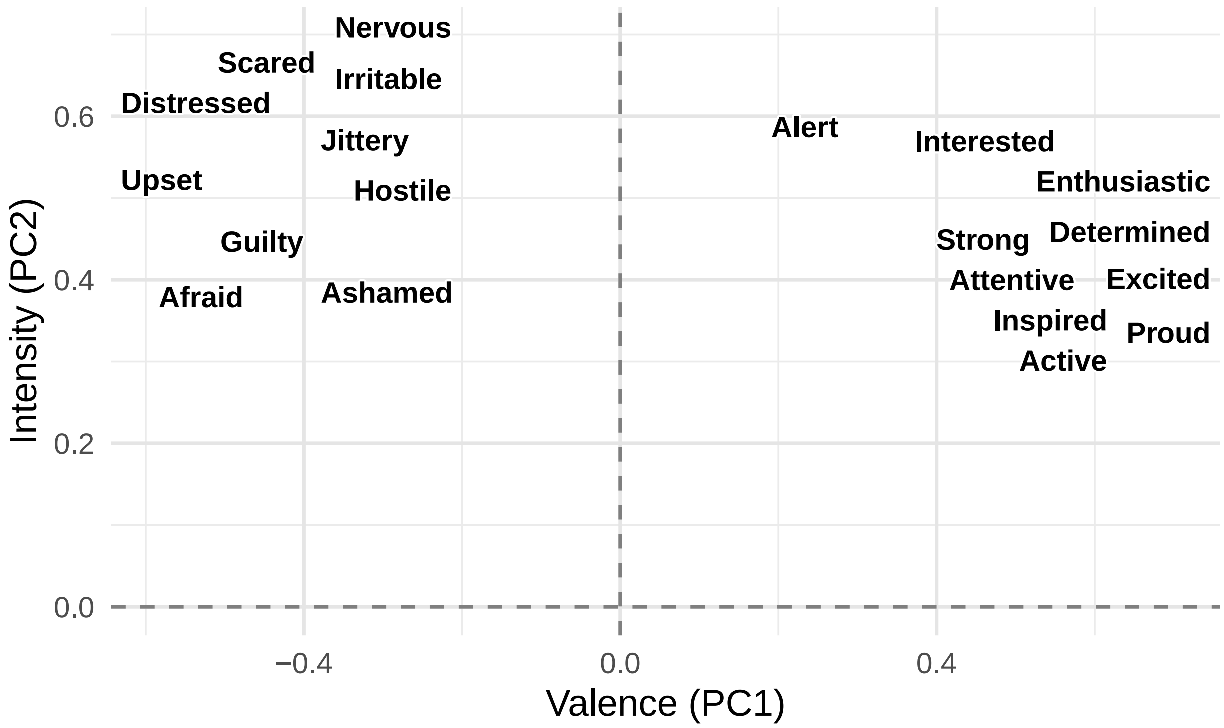
```
pca_results_psych$fit.off
```

```
## [1] 0.9696769
```

3.5 Plot

```
# Prepare dataframe for plot
loadings_df <- as.data.frame(unclass(pca_results_psych$loadings))
loadings_df$palavra <- rownames(loadings_df)


grafico_panas_2D_simples <- ggplot(
  data = loadings_df,
  aes(x = PC1, y = PC2, label = palavra)
) +

  # Reference lines
  geom_hline(yintercept = 0, linetype = "dashed", color = "gray50") +
  geom_vline(xintercept = 0, linetype = "dashed", color = "gray50") +

  # Text layer
  geom_text_repel(
    fontface = "bold",
    color = "black",
    bg.color = "white",
    bg.r = 0.1,
    segment.color = "transparent",
    max.overlaps = Inf,
    size = 4
  ) +

  labs(
    title = "",
    subtitle = "",
    x = "Valence (PC1)",
    y = "Intensity (PC2)"
  ) +

  theme_minimal(base_size = 14) +
  theme(
    panel.grid.major = element_line(color = "gray90"),
    plot.title = element_text(hjust = 0.5, face = "bold", size = 18),
    plot.subtitle = element_text(hjust = 0.5, size = 11),
    legend.position = "none"
  )
```

```r
# Display final plot
print(grafico_panas_2D_simples)
```




```r
#ggsave("mapaPANAS.png", plot = grafico_panas_2D_simples,
#       width = 12, height = 6, units = "in", dpi = 300,  bg = "white")
```

3.6 With rotation to extract components

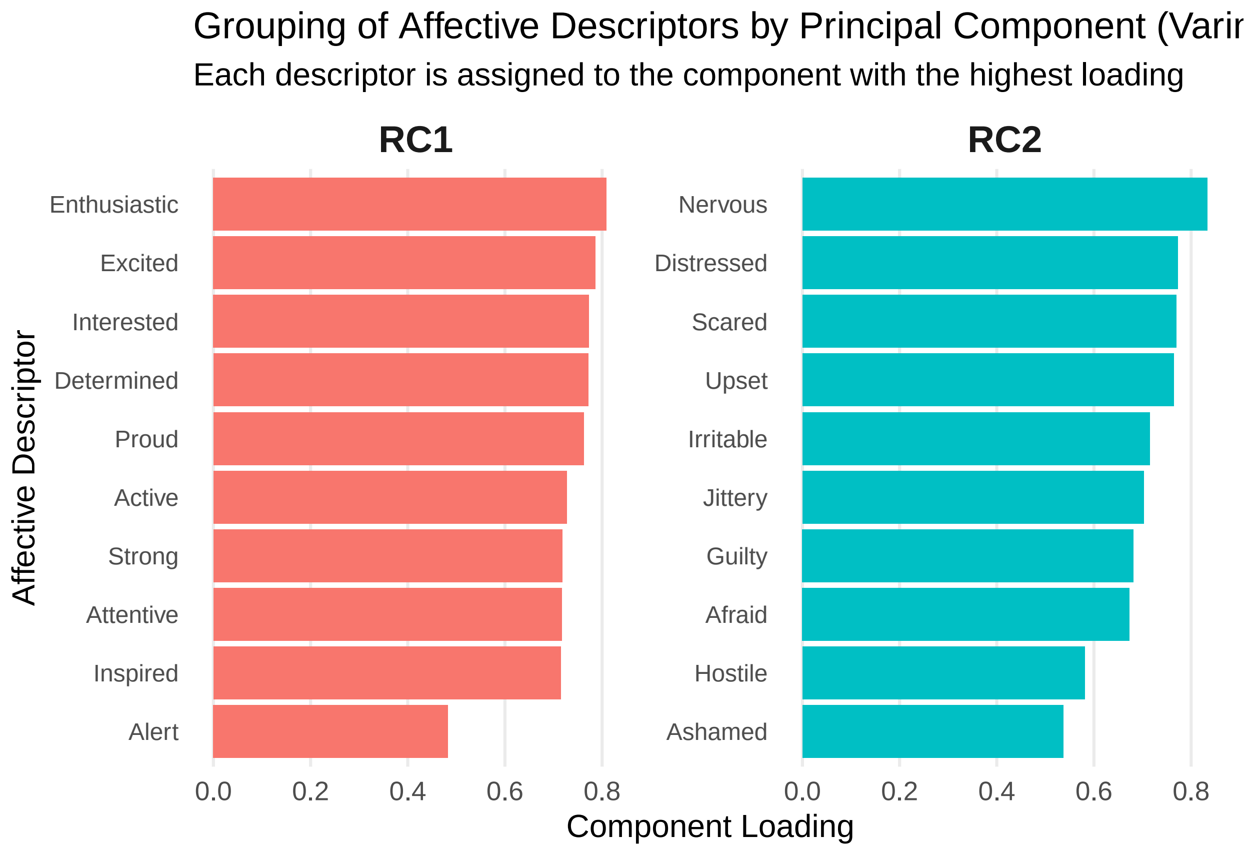
```r
cat("\n--- Running PCA to extract 2 components with Varimax ---\n")
```

```
##
## --- Running PCA to extract 2 components with Varimax ---
```

```r
pca_results_psych <- principal(
  r = panas_data,
  nfactors = 2,
  rotate = "varimax"
)

pca_results_psych$fit.off
```

```
## [1] 0.9696769
```

```r
# Extract loadings
loadings_df_unique <- as.data.frame(unclass(pca_results_psych$loadings))

loadings_df_unique <- loadings_df_unique %>%
  mutate(palavra = rownames(.)) %>%
  pivot_longer(
    cols = c("RC1", "RC2"),
    names_to = "Component",
    values_to = "Loading"
  ) %>%
  group_by(palavra) %>%
  # Filter to keep highest absolute loading
  filter(abs(Loading) == max(abs(Loading))) %>%
  ungroup() %>%
  filter(abs(Loading) > 0.4) %>%
  group_by(Component) %>%
  mutate(palavra = reorder_within(palavra, Loading, Component))


# Create plot
loadings_plot_unique <- ggplot(loadings_df_unique, aes(x = Loading, y = palavra, fill = Component)) +
  geom_col() +
  facet_wrap(~ Component, scales = "free_y") +
  scale_y_reordered() +

  # Aesthetics
  labs(
    title = "Grouping of Affective Descriptors by Principal Component (Varimax)",
    subtitle = "Each descriptor is assigned to the component with the highest loading",
    x = "Component Loading",
    y = "Affective Descriptor"
  ) +
  theme_minimal(base_size = 12) +
  theme(
    legend.position = "none",
    strip.text = element_text(face = "bold", size = 14),
    panel.grid.major.y = element_blank(),
    panel.grid.minor.x = element_blank(),
    axis.text.y = element_text(size = 9)
  )

# Display plot
print(loadings_plot_unique)
```



3.7 Formative vs. Reflective - PANAS

```
# 1. Define first-order measurement model (PA and NA)
# --- PART 1: First-Order PLS Model for PANAS ---

first_order_mm_panas <- constructs(
  composite("PA", c("Active", "Attentive", "Determined", "Excited",
                    "Interested", "Proud", "Alert", "Enthusiastic",
                    "Strong", "Inspired"),
            weights = mode_A),

  composite("NA", c("Ashamed", "Distressed", "Guilty", "Irritable",
                    "Scared", "Hostile", "Jittery", "Nervous",
                    "Afraid", "Upset"),
            weights = mode_A)
)

# 2. Structural model
first_order_sm_panas <- relationships(
  paths(from = "PA", to = "NA")
)

# 3. Estimate model
first_order_pls_panas <- estimate_pls(
```

```r
  data = panas_data,
  measurement_model = first_order_mm_panas,
  structural_model = first_order_sm_panas
)
```

```
## Generating the seminr model

## All 457 observations are valid.
```

```r
summary(first_order_pls_panas)
```

```
##
## Results from  package seminr (2.3.7)
##
## Path Coefficients:
##             NA
## R^2      0.068
## AdjR^2   0.066
## PA      -0.261
##
## Reliability:
##    alpha  rhoC   AVE  rhoA
## PA 0.901 0.894 0.477 0.787
## NA 0.888 0.906 0.494 0.933
##
## Alpha, rhoC, and rhoA should exceed 0.7 while AVE should exceed 0.5
```

```r
# 4. Extract scores
panas_scores <- first_order_pls_panas$construct_scores
panas_with_scores <- as.data.frame(cbind(panas_data, panas_scores))
```

3.8 Formative - PANAS

```r
# --- PART 2: Second-Order Formative Model for PANAS ---

second_order_mm_formative <- constructs(
  composite("PA", "PA"),
  composite("NA", "NA"),

  # Define anchor construct
  composite("Activation_Anchor", c("Excited", "Enthusiastic", "Irritable", "Nervous"), weights = mode_A

  # Second-order FORMATIVE construct
  composite("G_Factor_Formative", c("PA", "NA"), weights = mode_B)
)

# Structural model
second_order_sm_panas <- relationships(
  paths(from = "G_Factor_Formative", to = "Activation_Anchor")
)
```

```r
# Estimate model
pls_panas_formative <- estimate_pls(
  data = panas_with_scores,
  measurement_model = second_order_mm_formative,
  structural_model = second_order_sm_panas
)
```

```
## Generating the seminr model

## All 457 observations are valid.
```

```r
# Analyze VIF
summary_panas_formative <- summary(pls_panas_formative)
print(summary_panas_formative$validity$vif_items)
```

```
## G_Factor_Formative :
##    PA    NA
## 1.073 1.073
##
## Activation_Anchor :
##      Excited Enthusiastic    Irritable      Nervous
##        1.880        1.872        1.623        1.632
```

```r
# Bootstrap
boot_panas_formative <- bootstrap_model(pls_panas_formative, nboot = 5000)
```

```
## Bootstrapping model using seminr...

## SEMinR Model successfully bootstrapped
```

```r
summary(boot_panas_formative)$bootstrapped_weights
```

```
##                                     Original Est. Bootstrap Mean Bootstrap SD
## Excited  ->  Activation_Anchor              0.539          0.524        0.035
## Enthusiastic  ->  Activation_Anchor         0.512          0.499        0.034
## Irritable  ->  Activation_Anchor           -0.091         -0.076        0.111
## Nervous  ->  Activation_Anchor             -0.153         -0.134        0.125
## PA  ->  G_Factor_Formative                  0.954          0.935        0.076
## NA  ->  G_Factor_Formative                 -0.141         -0.116        0.210
##                                     T Stat. 2.5% CI 97.5% CI
## Excited  ->  Activation_Anchor       15.469   0.447    0.570
## Enthusiastic  ->  Activation_Anchor  14.996   0.422    0.540
## Irritable  ->  Activation_Anchor     -0.822  -0.247    0.166
## Nervous  ->  Activation_Anchor       -1.226  -0.321    0.150
## PA  ->  G_Factor_Formative           12.584   0.765    1.026
## NA  ->  G_Factor_Formative           -0.671  -0.450    0.348
```

##Reflective - PANAS

```r
# --- PART 3: Second-Order Reflective Model for PANAS ---

second_order_mm_reflective <- constructs(
  composite("PA", "PA"),
  composite("NA", "NA"),

  composite("Activation_Anchor", c("Excited", "Enthusiastic", "Irritable", "Nervous"), weights = mode_A

  # Second-order REFLECTIVE construct
  composite("G_Factor_Reflective", c("PA", "NA"), weights = mode_A)
)

# Structural model
second_order_sm_panas_reflective <- relationships(
  paths(from = "G_Factor_Reflective", to = "Activation_Anchor")
)

# Estimate model
pls_panas_reflective <- estimate_pls(
  data = panas_with_scores,
  measurement_model = second_order_mm_reflective,
  structural_model = second_order_sm_panas_reflective
)
```

```
## Generating the seminr model

## All 457 observations are valid.
```

```r
# Reliability
summary_panas_reflective <- summary(pls_panas_reflective)
print(summary_panas_reflective$reliability)
```

```
##                       alpha  rhoC   AVE  rhoA
## G_Factor_Reflective -0.706 0.029 0.626 0.441
## Activation_Anchor    0.486 0.114 0.433 0.596
##
## Alpha, rhoC, and rhoA should exceed 0.7 while AVE should exceed 0.5
```

```r
# Bootstrap
boot_panas_reflective <- bootstrap_model(pls_panas_reflective, nboot = 5000)
```

```
## Bootstrapping model using seminr...

## SEMinR Model successfully bootstrapped
```

```r
summary(boot_panas_reflective)$bootstrapped_loadings
```

```
##                                       Original Est. Bootstrap Mean Bootstrap SD
## Excited  ->  Activation_Anchor                0.791          0.797        0.045
## Enthusiastic  ->  Activation_Anchor           0.766          0.772        0.050
```

```
## Irritable  ->  Activation_Anchor          -0.484         -0.467        0.110
## Nervous  ->  Activation_Anchor            -0.533         -0.515        0.107
## PA  ->  G_Factor_Reflective                0.863          0.869        0.044
## NA  ->  G_Factor_Reflective               -0.713         -0.698        0.090
##                                    T Stat. 2.5% CI 97.5% CI
## Excited  ->  Activation_Anchor       17.468   0.727    0.888
## Enthusiastic  ->  Activation_Anchor  15.200   0.684    0.870
## Irritable  ->  Activation_Anchor     -4.418  -0.619   -0.204
## Nervous  ->  Activation_Anchor       -4.971  -0.653   -0.262
## PA  ->  G_Factor_Reflective          19.543   0.827    0.942
## NA  ->  G_Factor_Reflective          -7.950  -0.794   -0.488
```

3.9 Reflective with lavaan

Theoretical model does not work in BR (Brazil)

```
### 1. Two-Factor Correlated Model (Canonical Model)
#----------------------------------------------------

two_factor_syntax <- '
  PAf =~ Active + Attentive + Determined + Excited + Interested + Proud +
        Alert + Enthusiastic + Strong + Inspired

  NAf =~ Ashamed + Distressed + Guilty + Irritable + Scared + Hostile +
        Jittery + Nervous + Afraid + Upset
'

fit_two_factor <- cfa(
  two_factor_syntax,
  data = panas_data,
  ordered = TRUE,
  estimator = "WLSMV",
  std.lv = TRUE
)

fitMeasures(fit_two_factor, c("chisq", "df", "pvalue", "cfi", "rmsea", "rmsea.ci.lower", "rmsea.ci.uppe
```

```
##          chisq             df         pvalue            cfi          rmsea
##        953.755        169.000          0.000          0.970          0.101
## rmsea.ci.lower rmsea.ci.upper
##          0.095          0.107
```

```
semTools::compRelSEM(fit_two_factor)
```

```
##   PAf   NAf
## 0.913 0.911
```

##Theoretical model fit adjustment Literature suggests “Alert” loads on both factors.

```
### 2. Two-Factor Model with Cross-Loading for "Alert"
#---------------------------------------------------------
```

```r
crossload_syntax <- '
  PAf =~ Active + Attentive + Determined + Excited + Interested + Proud +
        Alert + Enthusiastic + Strong + Inspired

  NAf =~ Ashamed + Distressed + Guilty + Irritable + Scared + Hostile +
        Jittery + Nervous + Afraid + Upset + Alert  # Cross-loading added
'

fit_crossload <- cfa(
  crossload_syntax,
  data = panas_data,
  ordered = TRUE,
  estimator = "WLSMV",
  std.lv = TRUE
)

fitMeasures(fit_crossload, c("chisq", "df", "pvalue", "cfi", "rmsea", "rmsea.ci.lower", "rmsea.ci.upper
```

```
##          chisq             df         pvalue            cfi          rmsea
##        638.313        168.000          0.000          0.982          0.078
## rmsea.ci.lower rmsea.ci.upper
##          0.072          0.085
```

```r
summary(fit_crossload, fit.measures = TRUE, standardized = TRUE)
```

```
## lavaan 0.6-20 ended normally after 23 iterations
##
##   Estimator                                       DWLS
##   Optimization method                           NLMINB
##   Number of model parameters                       102
##
##   Number of observations                           457
##
## Model Test User Model:
##                                               Standard      Scaled
##   Test Statistic                               638.313     682.235
##   Degrees of freedom                               168         168
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.058
##   Shift parameter                                           78.647
##     simple second-order correction
##
## Model Test Baseline Model:
##
##   Test statistic                             26632.140    8829.609
##   Degrees of freedom                               190         190
##   P-value                                        0.000       0.000
##   Scaling correction factor                                  3.061
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.982       0.940
```

```
##   Tucker-Lewis Index (TLI)                       0.980      0.933
##
##   Robust Comparative Fit Index (CFI)                        0.845
##   Robust Tucker-Lewis Index (TLI)                           0.825
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.078      0.082
##   90 Percent confidence interval - lower         0.072      0.076
##   90 Percent confidence interval - upper         0.085      0.088
##   P-value H_0: RMSEA <= 0.050                    0.000      0.000
##   P-value H_0: RMSEA >= 0.080                    0.344      0.697
##
##   Robust RMSEA                                              0.108
##   90 Percent confidence interval - lower                    0.101
##   90 Percent confidence interval - upper                    0.115
##   P-value H_0: Robust RMSEA <= 0.050                        0.000
##   P-value H_0: Robust RMSEA >= 0.080                        1.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.072      0.072
##
## Parameter Estimates:
##
##   Parameterization                               Delta
##   Standard errors                           Robust.sem
##   Information                                 Expected
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PAf =~
##     Active            0.738    0.025   29.384    0.000    0.738    0.738
##     Attentive         0.727    0.025   29.429    0.000    0.727    0.727
##     Determined        0.787    0.023   33.952    0.000    0.787    0.787
##     Excited           0.828    0.016   51.124    0.000    0.828    0.828
##     Interested        0.790    0.021   37.248    0.000    0.790    0.790
##     Proud             0.774    0.019   40.463    0.000    0.774    0.774
##     Alert             0.479    0.034   14.015    0.000    0.479    0.479
##     Enthusiastic      0.840    0.015   55.769    0.000    0.840    0.840
##     Strong            0.722    0.023   31.430    0.000    0.722    0.722
##     Inspired          0.726    0.022   33.144    0.000    0.726    0.726
##   NAf =~
##     Ashamed           0.524    0.036   14.629    0.000    0.524    0.524
##     Distressed        0.790    0.019   40.603    0.000    0.790    0.790
##     Guilty            0.690    0.029   23.874    0.000    0.690    0.690
##     Irritable         0.721    0.024   29.952    0.000    0.721    0.721
##     Scared            0.781    0.022   36.113    0.000    0.781    0.781
##     Hostile           0.576    0.034   16.874    0.000    0.576    0.576
##     Jittery           0.687    0.027   25.636    0.000    0.687    0.687
##     Nervous           0.848    0.017   49.936    0.000    0.848    0.848
##     Afraid            0.727    0.026   27.686    0.000    0.727    0.727
##     Upset             0.785    0.021   37.766    0.000    0.785    0.785
```

```
##     Alert             0.361    0.038    9.630    0.000    0.361    0.361
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PAf ~~
##     NAf              -0.144    0.048   -2.983    0.003   -0.144   -0.144
##
## Thresholds:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     Active|t1        -1.872    0.117  -16.056    0.000   -1.872   -1.872
##     Active|t2        -1.399    0.085  -16.425    0.000   -1.399   -1.399
##     Active|t3        -0.885    0.068  -13.038    0.000   -0.885   -0.885
##     Active|t4         0.488    0.061    7.955    0.000    0.488    0.488
##     Attentive|t1     -1.904    0.120  -15.923    0.000   -1.904   -1.904
##     Attentive|t2     -1.399    0.085  -16.425    0.000   -1.399   -1.399
##     Attentive|t3     -0.829    0.067  -12.441    0.000   -0.829   -0.829
##     Attentive|t4      0.732    0.065   11.305    0.000    0.732    0.732
##     Determined|t1    -1.939    0.123  -15.768    0.000   -1.939   -1.939
##     Determined|t2    -1.303    0.081  -16.102    0.000   -1.303   -1.303
##     Determined|t3    -0.622    0.063   -9.872    0.000   -0.622   -0.622
##     Determined|t4     0.662    0.064   10.413    0.000    0.662    0.662
##     Excited|t1       -1.939    0.123  -15.768    0.000   -1.939   -1.939
##     Excited|t2       -1.266    0.079  -15.936    0.000   -1.266   -1.266
##     Excited|t3       -0.350    0.060   -5.829    0.000   -0.350   -0.350
##     Excited|t4        0.740    0.065   11.394    0.000    0.740    0.740
##     Interested|t1    -1.872    0.117  -16.056    0.000   -1.872   -1.872
##     Interested|t2    -1.444    0.087  -16.529    0.000   -1.444   -1.444
##     Interested|t3    -0.732    0.065  -11.305    0.000   -0.732   -0.732
##     Interested|t4     0.622    0.063    9.872    0.000    0.622    0.622
##     Proud|t1         -1.544    0.093  -16.650    0.000   -1.544   -1.544
##     Proud|t2         -0.885    0.068  -13.038    0.000   -0.885   -0.885
##     Proud|t3         -0.140    0.059   -2.382    0.017   -0.140   -0.140
##     Proud|t4          0.869    0.067   12.869    0.000    0.869    0.869
##     Alert|t1         -1.399    0.085  -16.425    0.000   -1.399   -1.399
##     Alert|t2         -0.943    0.069  -13.619    0.000   -0.943   -0.943
##     Alert|t3         -0.235    0.059   -3.968    0.000   -0.235   -0.235
##     Alert|t4          0.987    0.070   14.024    0.000    0.987    0.987
##     Enthusiastc|t1   -1.733    0.105  -16.481    0.000   -1.733   -1.733
##     Enthusiastc|t2   -1.061    0.072  -14.646    0.000   -1.061   -1.061
##     Enthusiastc|t3   -0.286    0.060   -4.806    0.000   -0.286   -0.286
##     Enthusiastc|t4    0.837    0.067   12.527    0.000    0.837    0.837
##     Strong|t1        -1.509    0.091  -16.625    0.000   -1.509   -1.509
##     Strong|t2        -0.951    0.069  -13.701    0.000   -0.951   -0.951
##     Strong|t3        -0.151    0.059   -2.569    0.010   -0.151   -0.151
##     Strong|t4         0.918    0.069   13.372    0.000    0.918    0.918
##     Inspired|t1      -1.758    0.107  -16.422    0.000   -1.758   -1.758
##     Inspired|t2      -1.061    0.072  -14.646    0.000   -1.061   -1.061
##     Inspired|t3      -0.190    0.059   -3.222    0.001   -0.190   -0.190
##     Inspired|t4       0.747    0.065   11.482    0.000    0.747    0.747
##     Ashamed|t1       -0.635    0.063  -10.053    0.000   -0.635   -0.635
##     Ashamed|t2        0.074    0.059    1.262    0.207    0.074    0.074
##     Ashamed|t3        0.814    0.066   12.269    0.000    0.814    0.814
##     Ashamed|t4        2.016    0.131   15.377    0.000    2.016    2.016
##     Distressed|t1    -1.090    0.073  -14.870    0.000   -1.090   -1.090
```

```
##     Distressed|t2    -0.488    0.061   -7.955    0.000   -0.488   -0.488
##     Distressed|t3     0.030    0.059    0.514    0.607    0.030    0.030
##     Distressed|t4     1.141    0.075   15.229    0.000    1.141    1.141
##     Guilty|t1        -0.602    0.063   -9.600    0.000   -0.602   -0.602
##     Guilty|t2         0.008    0.059    0.140    0.889    0.008    0.008
##     Guilty|t3         0.690    0.064   10.772    0.000    0.690    0.690
##     Guilty|t4         1.621    0.097   16.641    0.000    1.621    1.621
##     Irritable|t1     -1.303    0.081  -16.102    0.000   -1.303   -1.303
##     Irritable|t2     -0.451    0.061   -7.402    0.000   -0.451   -0.451
##     Irritable|t3      0.163    0.059    2.756    0.006    0.163    0.163
##     Irritable|t4      1.356    0.083   16.299    0.000    1.356    1.356
##     Scared|t1        -0.877    0.068  -12.953    0.000   -0.877   -0.877
##     Scared|t2        -0.163    0.059   -2.756    0.006   -0.163   -0.163
##     Scared|t3         0.344    0.060    5.736    0.000    0.344    0.344
##     Scared|t4         1.184    0.076   15.501    0.000    1.184    1.184
##     Hostile|t1       -0.367    0.060   -6.107    0.000   -0.367   -0.367
##     Hostile|t2        0.275    0.060    4.620    0.000    0.275    0.275
##     Hostile|t3        1.090    0.073   14.870    0.000    1.090    1.090
##     Hostile|t4        1.976    0.127   15.588    0.000    1.976    1.976
##     Jittery|t1       -1.329    0.082  -16.204    0.000   -1.329   -1.329
##     Jittery|t2       -0.635    0.063  -10.053    0.000   -0.635   -0.635
##     Jittery|t3       -0.052    0.059   -0.888    0.375   -0.052   -0.052
##     Jittery|t4        0.960    0.070   13.782    0.000    0.960    0.960
##     Nervous|t1       -1.042    0.072  -14.494    0.000   -1.042   -1.042
##     Nervous|t2       -0.367    0.060   -6.107    0.000   -0.367   -0.367
##     Nervous|t3        0.213    0.059    3.595    0.000    0.213    0.213
##     Nervous|t4        1.195    0.077   15.567    0.000    1.195    1.195
##     Afraid|t1        -0.207    0.059   -3.502    0.000   -0.207   -0.207
##     Afraid|t2         0.421    0.061    6.940    0.000    0.421    0.421
##     Afraid|t3         1.120    0.074   15.088    0.000    1.120    1.120
##     Afraid|t4         1.758    0.107   16.422    0.000    1.758    1.758
##     Upset|t1         -0.877    0.068  -12.953    0.000   -0.877   -0.877
##     Upset|t2         -0.247    0.059   -4.155    0.000   -0.247   -0.247
##     Upset|t3          0.275    0.060    4.620    0.000    0.275    0.275
##     Upset|t4          1.241    0.078   15.818    0.000    1.241    1.241
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Active            0.456                               0.456    0.456
##    .Attentive         0.471                               0.471    0.471
##    .Determined        0.380                               0.380    0.380
##    .Excited           0.315                               0.315    0.315
##    .Interested        0.376                               0.376    0.376
##    .Proud             0.401                               0.401    0.401
##    .Alert             0.690                               0.690    0.690
##    .Enthusiastic      0.294                               0.294    0.294
##    .Strong            0.479                               0.479    0.479
##    .Inspired          0.473                               0.473    0.473
##    .Ashamed           0.725                               0.725    0.725
##    .Distressed        0.377                               0.377    0.377
##    .Guilty            0.525                               0.525    0.525
##    .Irritable         0.480                               0.480    0.480
##    .Scared            0.390                               0.390    0.390
##    .Hostile           0.668                               0.668    0.668
```

```
##    .Jittery           0.528                                    0.528    0.528
##    .Nervous           0.280                                    0.280    0.280
##    .Afraid            0.471                                    0.471    0.471
##    .Upset             0.384                                    0.384    0.384
##     PAf               1.000                                    1.000    1.000
##     NAf               1.000                                    1.000    1.000
```

```r
semTools::compRelSEM(fit_crossload)
```

```
##   PAf   NAf
## 0.934 0.922
```

3.10 Reflective bifactor model fits the data better

```r
### 3. Orthogonal Bifactor Model
#---------------------------------

bifactor_syntax <- '
  G_Factor =~ Active + Ashamed + Attentive + Distressed + Determined + Guilty +
              Excited + Irritable + Interested + Scared + Proud + Hostile +
              Alert + Jittery + Enthusiastic + Nervous + Strong + Afraid +
              Inspired + Upset

  PAf =~ Active + Attentive + Determined + Excited + Interested + Proud +
                 Alert + Enthusiastic + Strong + Inspired

  NAf =~ Ashamed + Distressed + Guilty + Irritable + Scared + Hostile +
                 Jittery + Nervous + Afraid + Upset
'

fit_bifactor_orthogonal <- cfa(
  bifactor_syntax,
  data = panas_data,
  ordered = TRUE,
  orthogonal = TRUE,
  estimator = "WLSMV",
  std.lv = TRUE
)

fitMeasures(fit_bifactor_orthogonal, c("chisq", "df", "pvalue", "cfi", "rmsea", "rmsea.ci.lower", "rmse
```

```
##          chisq             df         pvalue            cfi          rmsea
##        503.450        150.000          0.000          0.987          0.072
## rmsea.ci.lower rmsea.ci.upper
##          0.065          0.079
```

```r
summary(fit_bifactor_orthogonal, standardized = TRUE)
```

```
## lavaan 0.6-20 ended normally after 64 iterations
##
```

```
##   Estimator                                       DWLS
##   Optimization method                           NLMINB
##   Number of model parameters                       120
##
##   Number of observations                           457
##
## Model Test User Model:
##                                              Standard      Scaled
##   Test Statistic                              503.450     682.823
##   Degrees of freedom                              150         150
##   P-value (Chi-square)                          0.000       0.000
##   Scaling correction factor                                 0.815
##   Shift parameter                                          65.010
##     simple second-order correction
##
## Parameter Estimates:
##
##   Parameterization                               Delta
##   Standard errors                           Robust.sem
##   Information                                 Expected
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   G_Factor =~
##     Active            0.279    0.060    4.655    0.000    0.279    0.279
##     Ashamed          -0.353    0.072   -4.901    0.000   -0.353   -0.353
##     Attentive         0.169    0.063    2.684    0.007    0.169    0.169
##     Distressed       -0.517    0.072   -7.207    0.000   -0.517   -0.517
##     Determined        0.226    0.060    3.751    0.000    0.226    0.226
##     Guilty           -0.532    0.062   -8.606    0.000   -0.532   -0.532
##     Excited           0.300    0.055    5.411    0.000    0.300    0.300
##     Irritable        -0.154    0.092   -1.672    0.094   -0.154   -0.154
##     Interested        0.111    0.065    1.707    0.088    0.111    0.111
##     Scared           -0.564    0.068   -8.268    0.000   -0.564   -0.564
##     Proud             0.240    0.057    4.206    0.000    0.240    0.240
##     Hostile          -0.387    0.065   -5.924    0.000   -0.387   -0.387
##     Alert            -0.407    0.077   -5.294    0.000   -0.407   -0.407
##     Jittery          -0.349    0.074   -4.711    0.000   -0.349   -0.349
##     Enthusiastic      0.230    0.057    4.022    0.000    0.230    0.230
##     Nervous          -0.379    0.084   -4.531    0.000   -0.379   -0.379
##     Strong            0.085    0.060    1.405    0.160    0.085    0.085
##     Afraid           -0.758    0.059  -12.867    0.000   -0.758   -0.758
##     Inspired          0.185    0.060    3.056    0.002    0.185    0.185
##     Upset            -0.443    0.073   -6.097    0.000   -0.443   -0.443
##   PAf =~
##     Active            0.687    0.031   22.269    0.000    0.687    0.687
##     Attentive         0.709    0.027   26.374    0.000    0.709    0.709
##     Determined        0.755    0.026   29.185    0.000    0.755    0.755
##     Excited           0.775    0.024   32.547    0.000    0.775    0.775
##     Interested        0.793    0.023   34.580    0.000    0.793    0.793
##     Proud             0.736    0.024   30.594    0.000    0.736    0.736
##     Alert             0.552    0.043   12.974    0.000    0.552    0.552
##     Enthusiastic      0.807    0.020   40.888    0.000    0.807    0.807
```

```
##     Strong             0.728    0.022   33.355    0.000    0.728    0.728
##     Inspired           0.701    0.024   28.810    0.000    0.701    0.701
##   NAf =~
##     Ashamed            0.386    0.061    6.312    0.000    0.386    0.386
##     Distressed         0.599    0.060    9.915    0.000    0.599    0.599
##     Guilty             0.455    0.063    7.245    0.000    0.455    0.455
##     Irritable          0.800    0.040   19.909    0.000    0.800    0.800
##     Scared             0.550    0.065    8.490    0.000    0.550    0.550
##     Hostile            0.424    0.058    7.301    0.000    0.424    0.424
##     Jittery            0.597    0.048   12.339    0.000    0.597    0.597
##     Nervous            0.779    0.042   18.359    0.000    0.779    0.779
##     Afraid             0.338    0.079    4.258    0.000    0.338    0.338
##     Upset              0.650    0.048   13.518    0.000    0.650    0.650
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   G_Factor ~~
##     PAf                0.000                               0.000    0.000
##     NAf                0.000                               0.000    0.000
##   PAf ~~
##     NAf                0.000                               0.000    0.000
##
## Thresholds:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     Active|t1         -1.872    0.117  -16.056    0.000   -1.872   -1.872
##     Active|t2         -1.399    0.085  -16.425    0.000   -1.399   -1.399
##     Active|t3         -0.885    0.068  -13.038    0.000   -0.885   -0.885
##     Active|t4          0.488    0.061    7.955    0.000    0.488    0.488
##     Ashamed|t1        -0.635    0.063  -10.053    0.000   -0.635   -0.635
##     Ashamed|t2         0.074    0.059    1.262    0.207    0.074    0.074
##     Ashamed|t3         0.814    0.066   12.269    0.000    0.814    0.814
##     Ashamed|t4         2.016    0.131   15.377    0.000    2.016    2.016
##     Attentive|t1      -1.904    0.120  -15.923    0.000   -1.904   -1.904
##     Attentive|t2      -1.399    0.085  -16.425    0.000   -1.399   -1.399
##     Attentive|t3      -0.829    0.067  -12.441    0.000   -0.829   -0.829
##     Attentive|t4       0.732    0.065   11.305    0.000    0.732    0.732
##     Distressed|t1     -1.090    0.073  -14.870    0.000   -1.090   -1.090
##     Distressed|t2     -0.488    0.061   -7.955    0.000   -0.488   -0.488
##     Distressed|t3      0.030    0.059    0.514    0.607    0.030    0.030
##     Distressed|t4      1.141    0.075   15.229    0.000    1.141    1.141
##     Determined|t1     -1.939    0.123  -15.768    0.000   -1.939   -1.939
##     Determined|t2     -1.303    0.081  -16.102    0.000   -1.303   -1.303
##     Determined|t3     -0.622    0.063   -9.872    0.000   -0.622   -0.622
##     Determined|t4      0.662    0.064   10.413    0.000    0.662    0.662
##     Guilty|t1         -0.602    0.063   -9.600    0.000   -0.602   -0.602
##     Guilty|t2          0.008    0.059    0.140    0.889    0.008    0.008
##     Guilty|t3          0.690    0.064   10.772    0.000    0.690    0.690
##     Guilty|t4          1.621    0.097   16.641    0.000    1.621    1.621
##     Excited|t1        -1.939    0.123  -15.768    0.000   -1.939   -1.939
##     Excited|t2        -1.266    0.079  -15.936    0.000   -1.266   -1.266
##     Excited|t3        -0.350    0.060   -5.829    0.000   -0.350   -0.350
##     Excited|t4         0.740    0.065   11.394    0.000    0.740    0.740
##     Irritable|t1      -1.303    0.081  -16.102    0.000   -1.303   -1.303
##     Irritable|t2      -0.451    0.061   -7.402    0.000   -0.451   -0.451
```

```
##     Irritable|t3      0.163    0.059    2.756    0.006    0.163    0.163
##     Irritable|t4      1.356    0.083   16.299    0.000    1.356    1.356
##     Interested|t1    -1.872    0.117  -16.056    0.000   -1.872   -1.872
##     Interested|t2    -1.444    0.087  -16.529    0.000   -1.444   -1.444
##     Interested|t3    -0.732    0.065  -11.305    0.000   -0.732   -0.732
##     Interested|t4     0.622    0.063    9.872    0.000    0.622    0.622
##     Scared|t1        -0.877    0.068  -12.953    0.000   -0.877   -0.877
##     Scared|t2        -0.163    0.059   -2.756    0.006   -0.163   -0.163
##     Scared|t3         0.344    0.060    5.736    0.000    0.344    0.344
##     Scared|t4         1.184    0.076   15.501    0.000    1.184    1.184
##     Proud|t1         -1.544    0.093  -16.650    0.000   -1.544   -1.544
##     Proud|t2         -0.885    0.068  -13.038    0.000   -0.885   -0.885
##     Proud|t3         -0.140    0.059   -2.382    0.017   -0.140   -0.140
##     Proud|t4          0.869    0.067   12.869    0.000    0.869    0.869
##     Hostile|t1       -0.367    0.060   -6.107    0.000   -0.367   -0.367
##     Hostile|t2        0.275    0.060    4.620    0.000    0.275    0.275
##     Hostile|t3        1.090    0.073   14.870    0.000    1.090    1.090
##     Hostile|t4        1.976    0.127   15.588    0.000    1.976    1.976
##     Alert|t1         -1.399    0.085  -16.425    0.000   -1.399   -1.399
##     Alert|t2         -0.943    0.069  -13.619    0.000   -0.943   -0.943
##     Alert|t3         -0.235    0.059   -3.968    0.000   -0.235   -0.235
##     Alert|t4          0.987    0.070   14.024    0.000    0.987    0.987
##     Jittery|t1       -1.329    0.082  -16.204    0.000   -1.329   -1.329
##     Jittery|t2       -0.635    0.063  -10.053    0.000   -0.635   -0.635
##     Jittery|t3       -0.052    0.059   -0.888    0.375   -0.052   -0.052
##     Jittery|t4        0.960    0.070   13.782    0.000    0.960    0.960
##     Enthusiastc|t1   -1.733    0.105  -16.481    0.000   -1.733   -1.733
##     Enthusiastc|t2   -1.061    0.072  -14.646    0.000   -1.061   -1.061
##     Enthusiastc|t3   -0.286    0.060   -4.806    0.000   -0.286   -0.286
##     Enthusiastc|t4    0.837    0.067   12.527    0.000    0.837    0.837
##     Nervous|t1       -1.042    0.072  -14.494    0.000   -1.042   -1.042
##     Nervous|t2       -0.367    0.060   -6.107    0.000   -0.367   -0.367
##     Nervous|t3        0.213    0.059    3.595    0.000    0.213    0.213
##     Nervous|t4        1.195    0.077   15.567    0.000    1.195    1.195
##     Strong|t1        -1.509    0.091  -16.625    0.000   -1.509   -1.509
##     Strong|t2        -0.951    0.069  -13.701    0.000   -0.951   -0.951
##     Strong|t3        -0.151    0.059   -2.569    0.010   -0.151   -0.151
##     Strong|t4         0.918    0.069   13.372    0.000    0.918    0.918
##     Afraid|t1        -0.207    0.059   -3.502    0.000   -0.207   -0.207
##     Afraid|t2         0.421    0.061    6.940    0.000    0.421    0.421
##     Afraid|t3         1.120    0.074   15.088    0.000    1.120    1.120
##     Afraid|t4         1.758    0.107   16.422    0.000    1.758    1.758
##     Inspired|t1      -1.758    0.107  -16.422    0.000   -1.758   -1.758
##     Inspired|t2      -1.061    0.072  -14.646    0.000   -1.061   -1.061
##     Inspired|t3      -0.190    0.059   -3.222    0.001   -0.190   -0.190
##     Inspired|t4       0.747    0.065   11.482    0.000    0.747    0.747
##     Upset|t1         -0.877    0.068  -12.953    0.000   -0.877   -0.877
##     Upset|t2         -0.247    0.059   -4.155    0.000   -0.247   -0.247
##     Upset|t3          0.275    0.060    4.620    0.000    0.275    0.275
##     Upset|t4          1.241    0.078   15.818    0.000    1.241    1.241
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Active            0.450                               0.450    0.450
```

```
##     .Ashamed          0.726                              0.726    0.726
##     .Attentive        0.469                              0.469    0.469
##     .Distressed       0.374                              0.374    0.374
##     .Determined       0.380                              0.380    0.380
##     .Guilty           0.510                              0.510    0.510
##     .Excited          0.309                              0.309    0.309
##     .Irritable        0.337                              0.337    0.337
##     .Interested       0.358                              0.358    0.358
##     .Scared           0.380                              0.380    0.380
##     .Proud            0.401                              0.401    0.401
##     .Hostile          0.670                              0.670    0.670
##     .Alert            0.530                              0.530    0.530
##     .Jittery          0.521                              0.521    0.521
##     .Enthusiastic     0.296                              0.296    0.296
##     .Nervous          0.250                              0.250    0.250
##     .Strong           0.463                              0.463    0.463
##     .Afraid           0.311                              0.311    0.311
##     .Inspired         0.474                              0.474    0.474
##     .Upset            0.382                              0.382    0.382
##      G_Factor         1.000                              1.000    1.000
##      PAf              1.000                              1.000    1.000
##      NAf              1.000                              1.000    1.000
```

```
semTools::compRelSEM(fit_bifactor_orthogonal)
```

```
## G_Factor      PAf      NAf
##    0.124    0.893    0.556
```

3.11 Constrained bifactor model

We apply constraints for parsimony.

```
### 4. Constrained Bifactor Model (for Parsimony)
#---------------------------------------------------

constrained_bifactor_syntax <- '
  G_Factor =~ Active + 0*Ashamed + Attentive + 0*Distressed + Determined +
              0*Guilty + Excited + 0*Irritable + Interested + 0*Scared +
              Proud + 0*Hostile + Alert + 0*Jittery +
              Enthusiastic + 0*Nervous + Strong + Afraid +
              Inspired + 0*Upset

  PAf =~ 0*Active + 0*Attentive + 0*Determined + Excited + Interested + Proud +
                0*Alert + Enthusiastic + Strong + Inspired

  NAf =~ Ashamed + Distressed + Guilty + Irritable + Scared + Hostile +
                Jittery + Nervous + Afraid + Upset + Alert
'

fit_bifactor_constrained <- cfa(
  constrained_bifactor_syntax,
  data = panas_data,
```

```r
  ordered = TRUE,
  orthogonal = TRUE,
  estimator = "WLSMV",
  std.lv = TRUE
)

fitMeasures(fit_bifactor_constrained, c("chisq", "df", "pvalue", "cfi", "rmsea", "rmsea.ci.lower", "rmse
```

```
##          chisq             df         pvalue            cfi          rmsea
##        591.050        162.000          0.000          0.984          0.076
## rmsea.ci.lower rmsea.ci.upper
##          0.070          0.083
```

```r
summary(fit_bifactor_constrained, standardized = TRUE)
```

```
## lavaan 0.6-20 ended normally after 32 iterations
##
##   Estimator                                       DWLS
##   Optimization method                           NLMINB
##   Number of model parameters                       108
##
##   Number of observations                           457
##
## Model Test User Model:
##                                               Standard      Scaled
##   Test Statistic                               591.050     357.748
##   Degrees of freedom                               162         162
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  2.423
##   Shift parameter                                          113.830
##     simple second-order correction
##
## Parameter Estimates:
##
##   Parameterization                               Delta
##   Standard errors                           Robust.sem
##   Information                                 Expected
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   G_Factor =~
##     Active            0.795    0.024   33.147    0.000    0.795    0.795
##     Ashamed           0.000                               0.000    0.000
##     Attentive         0.780    0.023   34.278    0.000    0.780    0.780
##     Distressed        0.000                               0.000    0.000
##     Determined        0.859    0.022   39.063    0.000    0.859    0.859
##     Guilty            0.000                               0.000    0.000
##     Excited           0.687    0.027   25.396    0.000    0.687    0.687
##     Irritable         0.000                               0.000    0.000
##     Interested        0.694    0.028   24.351    0.000    0.694    0.694
##     Scared            0.000                               0.000    0.000
```

```
##      Proud              0.687    0.026   26.075    0.000    0.687    0.687
##      Hostile            0.000                              0.000    0.000
##      Alert              0.464    0.038   12.084    0.000    0.464    0.464
##      Jittery            0.000                              0.000    0.000
##      Enthusiastic       0.668    0.027   24.995    0.000    0.668    0.668
##      Nervous            0.000                              0.000    0.000
##      Strong             0.620    0.030   20.469    0.000    0.620    0.620
##      Afraid            -0.315    0.049   -6.467    0.000   -0.315   -0.315
##      Inspired           0.579    0.032   18.274    0.000    0.579    0.579
##      Upset              0.000                              0.000    0.000
##    PAf =~
##      Active             0.000                              0.000    0.000
##      Attentive          0.000                              0.000    0.000
##      Determined         0.000                              0.000    0.000
##      Excited            0.483    0.034   14.324    0.000    0.483    0.483
##      Interested         0.404    0.037   11.064    0.000    0.404    0.404
##      Proud              0.358    0.041    8.668    0.000    0.358    0.358
##      Alert              0.000                              0.000    0.000
##      Enthusiastic       0.564    0.031   18.304    0.000    0.564    0.564
##      Strong             0.387    0.040    9.743    0.000    0.387    0.387
##      Inspired           0.477    0.037   13.045    0.000    0.477    0.477
##    NAf =~
##      Ashamed            0.524    0.036   14.699    0.000    0.524    0.524
##      Distressed         0.784    0.020   39.943    0.000    0.784    0.784
##      Guilty             0.681    0.028   23.932    0.000    0.681    0.681
##      Irritable          0.730    0.024   31.024    0.000    0.730    0.730
##      Scared             0.782    0.021   36.825    0.000    0.782    0.782
##      Hostile            0.581    0.034   17.314    0.000    0.581    0.581
##      Jittery            0.695    0.026   26.494    0.000    0.695    0.695
##      Nervous            0.855    0.016   52.130    0.000    0.855    0.855
##      Afraid             0.714    0.027   26.328    0.000    0.714    0.714
##      Upset              0.779    0.021   37.085    0.000    0.779    0.779
##      Alert              0.310    0.040    7.665    0.000    0.310    0.310
##
## Covariances:
##                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    G_Factor ~~
##      PAf                0.000                              0.000    0.000
##      NAf                0.000                              0.000    0.000
##    PAf ~~
##      NAf                0.000                              0.000    0.000
##
## Thresholds:
##                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##      Active|t1         -1.872    0.117  -16.056    0.000   -1.872   -1.872
##      Active|t2         -1.399    0.085  -16.425    0.000   -1.399   -1.399
##      Active|t3         -0.885    0.068  -13.038    0.000   -0.885   -0.885
##      Active|t4          0.488    0.061    7.955    0.000    0.488    0.488
##      Ashamed|t1        -0.635    0.063  -10.053    0.000   -0.635   -0.635
##      Ashamed|t2         0.074    0.059    1.262    0.207    0.074    0.074
##      Ashamed|t3         0.814    0.066   12.269    0.000    0.814    0.814
##      Ashamed|t4         2.016    0.131   15.377    0.000    2.016    2.016
##      Attentive|t1      -1.904    0.120  -15.923    0.000   -1.904   -1.904
##      Attentive|t2      -1.399    0.085  -16.425    0.000   -1.399   -1.399
```

```
##     Attentive|t3     -0.829    0.067  -12.441    0.000   -0.829   -0.829
##     Attentive|t4      0.732    0.065   11.305    0.000    0.732    0.732
##     Distressed|t1    -1.090    0.073  -14.870    0.000   -1.090   -1.090
##     Distressed|t2    -0.488    0.061   -7.955    0.000   -0.488   -0.488
##     Distressed|t3     0.030    0.059    0.514    0.607    0.030    0.030
##     Distressed|t4     1.141    0.075   15.229    0.000    1.141    1.141
##     Determined|t1    -1.939    0.123  -15.768    0.000   -1.939   -1.939
##     Determined|t2    -1.303    0.081  -16.102    0.000   -1.303   -1.303
##     Determined|t3    -0.622    0.063   -9.872    0.000   -0.622   -0.622
##     Determined|t4     0.662    0.064   10.413    0.000    0.662    0.662
##     Guilty|t1        -0.602    0.063   -9.600    0.000   -0.602   -0.602
##     Guilty|t2         0.008    0.059    0.140    0.889    0.008    0.008
##     Guilty|t3         0.690    0.064   10.772    0.000    0.690    0.690
##     Guilty|t4         1.621    0.097   16.641    0.000    1.621    1.621
##     Excited|t1       -1.939    0.123  -15.768    0.000   -1.939   -1.939
##     Excited|t2       -1.266    0.079  -15.936    0.000   -1.266   -1.266
##     Excited|t3       -0.350    0.060   -5.829    0.000   -0.350   -0.350
##     Excited|t4        0.740    0.065   11.394    0.000    0.740    0.740
##     Irritable|t1     -1.303    0.081  -16.102    0.000   -1.303   -1.303
##     Irritable|t2     -0.451    0.061   -7.402    0.000   -0.451   -0.451
##     Irritable|t3      0.163    0.059    2.756    0.006    0.163    0.163
##     Irritable|t4      1.356    0.083   16.299    0.000    1.356    1.356
##     Interested|t1    -1.872    0.117  -16.056    0.000   -1.872   -1.872
##     Interested|t2    -1.444    0.087  -16.529    0.000   -1.444   -1.444
##     Interested|t3    -0.732    0.065  -11.305    0.000   -0.732   -0.732
##     Interested|t4     0.622    0.063    9.872    0.000    0.622    0.622
##     Scared|t1        -0.877    0.068  -12.953    0.000   -0.877   -0.877
##     Scared|t2        -0.163    0.059   -2.756    0.006   -0.163   -0.163
##     Scared|t3         0.344    0.060    5.736    0.000    0.344    0.344
##     Scared|t4         1.184    0.076   15.501    0.000    1.184    1.184
##     Proud|t1         -1.544    0.093  -16.650    0.000   -1.544   -1.544
##     Proud|t2         -0.885    0.068  -13.038    0.000   -0.885   -0.885
##     Proud|t3         -0.140    0.059   -2.382    0.017   -0.140   -0.140
##     Proud|t4          0.869    0.067   12.869    0.000    0.869    0.869
##     Hostile|t1       -0.367    0.060   -6.107    0.000   -0.367   -0.367
##     Hostile|t2        0.275    0.060    4.620    0.000    0.275    0.275
##     Hostile|t3        1.090    0.073   14.870    0.000    1.090    1.090
##     Hostile|t4        1.976    0.127   15.588    0.000    1.976    1.976
##     Alert|t1         -1.399    0.085  -16.425    0.000   -1.399   -1.399
##     Alert|t2         -0.943    0.069  -13.619    0.000   -0.943   -0.943
##     Alert|t3         -0.235    0.059   -3.968    0.000   -0.235   -0.235
##     Alert|t4          0.987    0.070   14.024    0.000    0.987    0.987
##     Jittery|t1       -1.329    0.082  -16.204    0.000   -1.329   -1.329
##     Jittery|t2       -0.635    0.063  -10.053    0.000   -0.635   -0.635
##     Jittery|t3       -0.052    0.059   -0.888    0.375   -0.052   -0.052
##     Jittery|t4        0.960    0.070   13.782    0.000    0.960    0.960
##     Enthusiastc|t1   -1.733    0.105  -16.481    0.000   -1.733   -1.733
##     Enthusiastc|t2   -1.061    0.072  -14.646    0.000   -1.061   -1.061
##     Enthusiastc|t3   -0.286    0.060   -4.806    0.000   -0.286   -0.286
##     Enthusiastc|t4    0.837    0.067   12.527    0.000    0.837    0.837
##     Nervous|t1       -1.042    0.072  -14.494    0.000   -1.042   -1.042
##     Nervous|t2       -0.367    0.060   -6.107    0.000   -0.367   -0.367
##     Nervous|t3        0.213    0.059    3.595    0.000    0.213    0.213
##     Nervous|t4        1.195    0.077   15.567    0.000    1.195    1.195
```

```
##     Strong|t1        -1.509    0.091  -16.625    0.000   -1.509   -1.509
##     Strong|t2        -0.951    0.069  -13.701    0.000   -0.951   -0.951
##     Strong|t3        -0.151    0.059   -2.569    0.010   -0.151   -0.151
##     Strong|t4         0.918    0.069   13.372    0.000    0.918    0.918
##     Afraid|t1        -0.207    0.059   -3.502    0.000   -0.207   -0.207
##     Afraid|t2         0.421    0.061    6.940    0.000    0.421    0.421
##     Afraid|t3         1.120    0.074   15.088    0.000    1.120    1.120
##     Afraid|t4         1.758    0.107   16.422    0.000    1.758    1.758
##     Inspired|t1      -1.758    0.107  -16.422    0.000   -1.758   -1.758
##     Inspired|t2      -1.061    0.072  -14.646    0.000   -1.061   -1.061
##     Inspired|t3      -0.190    0.059   -3.222    0.001   -0.190   -0.190
##     Inspired|t4       0.747    0.065   11.482    0.000    0.747    0.747
##     Upset|t1         -0.877    0.068  -12.953    0.000   -0.877   -0.877
##     Upset|t2         -0.247    0.059   -4.155    0.000   -0.247   -0.247
##     Upset|t3          0.275    0.060    4.620    0.000    0.275    0.275
##     Upset|t4          1.241    0.078   15.818    0.000    1.241    1.241
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Active            0.367                               0.367    0.367
##    .Ashamed           0.725                               0.725    0.725
##    .Attentive         0.392                               0.392    0.392
##    .Distressed        0.385                               0.385    0.385
##    .Determined        0.262                               0.262    0.262
##    .Guilty            0.537                               0.537    0.537
##    .Excited           0.295                               0.295    0.295
##    .Irritable         0.467                               0.467    0.467
##    .Interested        0.355                               0.355    0.355
##    .Scared            0.389                               0.389    0.389
##    .Proud             0.400                               0.400    0.400
##    .Hostile           0.663                               0.663    0.663
##    .Alert             0.688                               0.688    0.688
##    .Jittery           0.516                               0.516    0.516
##    .Enthusiastic      0.235                               0.235    0.235
##    .Nervous           0.268                               0.268    0.268
##    .Strong            0.465                               0.465    0.465
##    .Afraid            0.392                               0.392    0.392
##    .Inspired          0.437                               0.437    0.437
##    .Upset             0.394                               0.394    0.394
##     G_Factor          1.000                               1.000    1.000
##     PAf               1.000                               1.000    1.000
##     NAf               1.000                               1.000    1.000
```

```
semTools::compRelSEM(fit_bifactor_constrained)
```

```
## G_Factor      PAf      NAf
##    0.736    0.276    0.909
```

3.12 Second-order model test

```r
### 5. Oblique Bifactor Model
#----------------------------------------------------

oblique_bifactor_syntax <- bifactor_syntax

fit_bifactor_oblique <- cfa(
  oblique_bifactor_syntax,
  data = panas_data,
  ordered = TRUE,
  orthogonal = FALSE, # Allows specific factors to correlate
  estimator = "WLSMV",
  std.lv = TRUE
)
```

```
## Warning: lavaan->lav_model_vcov():
##    Could not compute standard errors! The information matrix could not be
##    inverted. This may be a symptom that the model is not identified.
```

```
## Warning: lavaan->lav_test_satorra_bentler():
##    could not invert information matrix needed for robust test statistic
```

```
## Warning: lavaan->lav_object_post_check():
##    covariance matrix of latent variables is not positive definite ; use
##    lavInspect(fit, "cov.lv") to investigate.
```

```r
fitMeasures(fit_bifactor_oblique, c("chisq", "df", "pvalue", "cfi", "rmsea", "rmsea.ci.lower", "rmsea.ci
```

```
## Warning: lavaan->lav_object_post_check():
##    covariance matrix of latent variables is not positive definite ; use
##    lavInspect(fit, "cov.lv") to investigate.
## Warning: lavaan->lav_object_post_check():
##    covariance matrix of latent variables is not positive definite ; use
##    lavInspect(fit, "cov.lv") to investigate.
```

```
##          chisq             df         pvalue            cfi          rmsea
##        369.564        147.000          0.000          0.992          0.058
## rmsea.ci.lower rmsea.ci.upper
##          0.050          0.065
```

```r
summary(fit_bifactor_oblique, standardized = TRUE)
```

```
## lavaan 0.6-20 ended normally after 87 iterations
##
##   Estimator                                         DWLS
##   Optimization method                             NLMINB
##   Number of model parameters                         123
##
##   Number of observations                             457
##
## Model Test User Model:
```

```
##                                               Standard      Scaled
##   Test Statistic                               369.564          NA
##   Degrees of freedom                               147         147
##   P-value (Chi-square)                           0.000          NA
##   Scaling correction factor                                     NA
##   Shift parameter                                               NA
##
##
## Parameter Estimates:
##
##   Parameterization                               Delta
##   Standard errors                          Robust.sem
##   Information                                 Expected
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   G_Factor =~
##     Active            0.662       NA                      0.662    0.662
##     Ashamed          -0.134       NA                     -0.134   -0.134
##     Attentive         0.624       NA                      0.624    0.624
##     Distressed       -0.247       NA                     -0.247   -0.247
##     Determined        0.688       NA                      0.688    0.688
##     Guilty           -0.253       NA                     -0.253   -0.253
##     Excited           0.739       NA                      0.739    0.739
##     Irritable        -0.049       NA                     -0.049   -0.049
##     Interested        0.652       NA                      0.652    0.652
##     Scared           -0.193       NA                     -0.193   -0.193
##     Proud             0.690       NA                      0.690    0.690
##     Hostile          -0.098       NA                     -0.098   -0.098
##     Alert             0.220       NA                      0.220    0.220
##     Jittery          -0.060       NA                     -0.060   -0.060
##     Enthusiastic      0.734       NA                      0.734    0.734
##     Nervous          -0.089       NA                     -0.089   -0.089
##     Strong            0.605       NA                      0.605    0.605
##     Afraid           -0.376       NA                     -0.376   -0.376
##     Inspired          0.636       NA                      0.636    0.636
##     Upset            -0.249       NA                     -0.249   -0.249
##   PAf =~
##     Active            0.305       NA                      0.305    0.305
##     Attentive         0.363       NA                      0.363    0.363
##     Determined        0.364       NA                      0.364    0.364
##     Excited           0.348       NA                      0.348    0.348
##     Interested        0.448       NA                      0.448    0.448
##     Proud             0.329       NA                      0.329    0.329
##     Alert             0.476       NA                      0.476    0.476
##     Enthusiastic      0.387       NA                      0.387    0.387
##     Strong            0.387       NA                      0.387    0.387
##     Inspired          0.327       NA                      0.327    0.327
##   NAf =~
##     Ashamed           0.445       NA                      0.445    0.445
##     Distressed        0.638       NA                      0.638    0.638
##     Guilty            0.528       NA                      0.528    0.528
##     Irritable         0.711       NA                      0.711    0.711
```

```
##     Scared            0.670       NA                             0.670    0.670
##     Hostile           0.526       NA                             0.526    0.526
##     Jittery           0.669       NA                             0.669    0.669
##     Nervous           0.815       NA                             0.815    0.815
##     Afraid            0.479       NA                             0.479    0.479
##     Upset             0.633       NA                             0.633    0.633
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   G_Factor ~~
##     PAf               0.028       NA                             0.028    0.028
##     NAf              -0.482       NA                            -0.482   -0.482
##   PAf ~~
##     NAf               1.069       NA                             1.069    1.069
##
## Thresholds:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     Active|t1        -1.872       NA                            -1.872   -1.872
##     Active|t2        -1.399       NA                            -1.399   -1.399
##     Active|t3        -0.885       NA                            -0.885   -0.885
##     Active|t4         0.488       NA                             0.488    0.488
##     Ashamed|t1       -0.635       NA                            -0.635   -0.635
##     Ashamed|t2        0.074       NA                             0.074    0.074
##     Ashamed|t3        0.814       NA                             0.814    0.814
##     Ashamed|t4        2.016       NA                             2.016    2.016
##     Attentive|t1     -1.904       NA                            -1.904   -1.904
##     Attentive|t2     -1.399       NA                            -1.399   -1.399
##     Attentive|t3     -0.829       NA                            -0.829   -0.829
##     Attentive|t4      0.732       NA                             0.732    0.732
##     Distressed|t1    -1.090       NA                            -1.090   -1.090
##     Distressed|t2    -0.488       NA                            -0.488   -0.488
##     Distressed|t3     0.030       NA                             0.030    0.030
##     Distressed|t4     1.141       NA                             1.141    1.141
##     Determined|t1    -1.939       NA                            -1.939   -1.939
##     Determined|t2    -1.303       NA                            -1.303   -1.303
##     Determined|t3    -0.622       NA                            -0.622   -0.622
##     Determined|t4     0.662       NA                             0.662    0.662
##     Guilty|t1        -0.602       NA                            -0.602   -0.602
##     Guilty|t2         0.008       NA                             0.008    0.008
##     Guilty|t3         0.690       NA                             0.690    0.690
##     Guilty|t4         1.621       NA                             1.621    1.621
##     Excited|t1       -1.939       NA                            -1.939   -1.939
##     Excited|t2       -1.266       NA                            -1.266   -1.266
##     Excited|t3       -0.350       NA                            -0.350   -0.350
##     Excited|t4        0.740       NA                             0.740    0.740
##     Irritable|t1     -1.303       NA                            -1.303   -1.303
##     Irritable|t2     -0.451       NA                            -0.451   -0.451
##     Irritable|t3      0.163       NA                             0.163    0.163
##     Irritable|t4      1.356       NA                             1.356    1.356
##     Interested|t1    -1.872       NA                            -1.872   -1.872
##     Interested|t2    -1.444       NA                            -1.444   -1.444
##     Interested|t3    -0.732       NA                            -0.732   -0.732
##     Interested|t4     0.622       NA                             0.622    0.622
##     Scared|t1        -0.877       NA                            -0.877   -0.877
```

```
##     Scared|t2       -0.163       NA                           -0.163   -0.163
##     Scared|t3        0.344       NA                            0.344    0.344
##     Scared|t4        1.184       NA                            1.184    1.184
##     Proud|t1        -1.544       NA                           -1.544   -1.544
##     Proud|t2        -0.885       NA                           -0.885   -0.885
##     Proud|t3        -0.140       NA                           -0.140   -0.140
##     Proud|t4         0.869       NA                            0.869    0.869
##     Hostile|t1      -0.367       NA                           -0.367   -0.367
##     Hostile|t2       0.275       NA                            0.275    0.275
##     Hostile|t3       1.090       NA                            1.090    1.090
##     Hostile|t4       1.976       NA                            1.976    1.976
##     Alert|t1        -1.399       NA                           -1.399   -1.399
##     Alert|t2        -0.943       NA                           -0.943   -0.943
##     Alert|t3        -0.235       NA                           -0.235   -0.235
##     Alert|t4         0.987       NA                            0.987    0.987
##     Jittery|t1      -1.329       NA                           -1.329   -1.329
##     Jittery|t2      -0.635       NA                           -0.635   -0.635
##     Jittery|t3      -0.052       NA                           -0.052   -0.052
##     Jittery|t4       0.960       NA                            0.960    0.960
##     Enthusiastc|t1  -1.733       NA                           -1.733   -1.733
##     Enthusiastc|t2  -1.061       NA                           -1.061   -1.061
##     Enthusiastc|t3  -0.286       NA                           -0.286   -0.286
##     Enthusiastc|t4   0.837       NA                            0.837    0.837
##     Nervous|t1      -1.042       NA                           -1.042   -1.042
##     Nervous|t2      -0.367       NA                           -0.367   -0.367
##     Nervous|t3       0.213       NA                            0.213    0.213
##     Nervous|t4       1.195       NA                            1.195    1.195
##     Strong|t1       -1.509       NA                           -1.509   -1.509
##     Strong|t2       -0.951       NA                           -0.951   -0.951
##     Strong|t3       -0.151       NA                           -0.151   -0.151
##     Strong|t4        0.918       NA                            0.918    0.918
##     Afraid|t1       -0.207       NA                           -0.207   -0.207
##     Afraid|t2        0.421       NA                            0.421    0.421
##     Afraid|t3        1.120       NA                            1.120    1.120
##     Afraid|t4        1.758       NA                            1.758    1.758
##     Inspired|t1     -1.758       NA                           -1.758   -1.758
##     Inspired|t2     -1.061       NA                           -1.061   -1.061
##     Inspired|t3     -0.190       NA                           -0.190   -0.190
##     Inspired|t4      0.747       NA                            0.747    0.747
##     Upset|t1        -0.877       NA                           -0.877   -0.877
##     Upset|t2        -0.247       NA                           -0.247   -0.247
##     Upset|t3         0.275       NA                            0.275    0.275
##     Upset|t4         1.241       NA                            1.241    1.241
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Active            0.458                               0.458    0.458
##    .Ashamed           0.727                               0.727    0.727
##    .Attentive         0.466                               0.466    0.466
##    .Distressed        0.379                               0.379    0.379
##    .Determined        0.381                               0.381    0.381
##    .Guilty            0.528                               0.528    0.528
##    .Excited           0.319                               0.319    0.319
##    .Irritable         0.459                               0.459    0.459
```

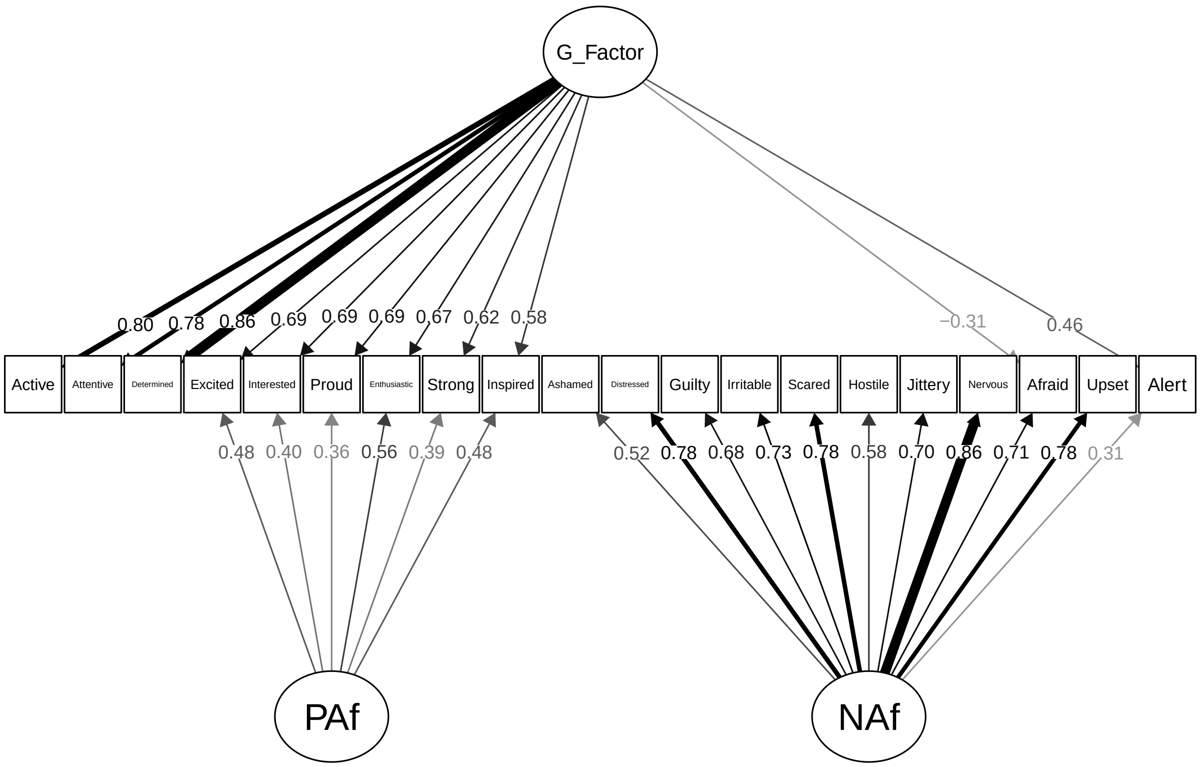
```
##    .Interested       0.358                             0.358    0.358
##    .Scared           0.390                             0.390    0.390
##    .Proud            0.403                             0.403    0.403
##    .Hostile          0.664                             0.664    0.664
##    .Alert            0.719                             0.719    0.719
##    .Jittery          0.510                             0.510    0.510
##    .Enthusiastic     0.295                             0.295    0.295
##    .Nervous          0.257                             0.257    0.257
##    .Strong           0.471                             0.471    0.471
##    .Afraid           0.455                             0.455    0.455
##    .Inspired         0.478                             0.478    0.478
##    .Upset            0.385                             0.385    0.385
##     G_Factor        1.000                             1.000    1.000
##     PAf             1.000                             1.000    1.000
##     NAf             1.000                             1.000    1.000
```

```
semTools::compRelSEM(fit_bifactor_oblique)
```

```
## G_Factor      PAf      NAf
##    0.133    0.234    0.667
```

3.13 Better model plot

```
#png("Figure9.png", height = 8, width = 12, units = 'in', res = 300)

semPaths(
  fit_bifactor_constrained,
  what = "std",
  whatLabels = "est",
  edge.color="black",

  bifactor = "G_Factor",

  layout = "tree2",
  residuals = FALSE,
  intercepts = FALSE,
  thresholds = FALSE,

  edge.label.cex = 0.7,
  sizeMan = 5,
  sizeLat = 10,
  sizeLat2=8,
  edge.label.position=0.85,

  style = "lisrel",
  nCharNodes = 0,
  mar = c(2, 1, 4, 1)
)
```




```r
#dev.off()
```

3.14 Study 2 Correlations

```r
# Extract factor scores
cfa_scores <- as.data.frame(lavPredict(fit_bifactor_constrained))

# PCA scores
pca_scores <- as.data.frame(pca_results_psych$scores)

# Combine scores
all_scores <- cbind(cfa_scores, pca_scores)

# Correlation Matrix Analysis
MVN_scores <- MVN::mvn(all_scores, univariate_test = "SW")
MVN_scores$univariate_normality
```

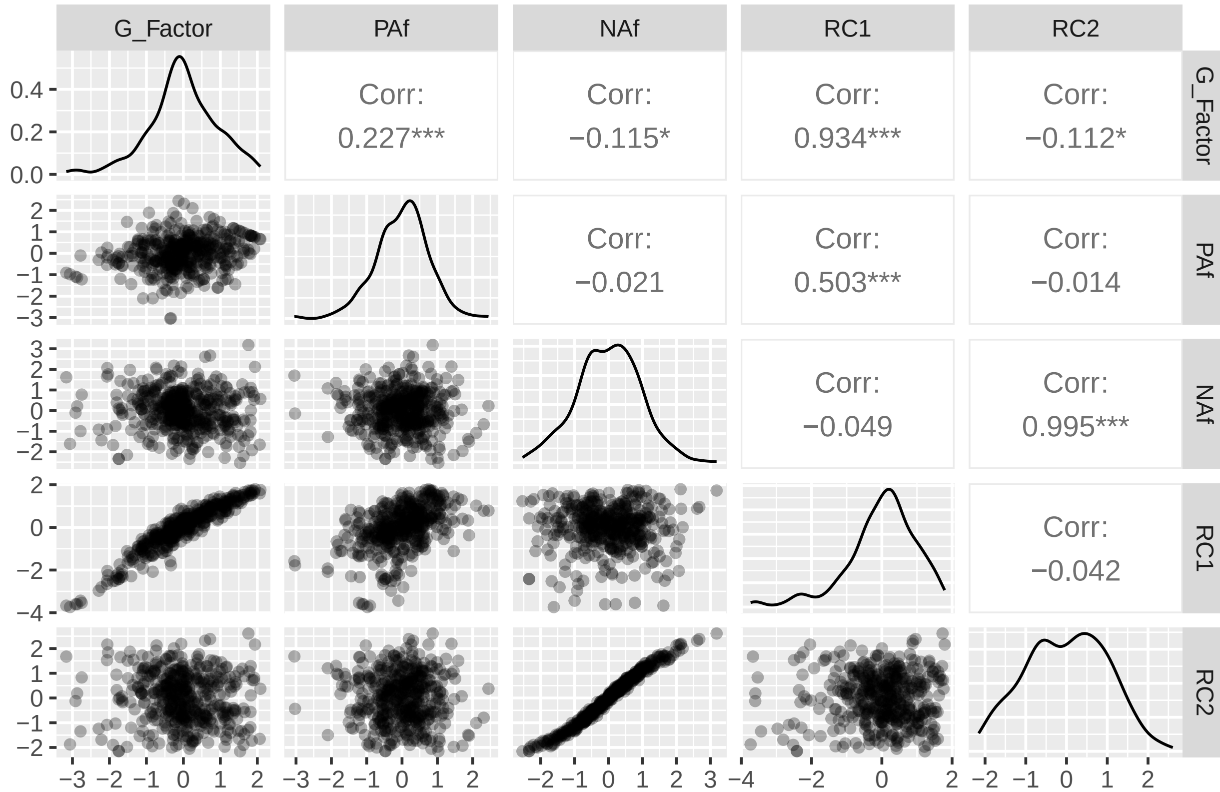
```
##            Test Variable Statistic p.value    Normality
## 1 Shapiro-Wilk G_Factor     0.984  <0.001   Not normal
## 2 Shapiro-Wilk      PAf     0.990   0.002   Not normal
## 3 Shapiro-Wilk      NAf     0.997   0.544       Normal
## 4 Shapiro-Wilk      RC1     0.946  <0.001   Not normal
## 5 Shapiro-Wilk      RC2     0.989   0.002   Not normal
```

```r
# Simple correlation matrix
correlation_matrix <- cor(all_scores, method = "spearman")
correlation_matrix_rounded <- round(correlation_matrix, 2)
print(correlation_matrix_rounded)
```

```
##          G_Factor   PAf   NAf   RC1   RC2
## G_Factor     1.00  0.23 -0.11  0.93 -0.11
## PAf          0.23  1.00 -0.02  0.50 -0.01
## NAf         -0.11 -0.02  1.00 -0.05  0.99
## RC1          0.93  0.50 -0.05  1.00 -0.04
## RC2         -0.11 -0.01  0.99 -0.04  1.00
```

```r
# Visual visualization with GGally
ggpairs_plot <- ggpairs(
  all_scores,
  title = "",
  upper = list(continuous = wrap("cor", method = "spearman", size = 4)),
  lower = list(continuous = wrap("points", alpha = 0.3))
)

print(ggpairs_plot)
```

```
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
## Warning in cor.test.default(x, y, method = method): Impossível calcular o valor
## exato de p com empates
```




```r
#ggsave("Figure10.png", plot = ggpairs_plot, bg = "white", width = 10,
#       height = 6, dpi = 300)
```

3.15 Bifactor model with specific factors covarying vs. previous bifactor model

```r
bifactor_model_syntax <- '
  # General Factor (G) - All items loading on a single global dimension
  G_Factor =~ Active + Ashamed + Attentive + Distressed + Determined +
              Guilty + Excited + Irritable + Interested + Scared +
              Proud + Hostile + Alert + Jittery + Enthusiastic +
              Nervous + Strong + Afraid + Inspired + Upset

  # Positive Affect (PA) Specific Factor
  PAf =~ Active + Attentive + Determined + Excited + Interested +
        Proud + Alert + Enthusiastic + Strong + Inspired

  # Negative Affect (NA) Specific Factor
  NAf =~ Ashamed + Distressed + Guilty + Irritable + Scared +
        Hostile + Jittery + Nervous + Afraid + Upset + Alert
'

#--- STEP 1: Run Orthogonal Bifactor Model ---
fit_bifactor_ortho <- cfa(bifactor_model_syntax,
                          data = panas_data,
```

```r
                          ordered = T,
                          orthogonal = T,
                          estimator = "WLSMV",
                          std.lv=TRUE)

#--- STEP 2: Run Oblique Bifactor Model ---
fit_bifactor_oblique <- cfa(bifactor_model_syntax,
                            data = panas_data,
                            ordered = T,
                            # orthogonal = T, # REMOVED to allow group factor correlations
                            estimator = "WLSMV",
                            std.lv=TRUE)
```

```
## Warning: lavaan->lav_model_vcov():
##    Could not compute standard errors! The information matrix could not be
##    inverted. This may be a symptom that the model is not identified.

## Warning: lavaan->lav_test_satorra_bentler():
##    could not invert information matrix needed for robust test statistic
```

```r
#--- STEP 3: Compare Models ---

fit_ortho_measures <- fitmeasures(fit_bifactor_ortho, c("chisq", "df", "pvalue", "cfi", "rmsea",
                                                        "rmsea.ci.lower","rmsea.ci.upper"))
fit_oblique_measures <- fitmeasures(fit_bifactor_oblique, c("chisq", "df", "pvalue", "cfi", "rmsea",
                                                            "rmsea.ci.lower","rmsea.ci.upper"))

# Print comparison
cat("--- Orthogonal Model Fit ---\n")
```

```
## --- Orthogonal Model Fit ---
```

```r
print(round(fit_ortho_measures, 3))
```

```
##          chisq             df         pvalue            cfi          rmsea
##        294.436        149.000          0.000          0.994          0.046
## rmsea.ci.lower rmsea.ci.upper
##          0.038          0.054
```

```r
cat("\n--- Oblique Model Fit ---\n")
```

```
##
## --- Oblique Model Fit ---
```

```r
print(round(fit_oblique_measures, 3))
```

```
##          chisq             df         pvalue            cfi          rmsea
##        291.546        146.000          0.000          0.994          0.047
## rmsea.ci.lower rmsea.ci.upper
##          0.039          0.055
```

```r
cat("\n--- Oblique Model Summary (Check AP~~AN Covariance) ---\n")
```

```
##
## --- Oblique Model Summary (Check AP~~AN Covariance) ---
```

```r
summary(fit_bifactor_oblique, standardized = TRUE, fit.measures = TRUE)
```

```
## lavaan 0.6-20 ended normally after 61 iterations
##
##   Estimator                                         DWLS
##   Optimization method                             NLMINB
##   Number of model parameters                         124
##
##   Number of observations                             457
##
## Model Test User Model:
##                                               Standard      Scaled
##   Test Statistic                               291.546          NA
##   Degrees of freedom                               146         146
##   P-value (Chi-square)                           0.000          NA
##   Scaling correction factor                                     NA
##   Shift parameter                                               NA
##
##
## Model Test Baseline Model:
##
##   Test statistic                             26632.140    8829.609
##   Degrees of freedom                               190         190
##   P-value                                        0.000       0.000
##   Scaling correction factor                                  3.061
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.994          NA
##   Tucker-Lewis Index (TLI)                       0.993          NA
##
##   Robust Comparative Fit Index (CFI)                            NA
##   Robust Tucker-Lewis Index (TLI)                               NA
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.047          NA
##   90 Percent confidence interval - lower         0.039          NA
##   90 Percent confidence interval - upper         0.055          NA
##   P-value H_0: RMSEA <= 0.050                    0.745          NA
##   P-value H_0: RMSEA >= 0.080                    0.000          NA
##
##   Robust RMSEA                                                  NA
##   90 Percent confidence interval - lower                        NA
##   90 Percent confidence interval - upper                        NA
##   P-value H_0: Robust RMSEA <= 0.050                            NA
##   P-value H_0: Robust RMSEA >= 0.080                            NA
```

```
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                          0.048       0.048
##
## Parameter Estimates:
##
##   Parameterization                              Delta
##   Standard errors                          Robust.sem
##   Information                                Expected
##   Information saturated (h1) model       Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   G_Factor =~
##     Active            0.787       NA                      0.787    0.787
##     Ashamed          -0.132       NA                     -0.132   -0.132
##     Attentive         0.869       NA                      0.869    0.869
##     Distressed       -0.223       NA                     -0.223   -0.223
##     Determined        0.806       NA                      0.806    0.806
##     Guilty           -0.247       NA                     -0.247   -0.247
##     Excited           0.659       NA                      0.659    0.659
##     Irritable        -0.005       NA                     -0.005   -0.005
##     Interested        0.671       NA                      0.671    0.671
##     Scared           -0.183       NA                     -0.183   -0.183
##     Proud             0.652       NA                      0.652    0.652
##     Hostile          -0.083       NA                     -0.083   -0.083
##     Alert             0.412       NA                      0.412    0.412
##     Jittery          -0.034       NA                     -0.034   -0.034
##     Enthusiastic      0.634       NA                      0.634    0.634
##     Nervous          -0.047       NA                     -0.047   -0.047
##     Strong            0.583       NA                      0.583    0.583
##     Afraid           -0.380       NA                     -0.380   -0.380
##     Inspired          0.539       NA                      0.539    0.539
##     Upset            -0.226       NA                     -0.226   -0.226
##   PAf =~
##     Active            0.157       NA                      0.157    0.157
##     Attentive        -0.016       NA                     -0.016   -0.016
##     Determined        0.241       NA                      0.241    0.241
##     Excited           0.593       NA                      0.593    0.593
##     Interested        0.502       NA                      0.502    0.502
##     Proud             0.501       NA                      0.501    0.501
##     Alert             0.163       NA                      0.163    0.163
##     Enthusiastic      0.666       NA                      0.666    0.666
##     Strong            0.510       NA                      0.510    0.510
##     Inspired          0.587       NA                      0.587    0.587
##   NAf =~
##     Ashamed           0.518       NA                      0.518    0.518
##     Distressed        0.777       NA                      0.777    0.777
##     Guilty            0.667       NA                      0.667    0.667
##     Irritable         0.742       NA                      0.742    0.742
##     Scared            0.775       NA                      0.775    0.775
##     Hostile           0.582       NA                      0.582    0.582
##     Jittery           0.705       NA                      0.705    0.705
```

```
##     Nervous           0.868       NA                           0.868    0.868
##     Afraid            0.686       NA                           0.686    0.686
##     Upset             0.773       NA                           0.773    0.773
##     Alert             0.357       NA                           0.357    0.357
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   G_Factor ~~
##     PAf              -0.104       NA                          -0.104   -0.104
##     NAf               0.088       NA                           0.088    0.088
##   PAf ~~
##     NAf              -0.077       NA                          -0.077   -0.077
##
## Thresholds:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     Active|t1        -1.872       NA                          -1.872   -1.872
##     Active|t2        -1.399       NA                          -1.399   -1.399
##     Active|t3        -0.885       NA                          -0.885   -0.885
##     Active|t4         0.488       NA                           0.488    0.488
##     Ashamed|t1       -0.635       NA                          -0.635   -0.635
##     Ashamed|t2        0.074       NA                           0.074    0.074
##     Ashamed|t3        0.814       NA                           0.814    0.814
##     Ashamed|t4        2.016       NA                           2.016    2.016
##     Attentive|t1     -1.904       NA                          -1.904   -1.904
##     Attentive|t2     -1.399       NA                          -1.399   -1.399
##     Attentive|t3     -0.829       NA                          -0.829   -0.829
##     Attentive|t4      0.732       NA                           0.732    0.732
##     Distressed|t1    -1.090       NA                          -1.090   -1.090
##     Distressed|t2    -0.488       NA                          -0.488   -0.488
##     Distressed|t3     0.030       NA                           0.030    0.030
##     Distressed|t4     1.141       NA                           1.141    1.141
##     Determined|t1    -1.939       NA                          -1.939   -1.939
##     Determined|t2    -1.303       NA                          -1.303   -1.303
##     Determined|t3    -0.622       NA                          -0.622   -0.622
##     Determined|t4     0.662       NA                           0.662    0.662
##     Guilty|t1        -0.602       NA                          -0.602   -0.602
##     Guilty|t2         0.008       NA                           0.008    0.008
##     Guilty|t3         0.690       NA                           0.690    0.690
##     Guilty|t4         1.621       NA                           1.621    1.621
##     Excited|t1       -1.939       NA                          -1.939   -1.939
##     Excited|t2       -1.266       NA                          -1.266   -1.266
##     Excited|t3       -0.350       NA                          -0.350   -0.350
##     Excited|t4        0.740       NA                           0.740    0.740
##     Irritable|t1     -1.303       NA                          -1.303   -1.303
##     Irritable|t2     -0.451       NA                          -0.451   -0.451
##     Irritable|t3      0.163       NA                           0.163    0.163
##     Irritable|t4      1.356       NA                           1.356    1.356
##     Interested|t1    -1.872       NA                          -1.872   -1.872
##     Interested|t2    -1.444       NA                          -1.444   -1.444
##     Interested|t3    -0.732       NA                          -0.732   -0.732
##     Interested|t4     0.622       NA                           0.622    0.622
##     Scared|t1        -0.877       NA                          -0.877   -0.877
##     Scared|t2        -0.163       NA                          -0.163   -0.163
##     Scared|t3         0.344       NA                           0.344    0.344
```

```
##     Scared|t4         1.184       NA                              1.184    1.184
##     Proud|t1         -1.544       NA                             -1.544   -1.544
##     Proud|t2         -0.885       NA                             -0.885   -0.885
##     Proud|t3         -0.140       NA                             -0.140   -0.140
##     Proud|t4          0.869       NA                              0.869    0.869
##     Hostile|t1       -0.367       NA                             -0.367   -0.367
##     Hostile|t2        0.275       NA                              0.275    0.275
##     Hostile|t3        1.090       NA                              1.090    1.090
##     Hostile|t4        1.976       NA                              1.976    1.976
##     Alert|t1         -1.399       NA                             -1.399   -1.399
##     Alert|t2         -0.943       NA                             -0.943   -0.943
##     Alert|t3         -0.235       NA                             -0.235   -0.235
##     Alert|t4          0.987       NA                              0.987    0.987
##     Jittery|t1       -1.329       NA                             -1.329   -1.329
##     Jittery|t2       -0.635       NA                             -0.635   -0.635
##     Jittery|t3       -0.052       NA                             -0.052   -0.052
##     Jittery|t4        0.960       NA                              0.960    0.960
##     Enthusiastc|t1   -1.733       NA                             -1.733   -1.733
##     Enthusiastc|t2   -1.061       NA                             -1.061   -1.061
##     Enthusiastc|t3   -0.286       NA                             -0.286   -0.286
##     Enthusiastc|t4    0.837       NA                              0.837    0.837
##     Nervous|t1       -1.042       NA                             -1.042   -1.042
##     Nervous|t2       -0.367       NA                             -0.367   -0.367
##     Nervous|t3        0.213       NA                              0.213    0.213
##     Nervous|t4        1.195       NA                              1.195    1.195
##     Strong|t1        -1.509       NA                             -1.509   -1.509
##     Strong|t2        -0.951       NA                             -0.951   -0.951
##     Strong|t3        -0.151       NA                             -0.151   -0.151
##     Strong|t4         0.918       NA                              0.918    0.918
##     Afraid|t1        -0.207       NA                             -0.207   -0.207
##     Afraid|t2         0.421       NA                              0.421    0.421
##     Afraid|t3         1.120       NA                              1.120    1.120
##     Afraid|t4         1.758       NA                              1.758    1.758
##     Inspired|t1      -1.758       NA                             -1.758   -1.758
##     Inspired|t2      -1.061       NA                             -1.061   -1.061
##     Inspired|t3      -0.190       NA                             -0.190   -0.190
##     Inspired|t4       0.747       NA                              0.747    0.747
##     Upset|t1         -0.877       NA                             -0.877   -0.877
##     Upset|t2         -0.247       NA                             -0.247   -0.247
##     Upset|t3          0.275       NA                              0.275    0.275
##     Upset|t4          1.241       NA                              1.241    1.241
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Active            0.381                               0.381    0.381
##    .Ashamed           0.726                               0.726    0.726
##    .Attentive         0.242                               0.242    0.242
##    .Distressed        0.377                               0.377    0.377
##    .Determined        0.333                               0.333    0.333
##    .Guilty            0.523                               0.523    0.523
##    .Excited           0.295                               0.295    0.295
##    .Irritable         0.449                               0.449    0.449
##    .Interested        0.368                               0.368    0.368
##    .Scared            0.391                               0.391    0.391
```

```
##    .Proud             0.391                                 0.391    0.391
##    .Hostile           0.662                                 0.662    0.662
##    .Alert             0.674                                 0.674    0.674
##    .Jittery           0.506                                 0.506    0.506
##    .Enthusiastic      0.242                                 0.242    0.242
##    .Nervous           0.251                                 0.251    0.251
##    .Strong            0.462                                 0.462    0.462
##    .Afraid            0.431                                 0.431    0.431
##    .Inspired          0.431                                 0.431    0.431
##    .Upset             0.382                                 0.382    0.382
##     G_Factor          1.000                                 1.000    1.000
##     PAf               1.000                                 1.000    1.000
##     NAf               1.000                                 1.000    1.000
```

```r
sessionInfo()
```

```
## R version 4.5.0 (2025-04-11 ucrt)
## Platform: x86_64-w64-mingw32/x64
## Running under: Windows 11 x64 (build 26100)
##
## Matrix products: default
##   LAPACK version 3.12.1
##
## locale:
## [1] LC_COLLATE=Portuguese_Brazil.utf8  LC_CTYPE=Portuguese_Brazil.utf8
## [3] LC_MONETARY=Portuguese_Brazil.utf8 LC_NUMERIC=C
## [5] LC_TIME=Portuguese_Brazil.utf8
##
## time zone: America/Sao_Paulo
## tzcode source: internal
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
##  [1] DiagrammeRsvg_0.1      magick_2.9.0           DiagrammeR_1.0.11
##  [4] plotly_4.11.0          semPlot_1.1.7          GGally_2.4.0
##  [7] ggrepel_0.9.6          patchwork_1.3.2        ggplot2_4.0.1
## [10] EGAnet_2.3.0           cSEM_0.6.1             seminr_2.3.7
## [13] semTools_0.5-7         lavaan_0.6-20          MVN_6.2
## [16] GPArotation_2025.3-1   EFA.dimensions_0.1.8.4 psych_2.5.3
## [19] tidytext_0.4.3         stringr_1.6.0          stringi_1.8.7
## [22] janitor_2.2.1          tidyr_1.3.1            dplyr_1.1.4
## [25] readxl_1.4.5           readr_2.1.6            pacman_0.5.1
##
## loaded via a namespace (and not attached):
##   [1] matrixStats_1.5.0     lubridate_1.9.4       httr_1.4.7
##   [4] webshot_0.5.5         RColorBrewer_1.1-3    tools_4.5.0
##   [7] backports_1.5.0       utf8_1.2.6            R6_2.6.1
##  [10] vegan_2.7-2           lazyeval_0.2.2        mgcv_1.9-4
##  [13] nortest_1.0-4         jomo_2.7-6            permute_0.9-8
##  [16] withr_3.0.2           gridExtra_2.3         fdrtool_1.2.18
##  [19] progressr_0.18.0      polycor_0.8-1         qgraph_1.9.8
##  [22] textshaping_1.0.4     cli_3.6.5             sandwich_3.1-1
```

```
##  [25] labeling_0.4.3        mvtnorm_1.3-3         S7_0.2.1
##  [28] pbapply_1.7-4         pbivnorm_0.6.0        systemfonts_1.3.1
##  [31] foreign_0.8-90        R.utils_2.13.0        parallelly_1.44.0
##  [34] sessioninfo_1.2.3     lisrelToR_0.3         rstudioapi_0.17.1
##  [37] visNetwork_2.1.4      generics_0.1.4        shape_1.4.6.1
##  [40] gtools_3.9.5          vroom_1.6.6           car_3.1-3
##  [43] zip_2.3.3             OpenMx_2.22.10        Matrix_1.7-3
##  [46] clipr_0.8.0           abind_1.4-8           R.methodsS3_1.8.2
##  [49] lifecycle_1.0.4       multcomp_1.4-29       yaml_2.3.10
##  [52] snakecase_0.11.1      carData_3.0-5         grid_4.5.0
##  [55] promises_1.3.2        crayon_1.5.3          mitml_0.4-5
##  [58] lattice_0.22-7        chromote_0.5.1        pillar_1.11.1
##  [61] knitr_1.50            boot_1.3-32           estimability_1.5.1
##  [64] corpcor_1.6.10        future.apply_1.20.0   admisc_0.39
##  [67] codetools_0.2-20      pan_1.9               glue_1.8.0
##  [70] beepr_2.0             V8_8.0.1              data.table_1.17.0
##  [73] vctrs_0.6.5           png_0.1-8             Rdpack_2.6.4
##  [76] testthat_3.3.0        cellranger_1.1.0      gtable_0.3.6
##  [79] xfun_0.52             openxlsx_4.2.8.1      rbibutils_2.3
##  [82] coda_0.19-4.1         reformulas_0.4.2      survival_3.8-3
##  [85] audio_0.1-11          iterators_1.0.14      TH.data_1.1-5
##  [88] nlme_3.1-168          bit64_4.6.0-1         mi_1.2
##  [91] SnowballC_0.7.1       Deriv_4.2.0           rpart_4.1.24
##  [94] colorspace_2.1-1      Hmisc_5.2-3           nnet_7.3-20
##  [97] mnormt_2.1.1          tidyselect_1.2.1      processx_3.8.6
## [100] emmeans_2.0.0         moments_0.14.1        bit_4.6.0
## [103] compiler_4.5.0        curl_7.0.0            glmnet_4.1-8
## [106] htmlTable_2.4.3       mice_3.17.0           checkmate_2.3.2
## [109] scales_1.4.0          quadprog_1.5-8        sem_3.1-16
## [112] digest_0.6.38         minqa_1.2.8           rmarkdown_2.30
## [115] htmltools_0.5.8.1     pkgconfig_2.0.3       jpeg_0.1-11
## [118] base64enc_0.1-3       SimDesign_2.21        lme4_1.1-37
## [121] fastmap_1.2.0         rlang_1.1.6           htmlwidgets_1.6.4
## [124] farver_2.1.2          zoo_1.8-14            jsonlite_2.0.0
## [127] energy_1.7-12         dcurver_0.9.3         tokenizers_0.3.0
## [130] R.oo_1.27.1           magrittr_2.0.3        Formula_1.2-5
## [133] Rcpp_1.1.0            viridis_0.6.5         rockchalk_1.8.157
## [136] brio_1.1.5            MASS_7.3-65           plyr_1.8.9
## [139] ggstats_0.11.0        parallel_4.5.0        listenv_0.10.0
## [142] kutils_1.73           splines_4.5.0         hms_1.1.4
## [145] ps_1.9.1              igraph_2.2.1          reshape2_1.4.4
## [148] stats4_4.5.0          XML_3.99-0.20         evaluate_1.0.5
## [151] RcppParallel_5.1.11-1 nloptr_2.2.1          tzdb_0.5.0
## [154] foreach_1.5.2         webshot2_0.1.2        purrr_1.0.4
## [157] future_1.68.0         mirt_1.45.1           broom_1.0.10
## [160] xtable_1.8-4          janeaustenr_1.0.0     later_1.4.2
## [163] glasso_1.11           viridisLite_0.4.2     ragg_1.5.0
## [166] gsl_2.1-9             arm_1.14-4            tibble_3.2.1
## [169] websocket_1.4.4       cluster_2.1.8.1       timechange_0.3.0
## [172] globals_0.18.0
```