DASS-21 Structural Analysis: Psychometric Properties and Predictors of Anxiety Symptoms Among Students at the Federal University of Ouro Preto

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Contents

This document details a comprehensive data analysis undertaken to: 1) evaluate the psychometric properties (internal structure validity and reliability) of the Depression, Anxiety, and Stress Scale-21 (DASS-21) and 2) identify sociodemographic and lifestyle factors predicting anxiety symptoms within a sample of undergraduate students at the Federal University of Ouro Preto. These analyses were conducted using data from the research study 'Acute and chronic effects of receptive music therapy with the therapeutic gong in individuals with anxiety symptoms' (Original title: 'Efeitos agudos e crônicos da musicoterapia receptiva com o gongo terapêutico em indivíduos com sintomas de ansiedade'). All enrolled individuals provided informed consent and completed the DASS-21. The overall study received ethical approval from the Research Ethics Committee of the Federal University of Ouro Preto, Brazil (Certificate of Presentation for Ethical Consideration - CAAE: 77536623.2.0000.5150).

Data import and cleaning

259 paticipants consent with participation

```r
library(readxl)
library(dplyr)
library(tidyr)
library(kableExtra)
library(knitr)
library(mice)
library(psych)
library(lavaan)
library(semTools)
library(semPlot)
library(olsrr)
library(car)
library(lm.beta)
library(bootnet)
library(qgraph)

data <- read_excel("~/PedroOP/dados_limpos.xlsx")
data <- data[c(-88,-89,-90,-91)] #empty columns
```

Proportions of academic community participating.

The initial dataset comprised N=259 participants. The Comunidade variable was recoded from Portuguese to English categories. The distribution of participants across these academic community categories is presented below:

```r
# Total number of participants
total <- nrow(data)

# Recode community categories to English
data$Community <- dplyr::recode(data$Comunidade,
                                "Comunidade Externa" = "External Community",
                                "Estudante de graduação" = "Undergraduate Student",
                                "Estudante de pós-graduação" = "Graduate Student",
                                "Servidor Docente" = "Faculty Staff",
                                "Servidor Técnico" = "Technical Staff")

# Number of participants in each community category
(community <- table(data$Community))
```

```
##
##    External Community         Faculty Staff      Graduate Student
##                    12                     3                    15
##       Technical Staff Undergraduate Student
##                    12                   217
```

```r
# Calculate the percentage for each category
percent_community <- (community / total) * 100

# Result
round(percent_community, 2)
```

```
##
```

```
##    External Community         Faculty Staff      Graduate Student
##                  4.63                  1.16                  5.79
##       Technical Staff Undergraduate Student
##                  4.63                 83.78
```

Given that undergraduate students represented 83.78% (n=217) of the total sample, and to ensure a more homogeneous group for the primary analyses of anxiety psychometrics and predictors, the dataset was subsetted to include only these participants. All subsequent analyses are based on this subgroup.

```r
data <- subset(data, Community == "Undergraduate Student")
DASS <- data[c(64:84)]
sum(is.na(DASS))
```

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

Data imputation

A single missing value was identified on item i15 (verificado pela saída de mice que se repete i15) of the DASS-21 within the undergraduate student subsample. To handle this missing data point, multiple imputation using Predictive Mean Matching (PMM) was performed via the mice package. PMM is suitable for imputing missing values in psychometric scales with ordinal item responses. We specified m=5 imputed datasets and maxit=50 iterations.

```r
DASS <- data[c(64:84)]

imputed_data <- mice(DASS,
                     m = 5,
                     maxit = 50,
                     method = 'pmm',
                     seed = 500,
                     printFlag = FALSE)


DASS_complete <- complete(imputed_data)
data[c(64:84)] <- DASS_complete

DASS <- data[c(64:84)]
sum(is.na(DASS))
```

```
## [1] 0
```

For the primary analyses (CFA and regression), the first of the five imputed datasets was extracted using complete(imputed_data) to create a complete DASS-21 dataset for all 217 undergraduate students. This approach was chosen for simplicity given the minimal amount of missing data (a single value). Subsequent analyses proceed with this completed dataset.

Sociodemographic data

- Age: Mean = 25.89 (SD = 5.94, min = 18, max = 52)
- Ethnicity/Race: 47.0% White, 46.54% Black/Brown, 6.45% Other

- Sex: Female = 81.10%; Male = 18.89%
- Gender: Cisgender woman = 78.34%; Cisgender man = 17.51%; Non-binary = 2.76%; Other = 1.38% each
- Religion: Christian = 46.54%, No religion = 37.77%, Other = 5.99%, Atheist = 5.53%, African-based religions = 4.61%
- Yoga practice: No = 90.78%, Yes = 9.22%
- Exercise: No = 51.15%, Yes = 48.85%
- Sleep satisfaction: No = 73.73%, Yes = 26.27%
- Mental disorder diagnosis: No = 39.63%, Yes = 60.37%

Table 1: Sociodemographic Characteristics of Undergraduate Student Participants (N=217)

Characteristic	Category	Value / N (%)
Age (Years)		
Age (Years)	Mean (SD)	25.96 (5.94)
Age (Years)	Median	25
Age (Years)	Range (Min-Max)	18-52
Ethnicity/Race		
Ethnicity/Race	Black/Brown	101 (46.54%)
Ethnicity/Race	Other	14 (6.45%)
Ethnicity/Race	White	102 (47%)
Biological Sex		
Biological Sex	Female	176 (81.11%)
Biological Sex	Male	41 (18.89%)
Gender Identity		
Gender Identity	Man (Cisgender)	38 (17.51%)
Gender Identity	Non-binary	6 (2.76%)
Gender Identity	Other	1 (0.46%)
Gender Identity	Transgender	2 (0.92%)
Gender Identity	Woman (Cisgender)	170 (78.34%)
Religion		
Religion	African-based religions	10 (4.61%)
Religion	Atheist	13 (5.99%)
Religion	Christianity	101 (46.54%)
Religion	No religion/Agnostic	81 (37.33%)
Religion	Other	12 (5.53%)
Yoga/Meditation Practice		
Yoga/Meditation Practice	No	197 (90.78%)
Yoga/Meditation Practice	Yes	20 (9.22%)
Physical Exercise		
Physical Exercise	No	111 (51.15%)
Physical Exercise	Yes	106 (48.85%)
Sleep Satisfaction		
Sleep Satisfaction	No	160 (73.73%)
Sleep Satisfaction	Yes	57 (26.27%)
Mental Illness Diagnosis (Self-Reported)		
Mental Illness Diagnosis (Self-Reported)	No	86 (39.63%)
Mental Illness Diagnosis (Self-Reported)	Yes	131 (60.37%)

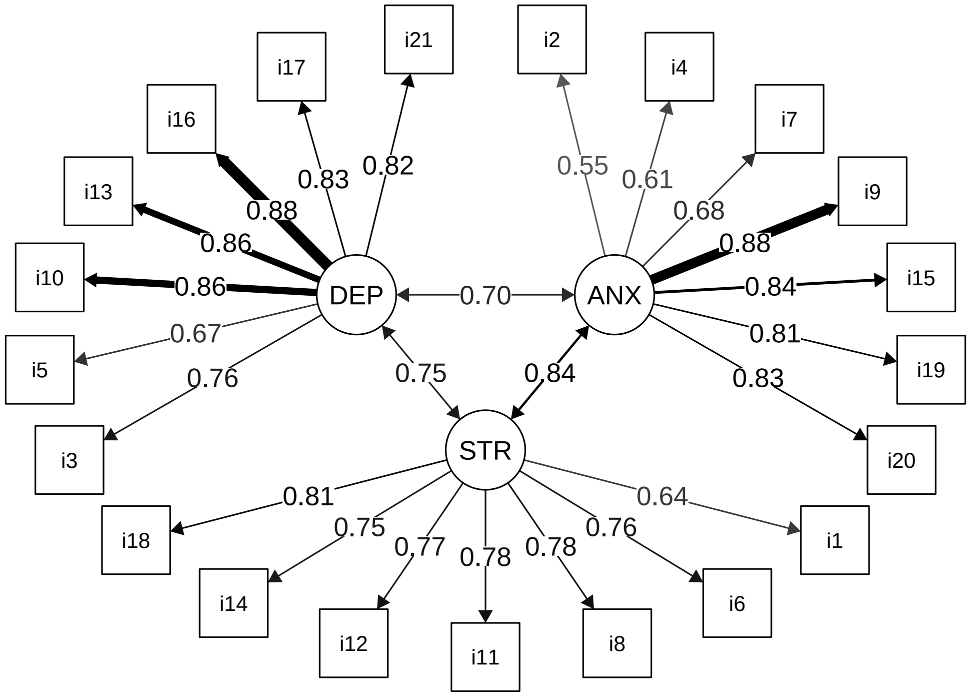
Evidence of internal structure validity and reliability of the DASS-21

To evaluate the internal structure validity of the DASS-21, a Confirmatory Factor Analysis (CFA) was conducted on the undergraduate student data (N=217). The analysis tested the widely accepted three-factor model (Anxiety, Depression, Stress). Given the ordinal nature of the DASS-21 items (responses on a Likert-type scale), the Weighted Least Squares Mean and Variance adjusted (WLSMV) estimator was employed. Factor variances were standardized (std.lv=TRUE) for model identification and interpretation

```
model_DASS <-
'
ANX =~ i2 + i4 + i7 + i9 + i15 + i19 + i20

STR =~ i1 + i6 + i8 + i11 + i12 + i14 + i18

DEP =~ i3 + i5 + i10 + i13 + i16 + i17 + i21
'

fit_model_DASS <- cfa(model_DASS, data = data, ordered = T,
                      estimator = "WLSMV", std.lv=TRUE)

fitMeasures(fit_model_DASS, fit.measures = c("chisq","df","cfi", "tli", "rmsea",
                                             "rmsea.ci.lower", "rmsea.ci.upper"))
```

```
##          chisq             df            cfi            tli          rmsea
##        258.393        186.000          0.996          0.996          0.042
## rmsea.ci.lower rmsea.ci.upper
##          0.029          0.054
```

```
semplot_DASS <- semPaths(fit_model_DASS,"std",layout="circle2",residuals=F,
                         sizeLat=7,sizeLat2=7,edge.color="black",edge.label.cex=1.0,
                         mar=c(4,4,4,4),esize=7,curvePivot = T, intercepts=F,
                         thresholds = F, sizeInt = 10,
                         nCharNodes=0,sizeMan=6, edge.label.position=0.5)
```



Model fit was assessed using several indices. The obtained fit statistics were: $\chi(186) = 258.393$, $p < .001$; CFI = 0.996; TLI = 0.996; RMSEA = 0.042 (90% CI: 0.029, 0.054). While the chi-square test was significant, which is common with larger sample sizes, the CFI and TLI values exceed the recommended cutoff of >0.95, and the RMSEA is below the <0.06 (or <0.08) threshold, with its confidence interval also indicating good fit. Collectively, these indices suggest an adequate fit of the three-factor model to the data.

Testing reliability

Internal consistency reliability for the DASS-21 subscales was examined using multiple coefficients appropriate for factor analytic models and ordinal data.

As shown in the output below, all subscales demonstrated good to excellent reliability. Ordinal alpha coefficients, which are suitable for categorical indicators, were 0.89 (Anxiety), 0.90 (Stress), and 0.93 (Depression). McDonald's omega hierarchical (omega) values were also robust: 0.88 (Anxiety), 0.87 (Stress), and 0.91 (Depression). Average Variance Extracted (AVE) values were all above 0.50, supporting convergent validity within each factor

Composite reliability (CR), another measure of internal consistency based on the factor model, was also calculated. The CR values were 0.90 for Anxiety, 0.93 for Depression, and 0.90 for Stress, further supporting the reliability of the subscales.

```r
round(semTools::reliability(fit_model_DASS), 2)
```

```
##             ANX  STR  DEP
## alpha      0.86 0.86 0.90
## alpha.ord  0.89 0.90 0.93
```

```
## omega      0.88 0.87 0.91
## omega2     0.88 0.87 0.91
## omega3     0.89 0.89 0.92
## avevar     0.57 0.57 0.66
```

```r
source("comp_reliability.R")
comp_reliability(fit_model_DASS)
```

```
## Warning: Use of .data in tidyselect expressions was deprecated in tidyselect 1.2.0.
## i Please use `"lhs"` instead of `.data$lhs`
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.

## Warning: Use of .data in tidyselect expressions was deprecated in tidyselect 1.2.0.
## i Please use `"est"` instead of `.data$est`
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.

## Warning: Use of .data in tidyselect expressions was deprecated in tidyselect 1.2.0.
## i Please use `"op"` instead of `.data$op`
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.

## # A tibble: 3 x 2
##   lhs   composite_reliability
##   <chr>                 <dbl>
## 1 ANX                   0.899
## 2 DEP                   0.932
## 3 STR                   0.903
```

Estimation of factor scores based on the factor structure

Factor scores representing latent Anxiety, Stress, and Depression levels for each participant were estimated from the fitted CFA model using the lavPredict function in lavaan (empirical Bayes modal estimates). These scores were then merged back into the main dataset for use as outcome variables in subsequent regression analyses.

```r
#Factorial sores (FCA - DASS)
latent_scores_DASS <- lavaan::lavPredict(fit_model_DASS, newdata = data,
                                         type = "lv")
#Latent scores

ANX_fscores <- latent_scores_DASS[, "ANX"]
STR_fscores <- latent_scores_DASS[, "STR"]
DEP_fscores <- latent_scores_DASS[, "DEP"]

data$ANX_fscores <- ANX_fscores
data$STR_fscores <- STR_fscores
data$DEP_fscores <- DEP_fscores
```

Testing which sociodemographical better predicts anxiety

To investigate potential predictors of anxiety (as measured by the DASS-21 Anxiety factor scores), a multiple linear regression analysis was conducted. The predictor variables considered were all of socio-demographical. A stepwise forward selection procedure based on the Akaike Information Criterion (AIC) was employed to identify the most parsimonious and statistically significant model with the remaining variablesYoga, Sleeping satisfaction and mental illness.

- The presence of a mental disorder was the strongest individual predictor, independently explaining approximately 7.5% of the variance in anxiety scores.
- When sleep satisfaction was added to the model, it explained an additional 3.3% of the variance in anxiety, beyond what was already accounted for by mental disorder.
- Finally, the inclusion of yoga/meditation practice in the model contributed to explaining a further 2.3% of the variance in anxiety scores, after controlling for the effects of mental disorder and sleep satisfaction.

In total, the model incorporating these three variables (mental disorder, sleep satisfaction, and yoga/meditation) was able to explain approximately 13.1% (R^2) of the variability in participants' anxiety levels."

```r
#setting linear model
ansiedade <- lm(ANX_fscores ~
                + `Yoga/Meditação` + Satisfação_sono
                + Transtorno_mental, data = data)

summary(ansiedade)
```

```
##
## Call:
## lm(formula = ANX_fscores ~ +'Yoga/Meditação' + Satisfação_sono +
##     Transtorno_mental, data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.9660 -0.5462 -0.1435  0.5621  2.5060
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)           -0.1543     0.1014  -1.522  0.12951
## 'Yoga/Meditação'Sim.  -0.4814     0.2040  -2.359  0.01921 *
## Satisfação_sonoSim    -0.3621     0.1340  -2.702  0.00745 **
## Transtorno_mentalSim   0.5098     0.1204   4.233 3.43e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8671 on 213 degrees of freedom
## Multiple R-squared:  0.1309, Adjusted R-squared:  0.1187
## F-statistic:  10.7 on 3 and 213 DF,  p-value: 1.404e-06
```

```r
#backward method
ols_step_forward_aic(ansiedade)
```

```
##
##
##                                   Stepwise Summary
## ----------------------------------------------------------------------------------
## Step    Variable               AIC        SBC       SBIC        R2       Adj. R2
## ----------------------------------------------------------------------------------
##  0      Base Model           584.341    591.100    -31.734    0.00000    0.00000
##  1      Transtorno_mental    569.445    579.584    -46.550    0.07491    0.07061
##  2      Satisfação_sono      563.483    577.002    -52.380    0.10823    0.09990
##  3      ‘Yoga/Meditação‘     559.884    576.784    -55.785    0.13095    0.11871
## ----------------------------------------------------------------------------------
##
## Final Model Output
## ------------------
##
##                           Model Summary
## ------------------------------------------------------------------
## R                          0.362       RMSE                 0.859
## R-Squared                  0.131       MSE                  0.738
## Adj. R-Squared             0.119       Coef. Var         6217.382
## Pred R-Squared             0.101       AIC                559.884
## MAE                        0.700       SBC                576.784
## ------------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##  AIC: Akaike Information Criteria
##  SBC: Schwarz Bayesian Criteria
##
##                                 ANOVA
## ----------------------------------------------------------------------
##                Sum of
##               Squares         DF    Mean Square      F         Sig.
## ----------------------------------------------------------------------
## Regression     24.130          3          8.043    10.698     0.0000
## Residual      160.140        213          0.752
## Total         184.270        216
## ----------------------------------------------------------------------
##
##                                         Parameter Estimates
## ------------------------------------------------------------------------------------------------
##                model      Beta    Std. Error    Std. Beta      t        Sig      lower     upper
## ------------------------------------------------------------------------------------------------
##          (Intercept)    -0.154         0.101                 -1.522    0.130    -0.354     0.046
## Transtorno_mentalSim     0.510         0.120        0.271     4.233    0.000     0.272     0.747
##   Satisfação_sonoSim    -0.362         0.134       -0.173    -2.702    0.007    -0.626    -0.098
## ‘Yoga/Meditação‘Sim.    -0.481         0.204       -0.151    -2.359    0.019    -0.884    -0.079
## ------------------------------------------------------------------------------------------------
```

```r
ols_step_forward_p(ansiedade)
```

```
##
##
##                                   Stepwise Summary
```

```
## ------------------------------------------------------------------------------
## Step    Variable               AIC        SBC       SBIC        R2       Adj. R2
## ------------------------------------------------------------------------------
##  0      Base Model           584.341    591.100    -31.734    0.00000    0.00000
##  1      Transtorno_mental    569.445    579.584    -46.550    0.07491    0.07061
##  2      Satisfação_sono      563.483    577.002    -52.380    0.10823    0.09990
##  3      ‘Yoga/Meditação‘     559.884    576.784    -55.785    0.13095    0.11871
## ------------------------------------------------------------------------------
##
## Final Model Output
## ------------------
##
##                          Model Summary
## ----------------------------------------------------------------
## R                        0.362       RMSE                  0.859
## R-Squared                0.131       MSE                   0.738
## Adj. R-Squared           0.119       Coef. Var          6217.382
## Pred R-Squared           0.101       AIC                 559.884
## MAE                      0.700       SBC                 576.784
## ----------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##  AIC: Akaike Information Criteria
##  SBC: Schwarz Bayesian Criteria
##
##                                ANOVA
## --------------------------------------------------------------------
##               Sum of
##              Squares          DF    Mean Square      F          Sig.
## --------------------------------------------------------------------
## Regression    24.130           3          8.043    10.698    0.0000
## Residual     160.140         213          0.752
## Total        184.270         216
## --------------------------------------------------------------------
##
##                                        Parameter Estimates
## ----------------------------------------------------------------------------------------------------
##               model      Beta    Std. Error    Std. Beta       t        Sig      lower      upper
## ----------------------------------------------------------------------------------------------------
##         (Intercept)    -0.154         0.101                 -1.522    0.130    -0.354      0.046
## Transtorno_mentalSim    0.510         0.120        0.271     4.233    0.000     0.272      0.747
##   Satisfação_sonoSim   -0.362         0.134       -0.173    -2.702    0.007    -0.626     -0.098
## ‘Yoga/Meditação‘Sim.   -0.481         0.204       -0.151    -2.359    0.019    -0.884     -0.079
## ----------------------------------------------------------------------------------------------------
```

```r
#betas
betas <- lm.beta(ansiedade)$standardized.coefficients
betas
```

```
##          (Intercept) ‘Yoga/Meditação‘Sim.   Satisfação_sonoSim
##                   NA           -0.1511050           -0.1729494
## Transtorno_mentalSim
##            0.2705926
```

Checking Model Assumptions

Diagnostic checks indicated that the assumptions for linear regression (normality of residuals, homoscedasticity, and independence of errors) were adequately met for the final model.

```
#Residuals normality
shapiro.test(resid(ansiedade)) #p > 0,05
```

```
##
##  Shapiro-Wilk normality test
##
## data:  resid(ansiedade)
## W = 0.98823, p-value = 0.07141
```

```
#Homoscedasticity
ols_test_breusch_pagan(ansiedade) #p > 0,05
```

```
##
##  Breusch Pagan Test for Heteroskedasticity
##  -----------------------------------------
##  Ho: the variance is constant
##  Ha: the variance is not constant
##
##                 Data
##  ---------------------------------------
##  Response : ANX_fscores
##  Variables: fitted values of ANX_fscores
##
##        Test Summary
##  ----------------------------
##  DF            =    1
##  Chi2          =    0.1682808
##  Prob > Chi2   =    0.6816443
```

```
#Residual autocorrelations
durbinWatsonTest(ansiedade)   # p > 0,05
```

```
##  lag Autocorrelation D-W Statistic p-value
##    1      -0.0553482      2.110178   0.376
##  Alternative hypothesis: rho != 0
```

Network Psychometric Analysis

A network psychometric analysis was conducted to explore the specific interrelationships among the DASS-21 anxiety symptoms (items i2, i4, i7, i9, i15, i19, i20). The network structure was estimated using the estimateNetwork function from the bootnet package, employing the EBICglasso (Extended Bayesian Information Criterion for Graphical LASSO) method with a tuning parameter of 0.5. This method performs regularization to yield a sparse network by shrinking small partial correlations to zero. Centrality indices (Strength, Closeness, Betweenness, and Expected Influence) were computed to identify influential symptoms. The stability of these centrality estimates was assessed via case-dropping bootstrap procedures (nBoots = 1000).

Network analysis of the DASS-21 anxiety items revealed several key insights into the structure of anxiety symptoms among the participants.

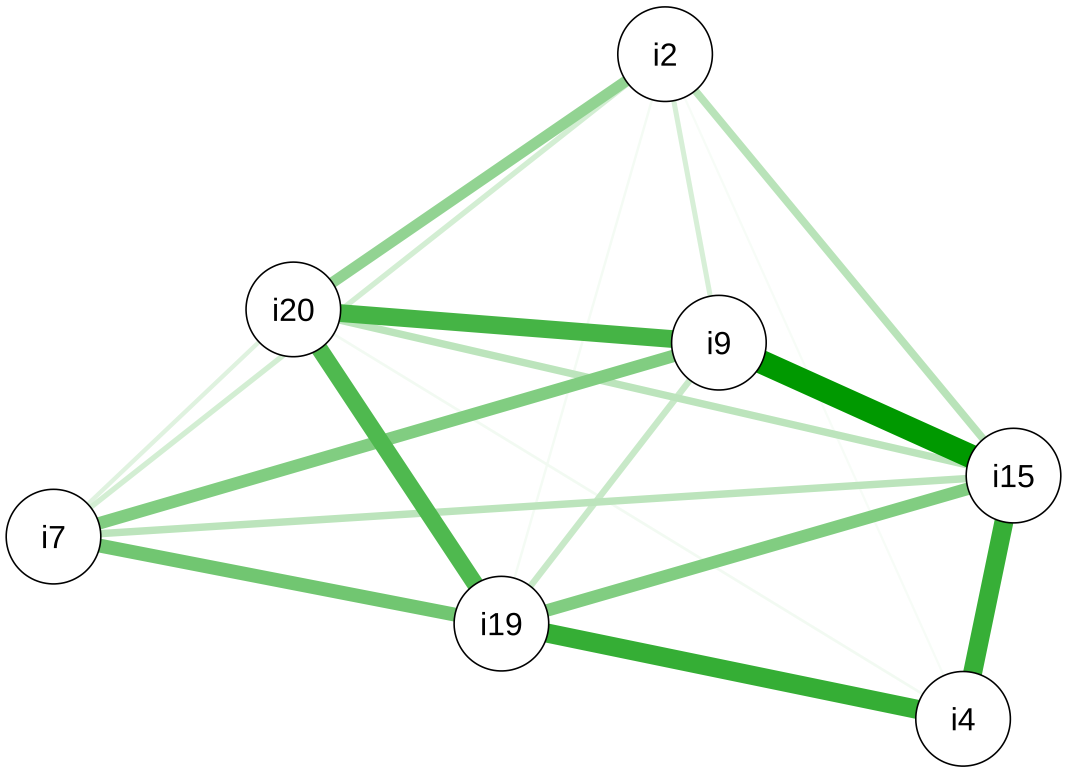
- The item 'i15: I felt I was close to panic' emerged as the most central symptom, exhibiting the highest strength centrality and expected influence. This suggests that feeling close to panic is a highly interconnected symptom within the anxiety network, strongly co-occurring with other anxiety symptoms and potentially playing a significant role in the overall experience or maintenance of anxiety.
- In terms of closeness centrality, which indicates how quickly a symptom can reach other symptoms in the network, 'i9: I was worried about situations in which I might panic and make a fool of myself' and 'i19: I was aware of the action of my heart in the absence of physical exertion' were equally prominent. This implies these symptoms are relatively well-connected and can efficiently 'transmit' or influence other symptoms in the network.
- The items 'i19: I was aware of the action of my heart in the absence of physical exertion' and 'i20: I felt scared without any good reason' showed the highest betweenness centrality, suggesting they frequently lie on the shortest paths connecting other pairs of symptoms. However, the correlation stability analysis indicated that the betweenness centrality measure was not reliable (CS-coefficient = 0.051, below the desired 0.7 threshold). Therefore, interpretations based on betweenness centrality should be made with extreme caution, as this metric may not be stable with smaller subsets of the data.
- Conversely, the stability analysis confirmed that strength, expected influence, and closeness centrality measures were substantially more reliable (CS-coefficients of 0.594 or higher), lending greater confidence to the findings regarding items i15, i9, and i19 for these respective centrality indices.

```r
# Selecting anxiety items
anx <- data[, c("i2", "i4", "i7", "i9", "i15", "i19", "i20")]
Network <- estimateNetwork(anx,
                           default = "EBICglasso", weighted = TRUE, tuning = 0.5)
```

```
## Estimating Network. Using package::function:
##   - qgraph::EBICglasso for EBIC model selection
##     - using glasso::glasso
```

```
## Warning in EBICglassoCore(S = S, n = n, gamma = gamma, penalize.diagonal =
## penalize.diagonal, : A dense regularized network was selected (lambda < 0.1 *
## lambda.max). Recent work indicates a possible drop in specificity. Interpret
## the presence of the smallest edges with care. Setting threshold = TRUE will
## enforce higher specificity, at the cost of sensitivity.
```

```r
labels <- c("i2: I was aware of dryness of my mouth",
            "i4: I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness i
            "i7: I experienced trembling (e.g. in the hands)",
            "i9: I was worried about situations in which I might panic and make a fool of myself",
            "i15: I felt I was close to panic",
            "i19: I was aware of the action of my heart in the absence of physical exertion (e.g. sense
            "i20: I felt scared without any good reason")

plot(Network, layout = "spring", theme = "classic")
```



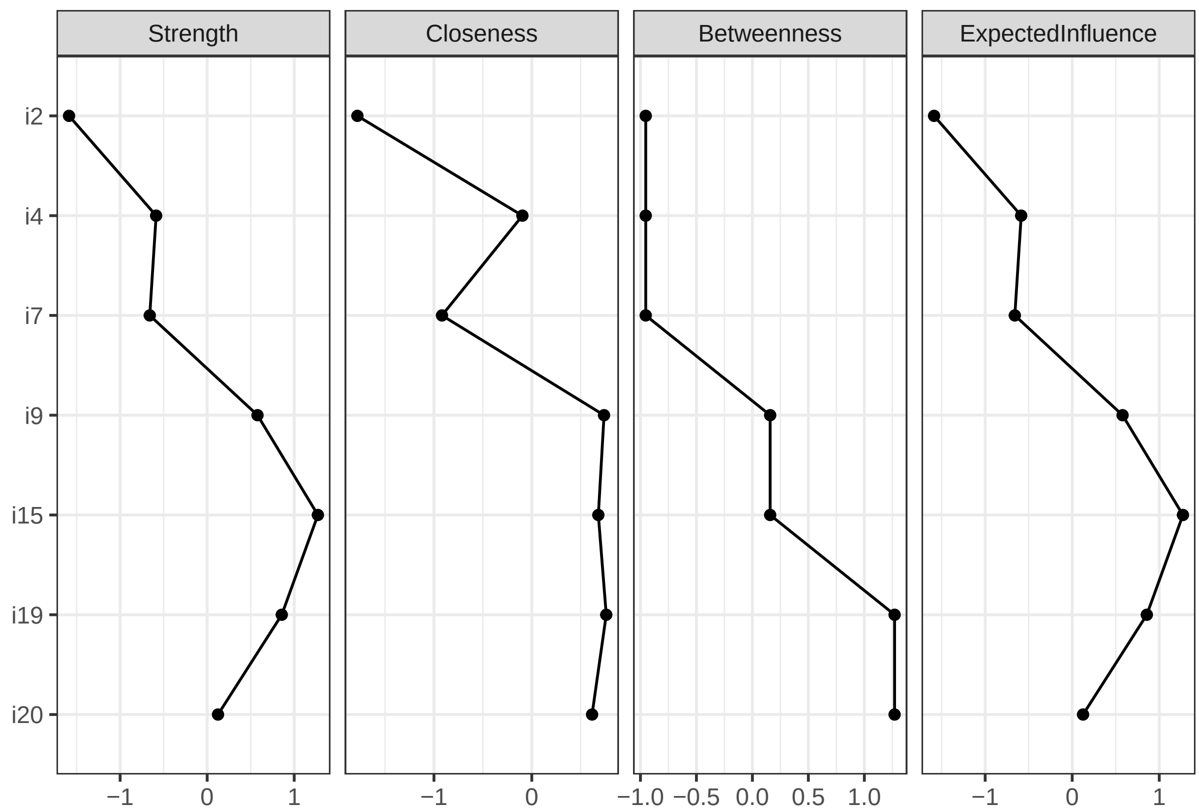

```
print(labels)
```

```
## [1] "i2: I was aware of dryness of my mouth"
## [2] "i4: I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the
## [3] "i7: I experienced trembling (e.g. in the hands)"
## [4] "i9: I was worried about situations in which I might panic and make a fool of myself"
## [5] "i15: I felt I was close to panic"
## [6] "i19: I was aware of the action of my heart in the absence of physical exertion (e.g. sense of he
## [7] "i20: I felt scared without any good reason"
```

Estimation of centrality

```
centralityPlot(Network, scale = c("z-scores"),
               include = c("Strength","Closeness","Betweenness","ExpectedInfluence"),
               theme_bw = TRUE, print = TRUE,
               verbose = TRUE, weighted = TRUE,
               decreasing = T)
```

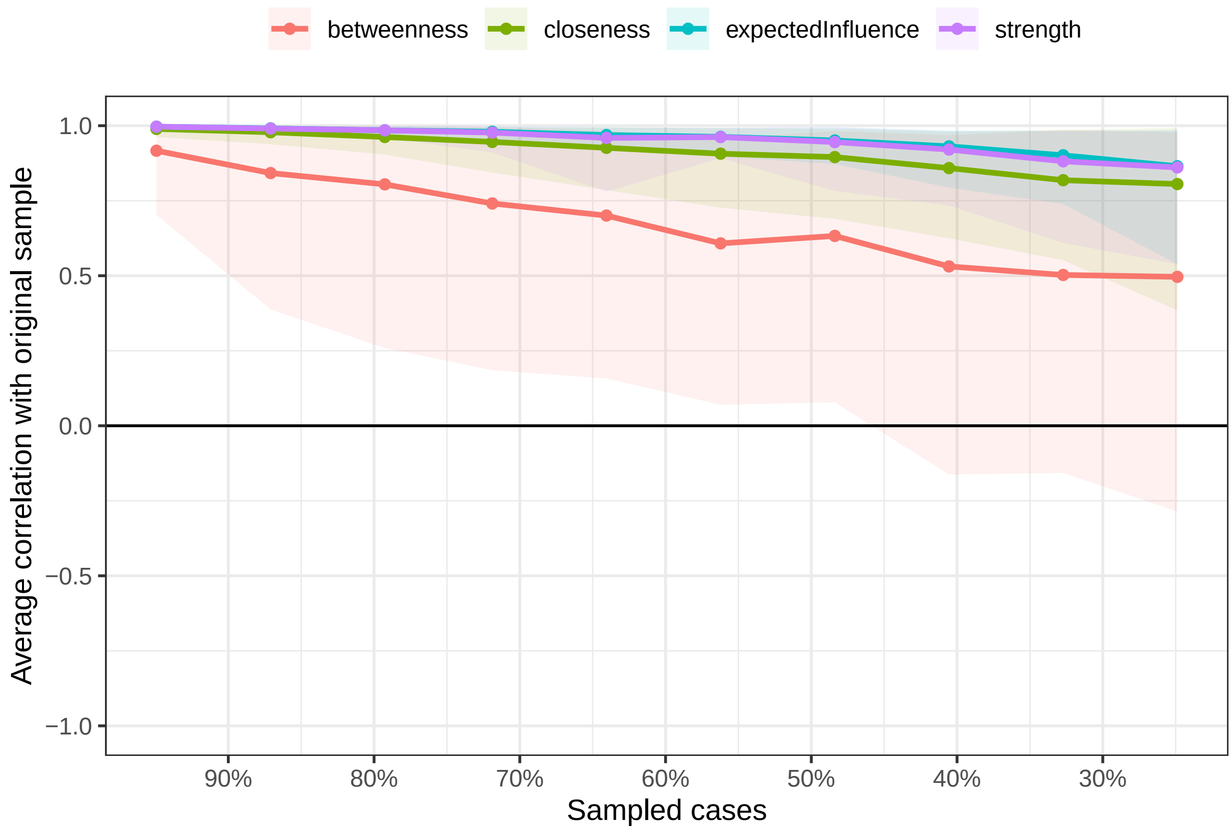
```
## Note: z-scores are shown on x-axis rather than raw centrality indices.
```




```r
#centralityTable(Network, standardized = TRUE,  relative = FALSE, weighted =
#                  TRUE, signed = TRUE)

centrality <- centrality_auto(Network)
centrality$node.centrality
```

```
##     Betweenness  Closeness  Strength ExpectedInfluence
## i2            0 0.01520809 0.4037449         0.4037449
## i4            0 0.02354500 0.6560016         0.6560016
## i7            0 0.01948108 0.6375321         0.6375321
## i9            2 0.02766894 0.9495975         0.9495975
## i15           2 0.02738080 1.1244795         1.1244795
## i19           4 0.02777984 1.0199022         1.0199022
## i20           4 0.02706466 0.8351734         0.8351734
```

```r
#Centrality Stability
boot1 <- bootnet(Network, nBoots = 1000, type = "case",
                 statistics = c("strength", "closeness", "betweenness", "expectedInfluence"),
                 verbose = FALSE)

plot(boot1, statistics= c("strength","closeness","betweenness","expectedInfluence"))
```




```r
#CS-coefficient
corStability(boot1)
```

```
## === Correlation Stability Analysis ===
##
## Sampling levels tested:
##    nPerson Drop%   n
## 1       54  75.1  89
## 2       71  67.3 105
## 3       88  59.4 108
## 4      105  51.6  86
## 5      122  43.8  96
## 6      139  35.9 103
## 7      156  28.1 103
## 8      172  20.7 101
## 9      189  12.9 108
## 10     206   5.1 101
##
## Maximum drop proportions to retain correlation of 0.7 in at least 95% of the samples:
##
## betweenness: 0.051 (CS-coefficient is lowest level tested)
##   - For more accuracy, run bootnet(..., caseMin = 0, caseMax = 0.129)
##
## closeness: 0.516
##   - For more accuracy, run bootnet(..., caseMin = 0.438, caseMax = 0.594)
##
```

```
## expectedInfluence: 0.673
##   - For more accuracy, run bootnet(..., caseMin = 0.594, caseMax = 0.751)
##
## strength: 0.673
##   - For more accuracy, run bootnet(..., caseMin = 0.594, caseMax = 0.751)
##
## Accuracy can also be increased by increasing both 'nBoots' and 'caseN'.
```

```r
sessionInfo()
```

```
## R version 4.4.2 (2024-10-31 ucrt)
## Platform: x86_64-w64-mingw32/x64
## Running under: Windows 11 x64 (build 26100)
##
## Matrix products: default
##
##
## 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] qgraph_1.9.8     bootnet_1.6      ggplot2_3.5.2    lm.beta_1.7-2
##  [5] car_3.1-3        carData_3.0-5    olsrr_0.6.1      semPlot_1.1.6
##  [9] semTools_0.5-6   lavaan_0.6-19    psych_2.5.3      mice_3.17.0
## [13] knitr_1.50       kableExtra_1.4.0 tidyr_1.3.1      dplyr_1.1.4
## [17] readxl_1.4.3
##
## loaded via a namespace (and not attached):
##   [1] RColorBrewer_1.1-3   rstudioapi_0.17.1    shape_1.4.6.1
##   [4] magrittr_2.0.3       TH.data_1.1-3        estimability_1.5.1
##   [7] jomo_2.7-6           farver_2.1.2         nloptr_2.2.1
##  [10] rmarkdown_2.29       vctrs_0.6.5          minqa_1.2.8
##  [13] base64enc_0.1-3      polynom_1.4-1        htmltools_0.5.8.1
##  [16] plotrix_3.8-4        weights_1.0.4        broom_1.0.8
##  [19] cellranger_1.1.0     Formula_1.2-5        mitml_0.4-5
##  [22] htmlwidgets_1.6.4    plyr_1.8.9           sandwich_3.1-1
##  [25] emmeans_1.10.6       zoo_1.8-14           igraph_2.1.4
##  [28] lifecycle_1.0.4      iterators_1.0.14     pkgconfig_2.0.3
##  [31] Matrix_1.7-1         R6_2.6.1             fastmap_1.2.0
##  [34] rbibutils_2.3        digest_0.6.37        OpenMx_2.21.13
##  [37] fdrtool_1.2.18       colorspace_2.1-1     ellipse_0.5.0
##  [40] Hmisc_5.2-3          labeling_0.4.3       gdata_3.0.1
##  [43] nnls_1.6             IsingSampler_0.2.3   abind_1.4-8
##  [46] compiler_4.4.2       proxy_0.4-27         doParallel_1.0.17
##  [49] withr_3.0.2          glasso_1.11          htmlTable_2.4.3
##  [52] backports_1.5.0      mgm_1.2-14           R.utils_2.12.3
```

```
##  [55] pan_1.9              MASS_7.3-61          corpcor_1.6.10
##  [58] gtools_3.9.5         tools_4.4.2          pbivnorm_0.6.0
##  [61] foreign_0.8-87       zip_2.3.1            nnet_7.3-19
##  [64] goftest_1.2-3        R.oo_1.27.0          glue_1.8.0
##  [67] quadprog_1.5-8       NetworkToolbox_1.4.2 nlme_3.1-166
##  [70] lisrelToR_0.3        grid_4.4.2           checkmate_2.3.2
##  [73] cluster_2.1.6        reshape2_1.4.4       generics_0.1.3
##  [76] snow_0.4-4           gtable_0.3.6         nortest_1.0-4
##  [79] class_7.3-22         R.methodsS3_1.8.2    data.table_1.17.0
##  [82] utf8_1.2.4           xml2_1.3.8           sem_3.1-16
##  [85] foreach_1.5.2        pillar_1.10.2        stringr_1.5.1
##  [88] rockchalk_1.8.157    splines_4.4.2        smacof_2.1-7
##  [91] networktools_1.5.2   lattice_0.22-6       survival_3.7-0
##  [94] kutils_1.73          tidyselect_1.2.1     pbapply_1.7-2
##  [97] reformulas_0.4.0     gridExtra_2.3        svglite_2.1.3
## [100] IsingFit_0.4         stats4_4.4.2         xfun_0.52
## [103] arm_1.14-4           stringi_1.8.7        yaml_2.3.10
## [106] boot_1.3-31          evaluate_1.0.3       codetools_0.2-20
## [109] wordcloud_2.6        mi_1.1               tibble_3.2.1
## [112] cli_3.6.4            RcppParallel_5.1.9   rpart_4.1.23
## [115] xtable_1.8-4         systemfonts_1.2.2    Rdpack_2.6.4
## [118] munsell_0.5.1        Rcpp_1.0.14          coda_0.19-4.1
## [121] png_0.1-8            XML_3.99-0.18        parallel_4.4.2
## [124] jpeg_0.1-10          lme4_1.1-37          glmnet_4.1-8
## [127] viridisLite_0.4.2    mvtnorm_1.3-3        e1071_1.7-16
## [130] scales_1.3.0         crayon_1.5.3         eigenmodel_1.11
## [133] openxlsx_4.2.7.1     purrr_1.0.2          rlang_1.1.5
## [136] multcomp_1.4-26      mnormt_2.1.1
```