Network Analysis

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Preparing Data

```
# Read in data
load("~/Desktop/School/GatesLab/NetworkAnalysis/FullMatrices.Rdata")

# Preview all data
# View(outReg)
```

Extract Submatrices for each Person

```
submatrix = list()
for (x in 1:length(outReg)) {
  submatrix = append(submatrix, list(outReg[[x]][["regression_matrix"]][1:26,1:26]))
}
# Convert all submatrices into double type
feature_names = c("energetic", "enthusiastic", "content", "irritable", "restless", "worried", "guilty",
subdf = list()
subdf_pos = list()
for (x in 1:length(outReg)) {
  subdf[[x]] = matrix(unlist(submatrix[x]), ncol = 26, byrow = FALSE, dimnames = list(feature_names, fea
  subdf_pos[[x]] = pmax(subdf[[x]], 0)
}
```

Extract Directed Graphs for each Person

```
dir_graph = list()
dir_graph_pos = list()
for(x in 1:length(outReg) ){
  dir_graph[[x]] = graph.adjacency(subdf[[x]], mode = "directed", weighted = TRUE)
  dir_graph_pos[[x]] = graph.adjacency(subdf_pos[[x]], mode = "directed", weighted = TRUE)
}
dir_graph[[19]]
```

```
## IGRAPH 989e814 DNW- 26 114 --
## + attr: name (v/c), weight (e/n)
## + edges from 989e814 (vertex names):
##  [1] energetic   ->enthusiastic energetic   ->down
##  [3] energetic   ->fatigue      energetic   ->tension
##  [5] energetic   ->ruminate     energetic   ->avoid_act
##  [7] enthusiastic->energetic    enthusiastic->positive
##  [9] enthusiastic->tension      enthusiastic->procrast
## [11] content     ->irritable    content     ->restless
## [13] content     ->worried      content     ->guilty
## [15] content     ->angry        content     ->down
## + ... omitted several edges
```

```
dir_graph_pos[[19]]
```

```
## IGRAPH aee728f DNW- 26 73 --
## + attr: name (v/c), weight (e/n)
## + edges from aee728f (vertex names):
##  [1] energetic   ->enthusiastic enthusiastic->energetic
##  [3] enthusiastic->positive     content     ->positive
##  [5] irritable   ->worried      irritable   ->angry
##  [7] irritable   ->threatened   irritable   ->ruminate
##  [9] restless    ->worried      restless    ->angry
## [11] restless    ->threatened   restless    ->avoid_people
## [13] worried     ->irritable    worried     ->restless
## [15] worried     ->guilty       worried     ->afraid
## + ... omitted several edges
```

Metrics for each Person

```
density = list()
overall_weight = list()
edge_weights = list()
global_efficiency = list()
variable_degrees = list()
variable_strengths = list()
betweenness = list()
cluster = list()
for(x in 1:length(outReg)) {
  density[[x]] = edge_density(dir_graph[[x]], loops = FALSE)
  overall_weight[[x]] = sum(strength(dir_graph[[x]]))
  edge_weights[[x]] = edge_attr(dir_graph_pos[[x]], "weight")

  global_efficiency[[x]] = efficiency(dir_graph_pos[[x]],
                                     type = c("global"),
                                     weights = edge_weights[[x]])
  variable_degrees[[x]] = degree(dir_graph[[x]])
  variable_strengths[[x]] = strength(dir_graph[[x]])

  betweenness[[x]] = estimate_betweenness(dir_graph_pos[[x]], cutoff=-1, weights =edge_weights[[x]])
  cluster[[x]] = cluster_walktrap(dir_graph_pos[[x]],
                                  weights = E(dir_graph_pos[[x]])$edge_weights,
                                  steps = 4)


}
print(paste0("Density of the first person's graph: ", round(density[[1]], 4)))
```

```
## [1] "Density of the first person's graph: 0.1077"
```

```r
print(paste0("Overall Weight of the first person's graph: ", round(overall_weight[[1]], 4)))
```

```
## [1] "Overall Weight of the first person's graph: 10.6119"
```

```r
print(paste0("Global Efficiency of the first person's graph: ", round(global_efficiency[[1]], 4)))
```

```
## [1] "Global Efficiency of the first person's graph: 12.5183"
```

```r
print("Degree of each variable in the first person's graph: ")
```

```
## [1] "Degree of each variable in the first person's graph: "
```

```r
print(variable_degrees[[1]])
```

```
##    energetic enthusiastic      content    irritable     restless      worried
##            4            4            3            8            5            9
##       guilty       afraid    anhedonia        angry     hopeless         down
##            1            9           12            7           11            8
##     positive      fatigue      tension  concentrate     accepted   threatened
##            7            0            7            3            1            3
##     ruminate    avoid_act     reassure     procrast        hours    difficult
##           13            3            1            2            2            8
##    unsatisfy avoid_people
##            1            8
```

```r
print("Strengths of each variable in the first person's graph: ")
```

```
## [1] "Strengths of each variable in the first person's graph: "
```

```r
print(variable_strengths[[1]])
```

```
##    energetic enthusiastic      content    irritable     restless      worried
##   0.76229416   0.96384765   0.47966325   0.83037658   0.57779129   1.20858363
##       guilty       afraid    anhedonia        angry     hopeless         down
##   0.02643344  -0.01065439   0.82426251   0.99845363   0.89364307   0.74160674
##     positive      fatigue      tension  concentrate     accepted   threatened
##   0.95930381   0.00000000   0.76755289   0.18317240   0.14779364   0.16860533
##     ruminate    avoid_act     reassure     procrast        hours    difficult
##   0.79906030   0.47042696   0.04843503  -0.06829517  -1.55552557  -0.56623424
##    unsatisfy avoid_people
##   0.20728066   0.75406944
```

```r
print("Betweenness Centrality of each variable in the first person's graph: ")
```

```
## [1] "Betweenness Centrality of each variable in the first person's graph: "
```

```r
print(betweenness[[1]])
```

```
##    energetic enthusiastic      content    irritable     restless      worried
##            0            5            0           40            1            0
##       guilty       afraid    anhedonia        angry     hopeless         down
##            0           10           49           26           85           37
##     positive      fatigue      tension  concentrate     accepted   threatened
##           46            0            2            0            0            0
##     ruminate    avoid_act     reassure     procrast        hours    difficult
##          111            0            0            0            0            0
##    unsatisfy avoid_people
##            0           51
```

```r
print("Clustering Walktrap of each variable in the first person's graph: ")
```

```
## [1] "Clustering Walktrap of each variable in the first person's graph: "
```

```r
print(cluster[[1]])
```

```
## IGRAPH clustering walktrap, groups: 11, mod: 0.27
## + groups:
##   $`1`
##   [1] "concentrate" "difficult"
##
##   $`2`
##   [1] "angry"        "down"         "ruminate"     "avoid_act"    "avoid_people"
##
##   $`3`
##   [1] "content"  "positive" "accepted"
##
##   $`4`
##   + ... omitted several groups/vertices
```

Computing Metric Summary Statistics

```r
density_mean = mean(unlist(density))
density_sd = sd(unlist(density))
density_range = range(unlist(density))

overall_weight_mean = mean(unlist(overall_weight))
overall_weight_sd = sd(unlist(overall_weight))
overall_weight_range = range(unlist(overall_weight))

global_efficiency_mean = mean(unlist(global_efficiency))
global_efficiency_sd = sd(unlist(global_efficiency))
global_efficiency_range = range(unlist(global_efficiency))

variable_degrees_mat = do.call(rbind, variable_degrees)
variable_degrees_mean = apply(variable_degrees_mat, 2, mean)
variable_degrees_sd = apply(variable_degrees_mat, 2, sd)
variable_degrees_range = apply(variable_degrees_mat, 2, range)

variable_strengths_mat = do.call(rbind, variable_strengths)
variable_strengths_mean = apply(variable_strengths_mat, 2, mean)
variable_strengths_sd = apply(variable_strengths_mat, 2, sd)
variable_strengths_range = apply(variable_strengths_mat, 2, range)

betweenness_mat = do.call(rbind, betweenness)
betweenness_mean = apply(betweenness_mat, 2, mean)
betweenness_sd = apply(betweenness_mat, 2, sd)
betweenness_range = apply(betweenness_mat, 2, range)

# store all summary stats in a df, build out table functionalities

net_stat = data.frame("Density" = c(density_mean, density_sd, density_range), "Overall Weight" = c(overa
row.names(net_stat) = c("Mean", "Standard Deviation", "Minimum", "Maximum")
```

```
# attr(net_stat, "row.names")
typeof(row.names(net_stat))
```

```
## [1] "character"
```

```
kt = knitr::kable(x =net_stat, row.names =TRUE, col.names = c("Density", "Overvall Weight", "Global Eff
# net_stat %>%
kt
```

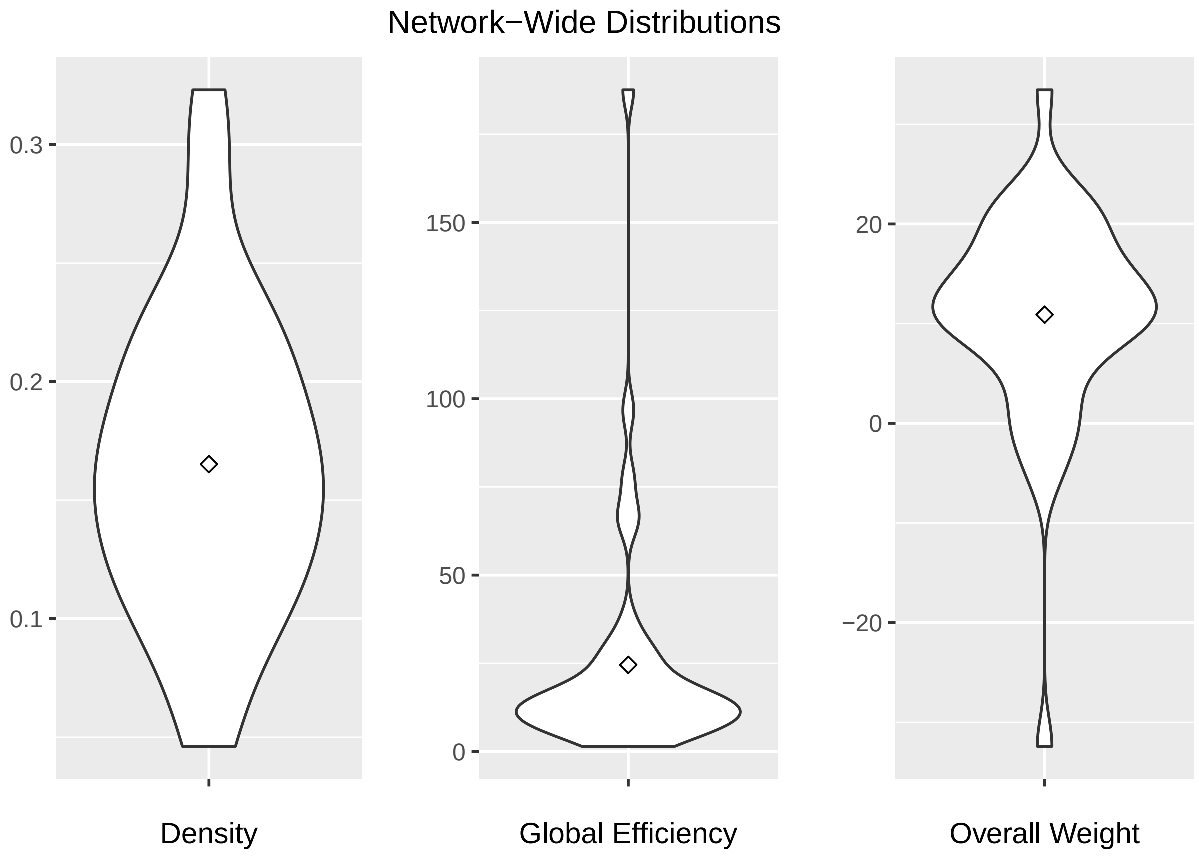
	Density	Overvall Weight	Global Efficiency
Mean	0.1651923	10.90231	24.557177
Standard Deviation	0.0643016	10.72964	33.724137
Minimum	0.0461538	-32.41157	1.450913
Maximum	0.3230769	33.45451	187.580449

```
# kable_styling(kt, latex_options = "striped", full_width = F)
```

Plots and Distribution

Distribution across each network-wide metric using data

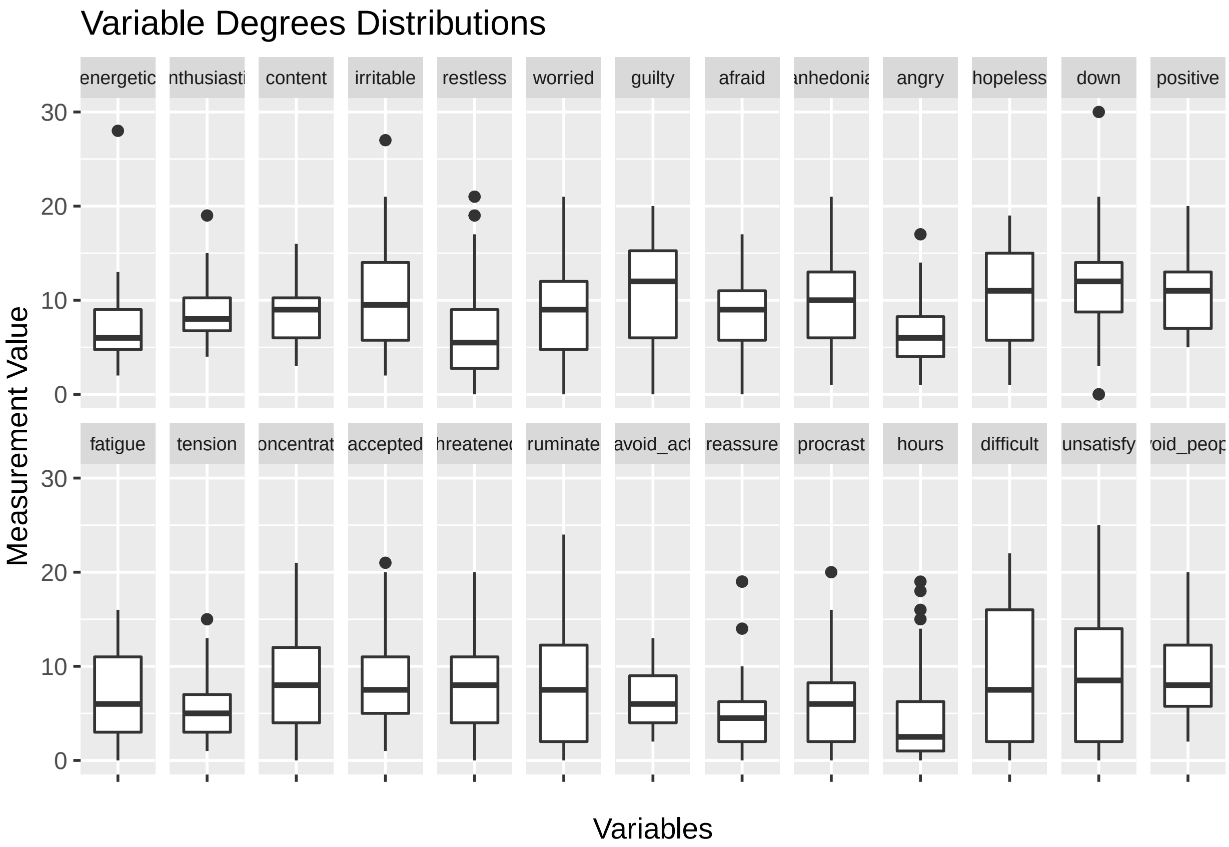
```
# Combine in network-wide metrics into a dataframe
network_df = data.frame(
  "Density" = unlist(density),
  "Overall Weight" = unlist(overall_weight),
  "Global Efficiency" = unlist(global_efficiency))

# Violin Plots
density_plot = ggplot(network_df, aes(y = Density, x = "")) +
  geom_violin() +
  stat_summary(fun=mean, geom="point", shape=23, size=2) +
  xlab("Density") +
  ylab("")
efficiency_plot = ggplot(network_df, aes(y = Global.Efficiency, x = "")) +
  geom_violin() +
  stat_summary(fun=mean, geom="point", shape=23, size=2) +
  xlab("Global Efficiency") +
  ylab("")
overall_weight_plot = ggplot(network_df, aes(y = Overall.Weight, x = "")) +
  geom_violin() +
  stat_summary(fun=mean, geom="point", shape=23, size=2) +
  xlab("Overall Weight") +
  ylab("")
grid.arrange(density_plot, efficiency_plot, overall_weight_plot, ncol = 3,
             top=textGrob("Network-Wide Distributions"))
```



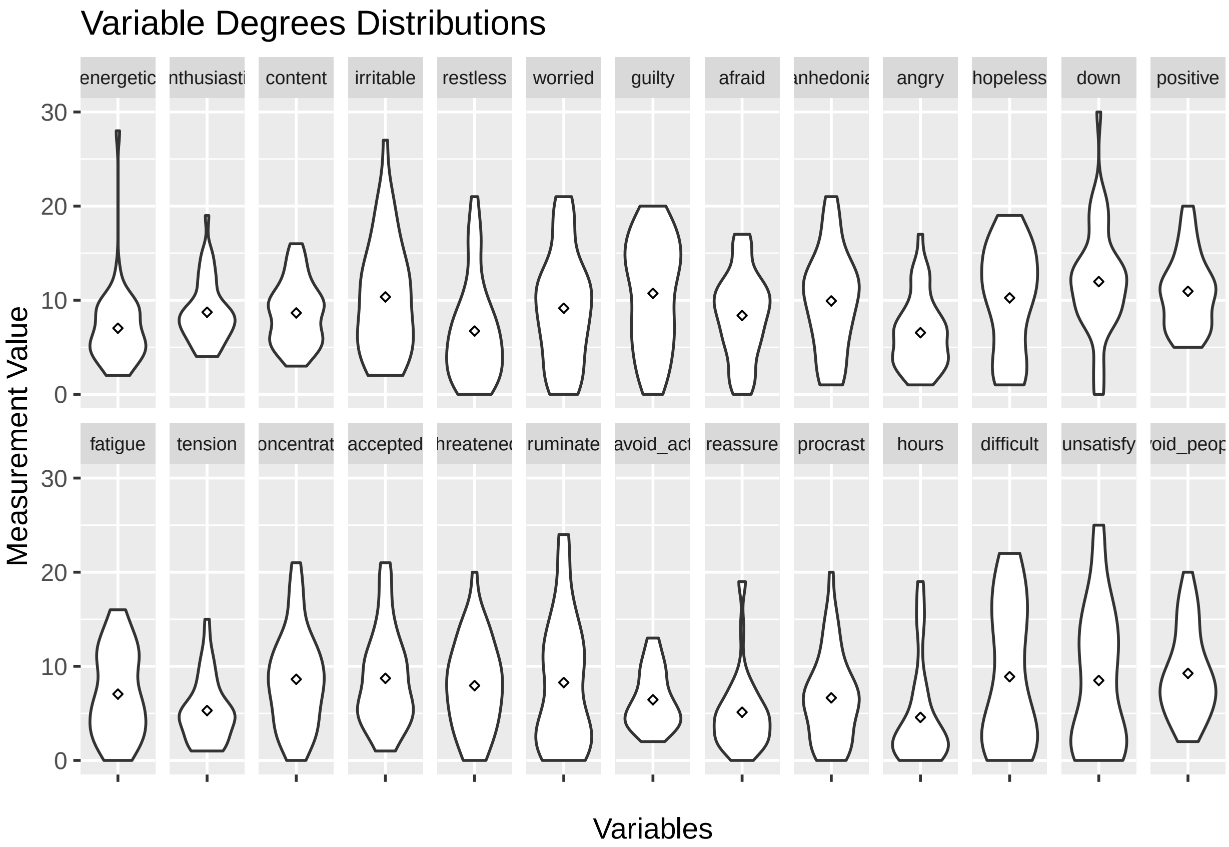
The above plot illustrates that the density, global efficiency, and overall weight measurements are set at different scales and show different distributions. Density shows a relatively symmetrical distribution, whereas global efficiency shows a right-skewed distribution and overall weight shows a left-skewed distribution.

Plot distributions across each variable-level metric

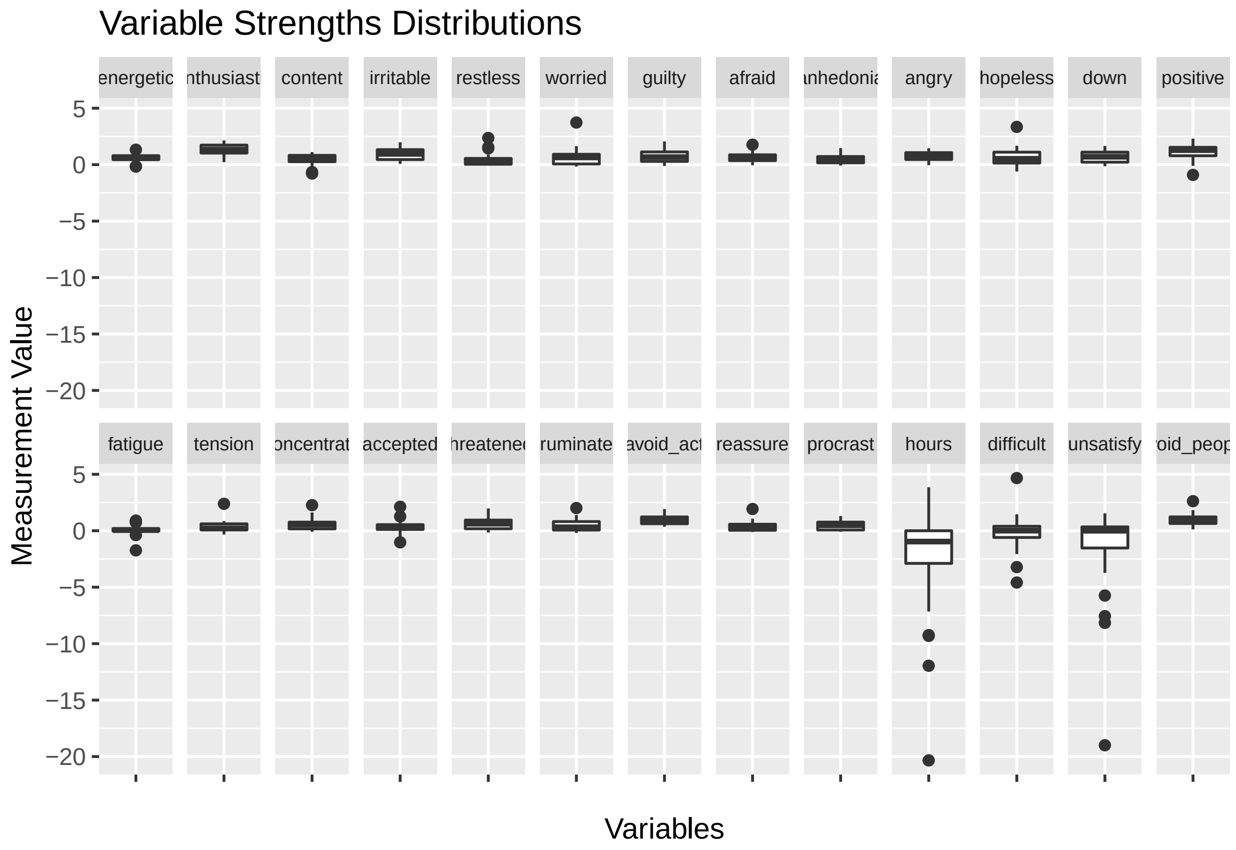
```
# Variable Degrees Boxplot
ggplot(stack(data.frame(variable_degrees_mat)), aes(x ="" , y = values)) +
  geom_boxplot() +
  facet_wrap(~ ind, ncol = 13) +
  ggtitle("Variable Degrees Distributions") +
  xlab("Variables") +
  ylab("Measurement Value") +
  theme( strip.text = element_text(size = 7))
```



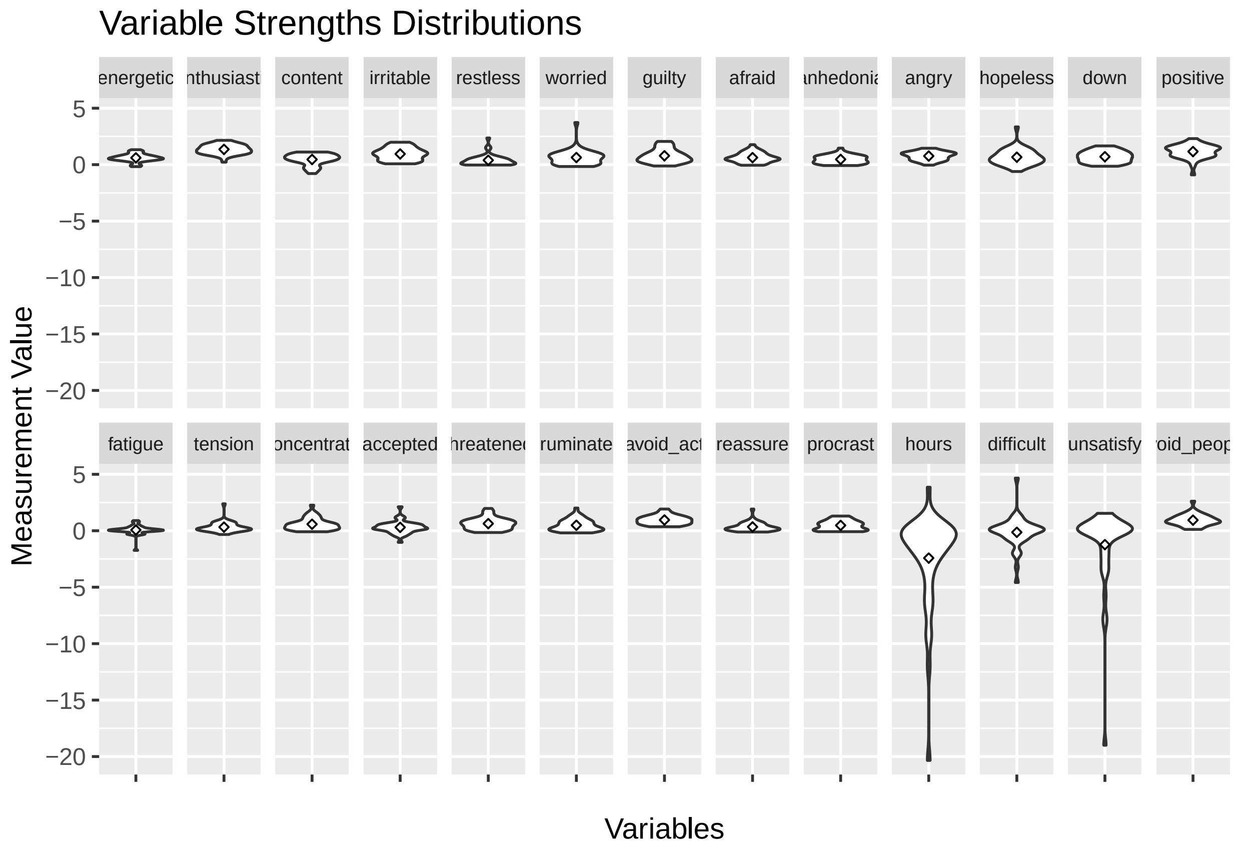
```r
# Variable Degrees Violin Plot
ggplot(stack(data.frame(variable_degrees_mat)), aes(x ="" , y = values)) +
  geom_violin() +
  facet_wrap(~ ind, ncol = 13) +
  ggtitle("Variable Degrees Distributions") +
  xlab("Variables") +
  ylab("Measurement Value") +
  theme( strip.text = element_text(size = 7)) +
  stat_summary(fun=mean, geom="point", shape=23, size=1)
```



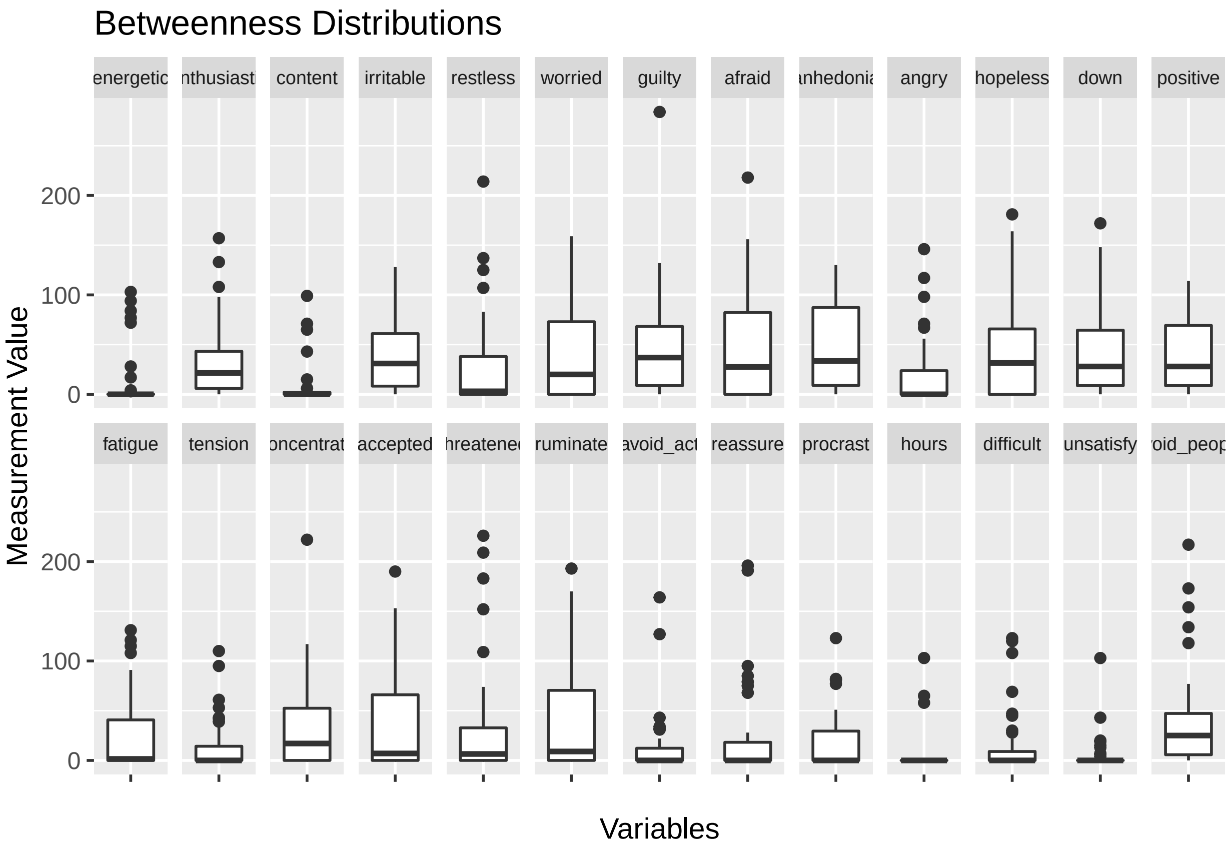
```r
# Variable Strengths Boxplot
ggplot(stack(data.frame(variable_strengths_mat)), aes(x ="" , y = values)) +
  geom_boxplot() +
  facet_wrap(~ ind, ncol = 13) +
  ggtitle("Variable Strengths Distributions") +
  xlab("Variables") +
  ylab("Measurement Value") +
  theme( strip.text = element_text(size = 7))
```



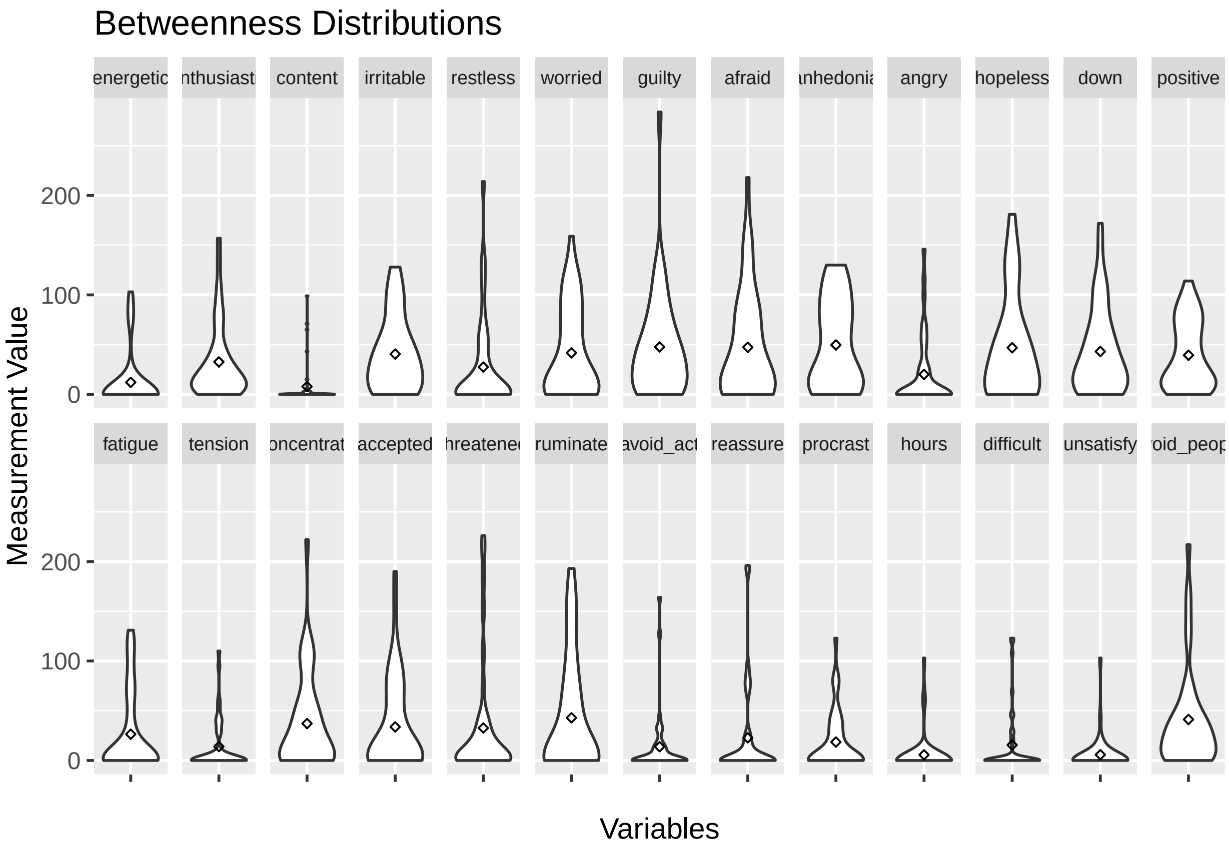
```
# Variable Strengths Violin Plot
ggplot(stack(data.frame(variable_strengths_mat)), aes(x ="" , y = values)) +
  geom_violin() +
  facet_wrap(~ ind, ncol = 13) +
  ggtitle("Variable Strengths Distributions") +
  xlab("Variables") +
  ylab("Measurement Value") +
  # ylim(-5,5) +
  theme( strip.text = element_text(size = 7)) +
  stat_summary(fun=mean, geom="point", shape=23, size=1)
```



```r
# Betweenness Boxplot
ggplot(stack(data.frame(betweenness_mat)), aes(x ="" , y = values)) +
  geom_boxplot() +
  facet_wrap(~ ind, ncol = 13) +
  ggtitle("Betweenness Distributions") +
  xlab("Variables") +
  ylab("Measurement Value") +
  theme( strip.text = element_text(size = 7))
```



```
# Betweenness Violin Plot
ggplot(stack(data.frame(betweenness_mat)), aes(x ="" , y = values)) +
  geom_violin() +
  facet_wrap(~ ind, ncol = 13) +
  ggtitle("Betweenness Distributions") +
  xlab("Variables") +
  ylab("Measurement Value") +
  theme( strip.text = element_text(size = 7)) +
  stat_summary(fun=mean, geom="point", shape=23, size=1)
```

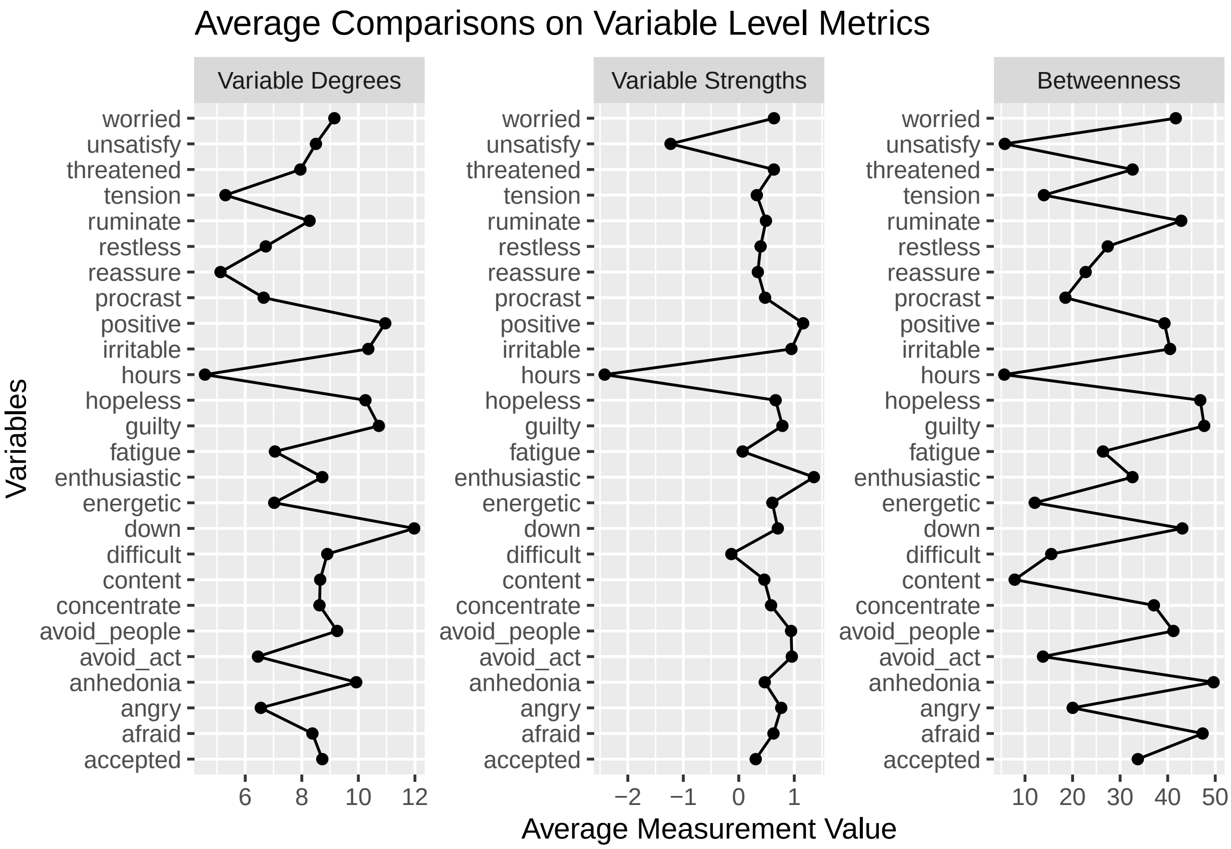


The above violin plots help to visualize the skewness in some of the variable distributions. Specifically, many of the variables show a right skewed distribution for betweenness. However, these distributions are not visibly apparent when we graph only the average measurement value, such as in the comparison plot below.

Plot the average measurement value for variable-level metrics

```
var_level_df = data.frame(
  variable = feature_names, variable_degrees_mean, variable_strengths_mean, betweenness_mean)
colnames(var_level_df) =
  c("Variable", "Variable Degrees", "Variable Strengths", "Betweenness")
ggplot(data.frame(stack(var_level_df),
  variable = c(feature_names, feature_names, feature_names)),
  aes(x = values, y = variable)) +
  geom_point() +
  geom_line(group = 1, orientation = "y") +
  facet_wrap( ~ ind, scales = "free") +
  ggtitle("Average Comparisons on Variable Level Metrics") +
  ylab("Variables") +
  xlab("Average Measurement Value")
```

```
## Warning in stack.data.frame(var_level_df): non-vector columns will be ignored
```


Average Comparisons on Variable Level Metrics
Variable Degrees
Variable Strengths
Betweenness
Variables
worried
unsatisfy
threatened
tension
ruminate
restless
reassure
procrast
positive
irritable
hours
hopeless
guilty
fatigue
enthusiastic
energetic
down
difficult
content
concentrate
avoid_people
avoid_act
anhedonia
angry
afraid
accepted
6
8
10
12
−2
−1
0
1
10
20
30
40
50
Average Measurement Value