Thanks for starting your work on the third assignment. In the assignment, you will be asked some conceptual questions, and you will also be asked to do run a few lines of R code. Please submit the assignment into the vault before the deadline in one of the following forms:

1) a .pdf with your answers and an R script with reproducible code, or
2) an R markdown document compiled from both.

In addition to the assignment, please read Molenaar's paper in ergodicity in the study materials. Thank you & Let's roll!

CONCEPTUAL QUESTIONS (3p):

Suppose a therapist measures a patient about 75 times on a set of depression symptoms, including a question on "suicidal thought". Suppose that you estimate a personalized graphical VAR model from this data, and find that the node "suicidal thought" is not connected in neither the temporal nor the contemporaneous network.

1a) (1p) List two (three + 1 BONUS POINT) potential reasons why the node "suicidal thought" may be disconnected in the resulting network.

1b) (1p) The therapist now asks you if you would recommend treating the symptom "suicidal thought". What would be you recommendation?

1c) (1p) Give an example (not one discussed in the lecture) of a relationship that can only be studied at the between-person level.

N= 1 TIME-SERIES (4p):

Download the file "Patient1.csv" from the study materials and read it into R:

```
Data1 <- read.csv("Patient1.csv")
```

This is the data of the patient described in https://psyarxiv.com/jnprz/. The variables `relaxed, sad, nervous, concentration, tired, rumination` and `bodily.discomfort` represent symptoms measured over time. These can be collected in a vector as follows:

```
Vars <- c("relaxed", "sad", "nervous", "concentration", "tired",
"rumination", "bodily.discomfort")
```

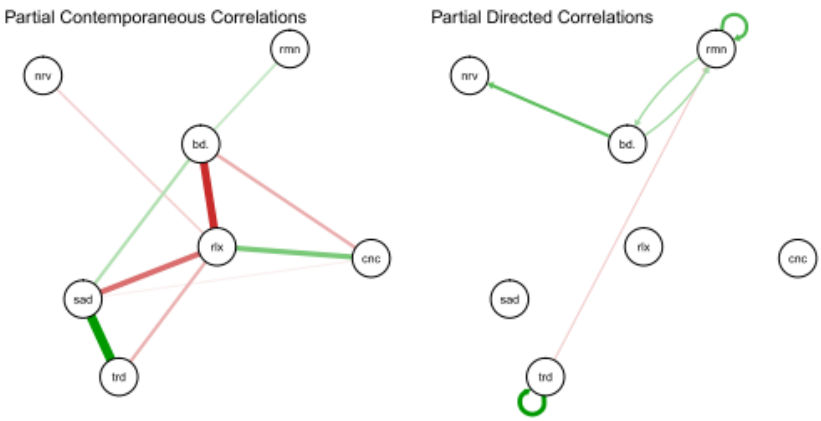
The variable `time` represents the moment of measurement. We can use this to compute which measurements come from the same day:

```
# Encode time variable in a way R understands:

Data1$time <- as.POSIXct(Data1$time, tz = "Europe/Amsterdam")

# Extract days:

Data1$Day <- as.Date(Data1$time, tz = "Europe/Amsterdam")
```

Before you continue with this assignment, install and load the `graphicalVAR` package and look at the help file for the function `graphicalVAR`.

2a) (1p) Estimate a graphical VAR model on the dataset using EBIC tuning parameter $\gamma = 0$. Tip: use the arguments `vars = Vars` to set the variables to be estimated and `dayvar = "Day"` to remove nights.

We can use the plot method to plot the temporal and contemporaneous networks using the same layout, assuming the results are stored in the object `Results`:



2b) (1p) Write a short interpretation on the estimated contemporaneous and temporal networks (max. 150 words).

We can also use the time variable to check for trends in the data. To test if the variable "tired" features a trend, we can run a linear regression on time:

```
lm_tired <- lm(tired ~ time, data = Data1)

summary(lm_tired)
```

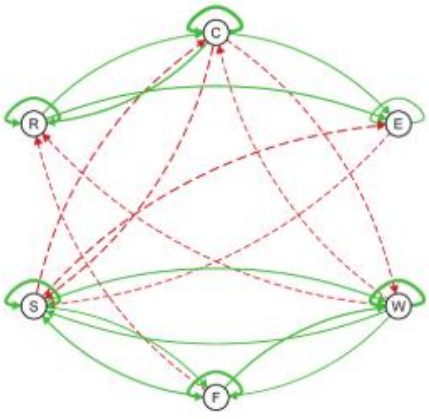
This effect is significant. We can now "detrend" tired as follows:

```
Data1$tired[!is.na(Data1$tired)] <- residuals(lm_tired)
```

2c) (2p) Check all variables for trends and detrend if necessary **(1p)**. Next, estimate the graphical VAR model based on the detrended data and compare your results to results based on non-detrended data **(1p)**.

N>1 TIME-SERIES

In 2013, PlosOne published a paper by Laura Bringmann and colleagues[1] on the estimation of multi-level vector autoregression (VAR) models and their use in psychopathology. Bringmann and colleagues only investigated temporal networks, and reported the following temporal network at baseline:



C = cheerful, E = pleasant event, W = worry, F = fearful, S = sad and R = relaxed. This network was made with an older version of `qgraph` (self-loops are now drawn differently and edges curve opposite).

[1] Bringmann, L. F., Vissers, N., Wichers, M., Geschwind, N., Kuppens, P., Peeters, F., ... & Tuerlinckx, F. (2013). A network approach to psychopathology: new insights into clinical longitudinal data. PloS one, 8(4), e60188.

The data used by Bringmann and colleagues was also published. In IS, you can find the subset of the data of patients at baseline. This can be loaded in R as follows:

```
Data2 <- read.table(file="BringmannData.csv",header=TRUE,sep=",")

head(Data2)
```

We can use this data to estimate a multi-level VAR model:

```
vars <- c("cheerful","pleasant","worry","fearful","sad","relaxed")

idvar <- "id"

beepvar <- "beep"

dayvar <- "day"

library("mlVAR")

res <- mlVAR(Data2, vars, idvar, dayvar, beepvar, lags = 1, temporal
= "correlated", contemporaneous = "correlated")
```

3a) (1p) Plot the average (fixed effects) temporal network, using, similarly to Bringmann and colleagues, a circular layout and **hiding** non-significant edges.

The `mlVAR` package was originally based on the R codes supplied in the supplementary materials of this paper. Since then, centring of VAR models to detangle within- from between-subject processes has been worked out[2], allowing for a slightly different estimation of the VAR model now implemented in `mlVAR`. Finally, the underlying software used (the R package `lme4`) has gone through some changes as well. As a result, `mlVAR` now returns a slightly different network structure. As described in the lecture, `mlVAR` also estimates contemporaneous networks. These networks show the relationships at the same time point after controlling for temporal effects.

3b) (1p) Plot the average (fixed effects) contemporaneous partial correlation network. Use a circle layout and hide non-significant edges. Use the "and" rule to minimize type-1 error rate in showing edges (see the `qgraph` documentation). Compare the network to the temporal network. Are the results what you expect?

In addition to the contemporaneous network, `mlVAR` also estimates a between-subjects network by investigating between-subject prediction of the mean of one variable given the means of other variables.

3c) (1p) Plot the between-subjects partial correlation network. Use a circle layout and hide non-significant edges. Use the "and" rule to minimize type-1 error rate in showing edges. Can you describe in words what a negative relationship between sad and experiencing pleasant events at the between-subjects level means? Compare the network to the temporal and contemporaneous networks, are the results what you expect?

Hint: The between-subjects network shows less connections, as this is a network between means there generally are less observations making it harder to reach statistical significance.

[2] Hamaker, E. L., & Grasman, R. P. (2015). To center or not to center? Investigating inertia with a multilevel autoregressive model. Frontiers in psychology, 5, 1492.