Making graphs in R

Using the **qgraph** package

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All codes in these slides were run using R version 3.1.0 (2014-04-10) and **qgraph** version 1.2.5 and were made on `Windows 7 x64 x86-64 build 9200`.

Get the latest version of R from www.r-project.org and the latest version of **qgraph** from CRAN:

```
install.packages("qgraph",dep=TRUE)
```

Make sure you can load qgraph:

```
library("qgraph")
```

And that you have version 1.2.3 or higher:

```
packageDescription('qgraph')$Version

## [1] "1.2.5"
```

If this fails, make sure you have the latest (2.15) version of R and that all depended/imported/suggested packages are installed (see CRAN).

Defaults

Note that the following defaults are set for this presentation:

```
options(
  qgraph = list(
    border.width = 2,
    asize = 8,
    unCol = "black",
    vsize = 10,
    esize = 3)
)
```

So the codes can create different looking graphs on your screen!

Help on R

Do it yourself. . .

- For basic understanding of R: Read through a R manual!
  - How do I make a matrix?
  - How do I index an object?
  - What is a list?
  - Try a short one first! (R for beginners)
- Help on how to use a function: Use the `?` function (e.g. `?matrix`)
  - How do I define a matrix by row?
  - How do I set `mean()` to omit NA's?
- Find a certain function: Use the `??` function
  - What is a function to reduce a string to a certain amount of characters?
    - `??trim`
- Or use google!

Help on R

. . . or ask for help!

- Stackoverflow websites (see next slide)
- For problems concerning specific packages: Mail the maintainer
- For short questions, you can use Twitter or Google+ with hashtag #rstats

Stackexchange

Stackexchange is a series of free question and answer websites on many different topics. Two are very useful for whenever you get stuck in **R**:

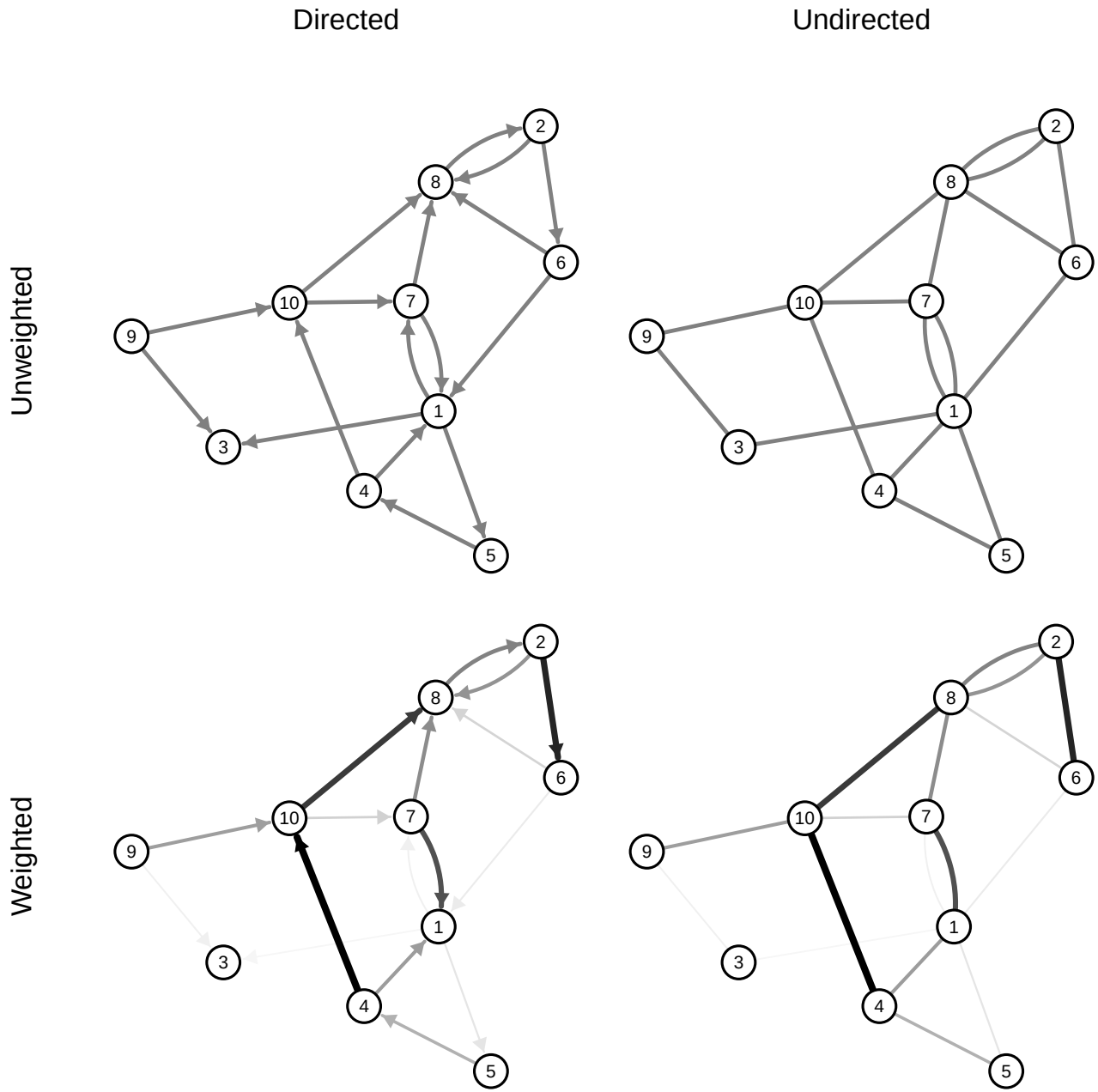
For programming technical questions regarding **R** see:
`http://stackoverflow.com/`

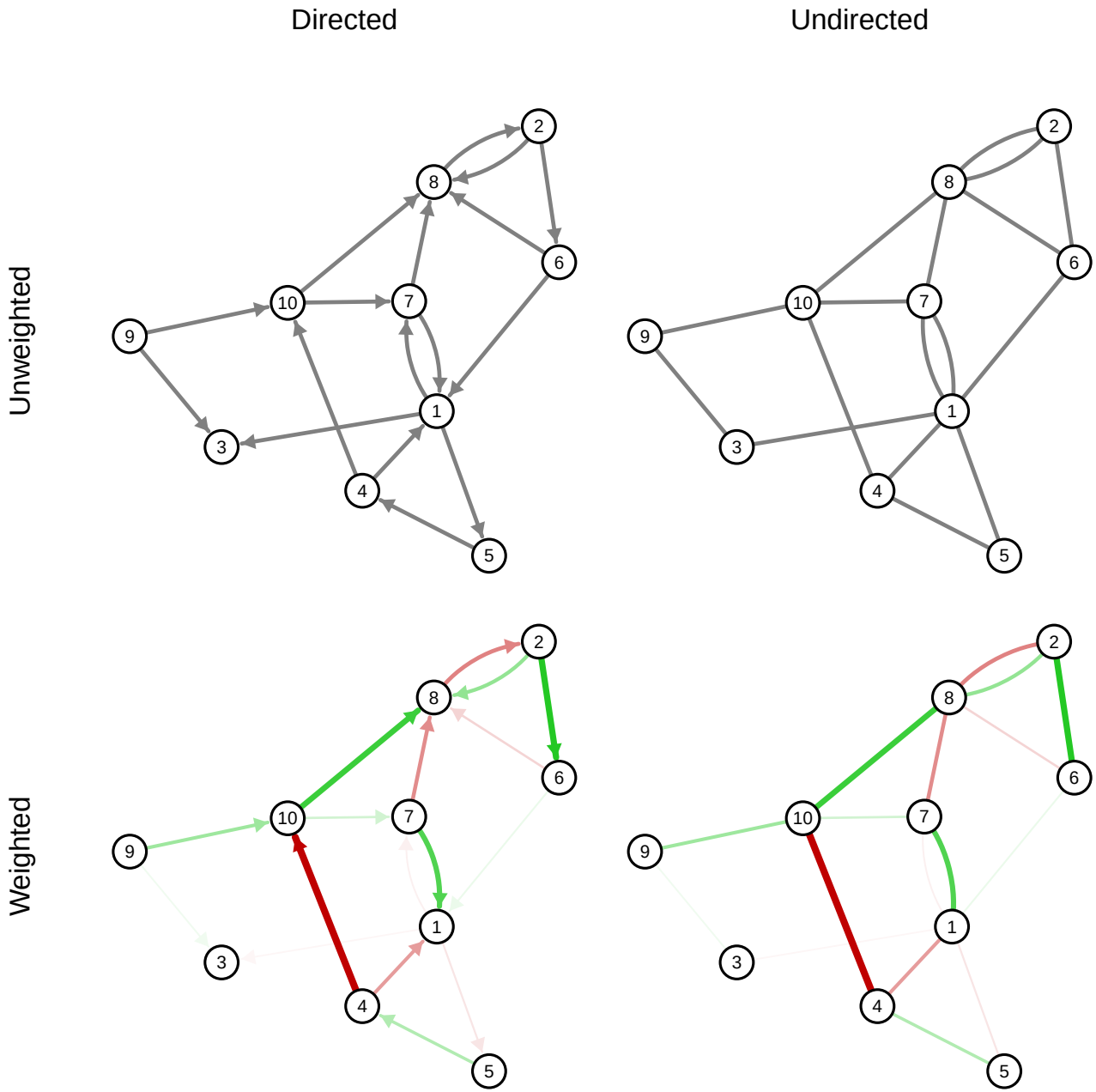
For statistical questions regarding **R** see:
`http://crossvalidated.com/`

In both of these make sure you use the tag `r` and include a reproducible example:
`http://stackoverflow.com/q/5963269/567015`

Graphs

- A graph is a *network* that consists of n nodes (or vertices) that are connected with m edges.
- Each edge can have a *weight* indicating the strength of that connection
- An edge can be directed (have an arrow) or undirected


Directed
Undirected
Unweighted
Weighted
1
2
3
4
5
6
7
8
9
10


Directed
Undirected
Unweighted
Weighted
1
2
3
4
5
6
7
8
9
10

The `qgraph()` function

- The main function in **qgraph** is `qgraph()`
  - Most other functions are either wrapping functions using `qgraph()` or functions used in `qgraph()`
- The `qgraph()` function requires only one argument (`input`)
- A lot of other arguments can be specified, but these are all optional

Usage:

```
qgraph( input, ... )
```

Weights matrices

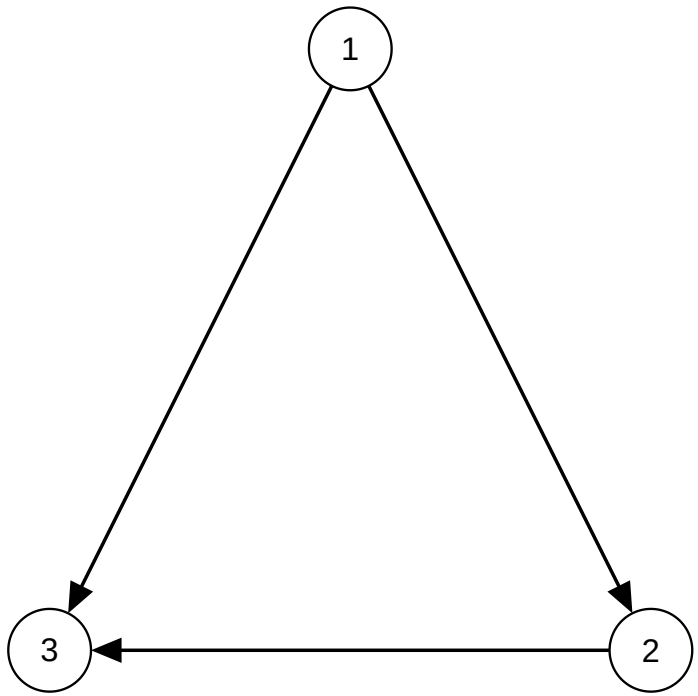
- The `input` argument is the input. This can be a *weights matrix*
- A weights matrix is a square *n* by *n* matrix in which each element indicates the relationship between two variables
- Any relationship can be used as long as:
  - A 0 indicates no relationship
  - Absolute negative values are similar in strength to positive values
- We will first look at unweighted graphs, in which case the weights matrix is the same as an *adjacency matrix*
  - A 1 indicates a connection
  - A 0 indicates a connection
  - Rows indicate the node of origin
  - Columns indicate the node of destination
  - By default the diagonal is omitted
  - By default, a symetrical weights matrix is interpreted as an unweighted graph

Weights matrices

```
input <- matrix(c(
         0,1,1,
         0,0,1,
         0,0,0),3,3,byrow=TRUE)
print(input)
```

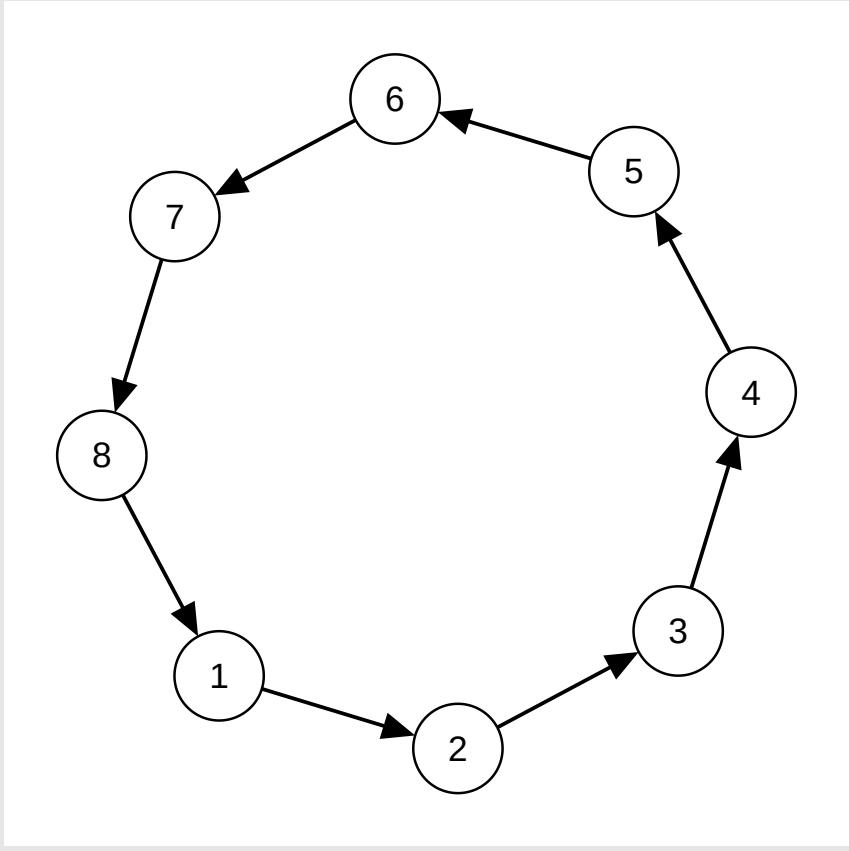
```
##      [,1] [,2] [,3]
## [1,]    0    1    1
## [2,]    0    0    1
## [3,]    0    0    0
```

```
qgraph(input)
```



Weights matrices

Exercise: Create this graph



The layout should be right automatically, only use one argument in `qgraph()`

Weights matrices

To make this graph, we need this matrix:

```
##       [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
## [1,]    0    1    0    0    0    0    0    0
## [2,]    0    0    1    0    0    0    0    0
## [3,]    0    0    0    1    0    0    0    0
## [4,]    0    0    0    0    1    0    0    0
## [5,]    0    0    0    0    0    1    0    0
## [6,]    0    0    0    0    0    0    1    0
## [7,]    0    0    0    0    0    0    0    1
## [8,]    1    0    0    0    0    0    0    0
```

Weights matrices

These matrices become quite large, so manually defining the matrix is not effective. So some tricks are needed to make the matrix:

```
input <- matrix(0,8,8)
input[1,2] <- 1
input[2,3] <- 1
input[3,4] <- 1
input[4,5] <- 1
input[5,6] <- 1
input[6,7] <- 1
input[7,8] <- 1
input[8,1] <- 1
```

Weights matrices

```
print(input)
```

```
##       [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
## [1,]    0    1    0    0    0    0    0    0
## [2,]    0    0    1    0    0    0    0    0
## [3,]    0    0    0    1    0    0    0    0
## [4,]    0    0    0    0    1    0    0    0
## [5,]    0    0    0    0    0    1    0    0
## [6,]    0    0    0    0    0    0    1    0
## [7,]    0    0    0    0    0    0    0    1
## [8,]    1    0    0    0    0    0    0    0
```

Weights matrices

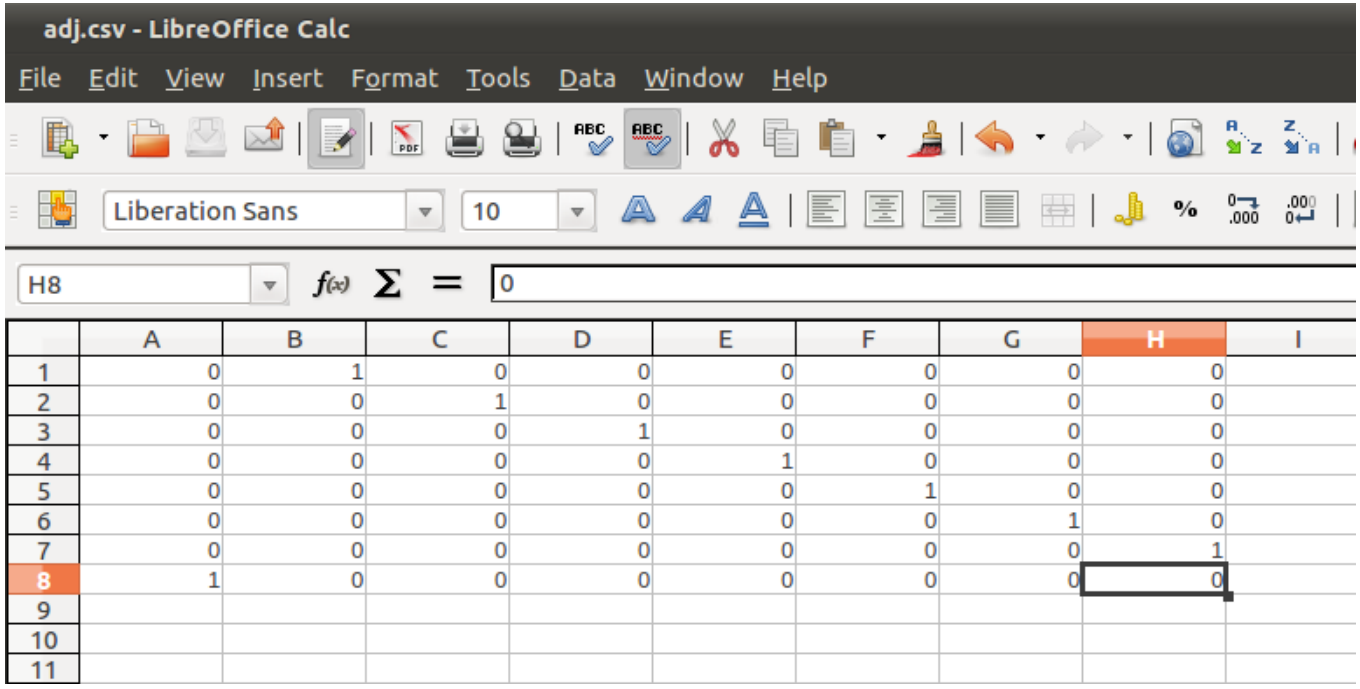
You can also change matrices manually (doesn't work in RStudio):

```
input <- matrix(0,8,8)
fix(input)
```

Or read the matrix from a text file!

Weights matrices

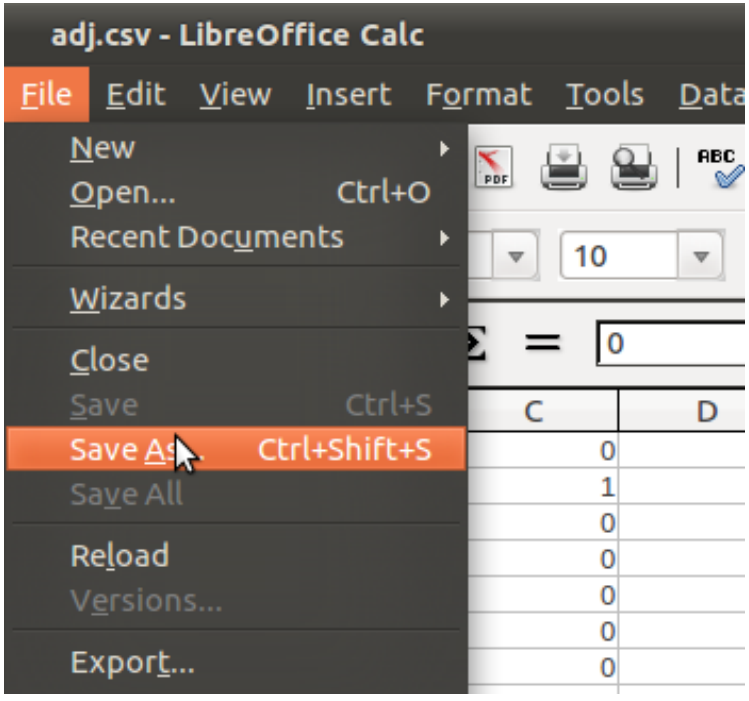
First make the matrix in a spreadsheet program (here LibreOffice)



	A	B	C	D	E	F	G	H	I
1	0	1	0	0	0	0	0	0	
2	0	0	1	0	0	0	0	0	
3	0	0	0	1	0	0	0	0	
4	0	0	0	0	1	0	0	0	
5	0	0	0	0	0	1	0	0	
6	0	0	0	0	0	0	1	0	
7	0	0	0	0	0	0	0	1	
8	1	0	0	0	0	0	0	0	
9									
10									
11									

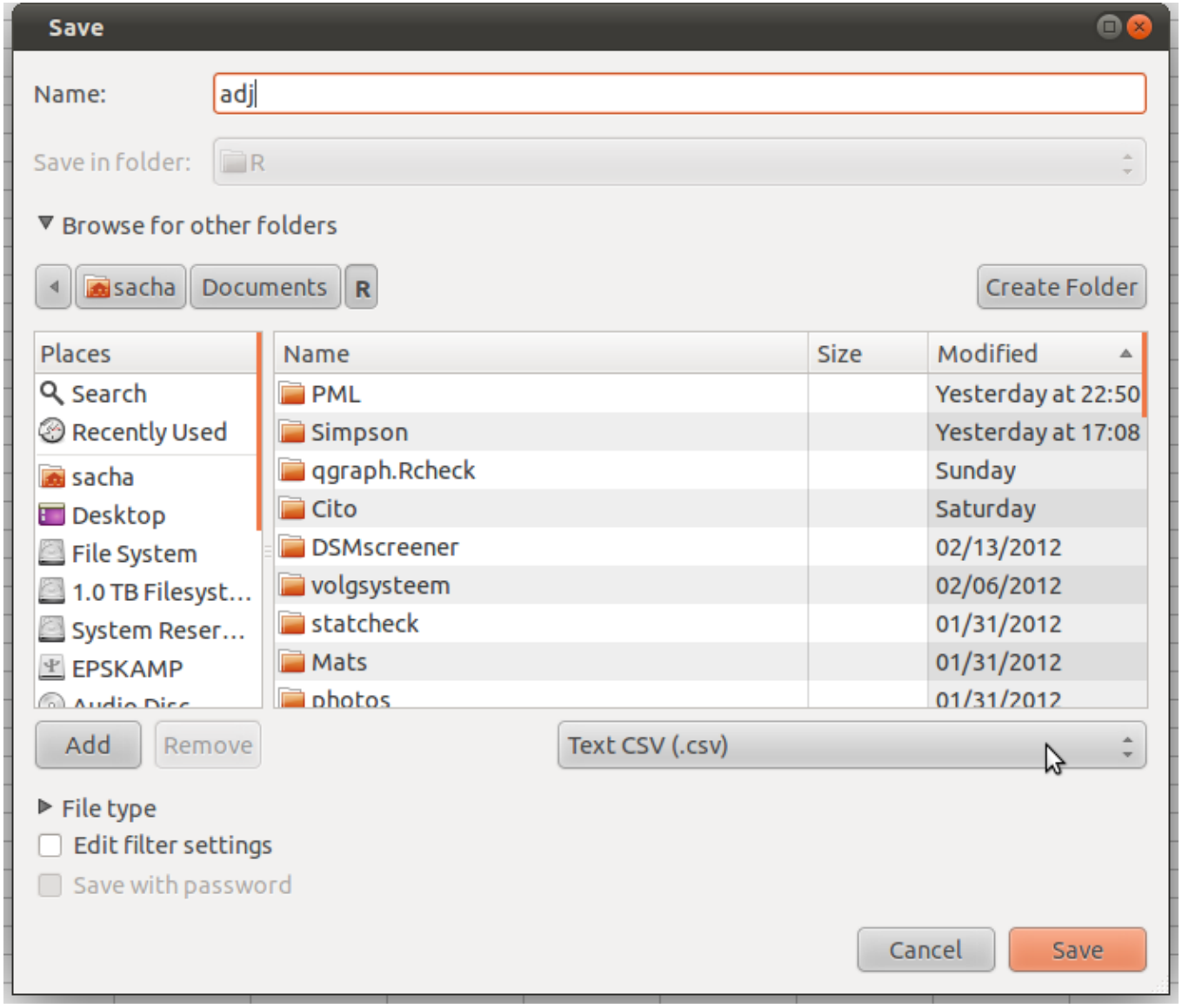
Weights matrices

Next save as or export



Weights matrices

Save as CSV (comma delimited text file) or tab delimited:



Weights matrices

Read in R (for tab delimited use `read.table()`:

```
input <- read.csv("adj.csv",header=FALSE)
print(input)

##   V1 V2 V3 V4 V5 V6 V7 V8
## 1  0  1  0  0  0  0  0  0
## 2  0  0  1  0  0  0  0  0
## 3  0  0  0  1  0  0  0  0
## 4  0  0  0  0  1  0  0  0
## 5  0  0  0  0  0  1  0  0
## 6  0  0  0  0  0  0  1  0
## 7  0  0  0  0  0  0  0  1
## 8  1  0  0  0  0  0  0  0
```

Weights matrices

These methods are not **reproducible**. Scripts should not depend on manual input. An easy way to change this is to first define a matrix. then run `dput()` on the object and use that result in your script:

```
dput(input)

## structure(c(0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0,
## 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0,
## 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0,
## 0, 0, 0, 1, 0), .Dim = c(8L, 8L))
```

Weights matrices

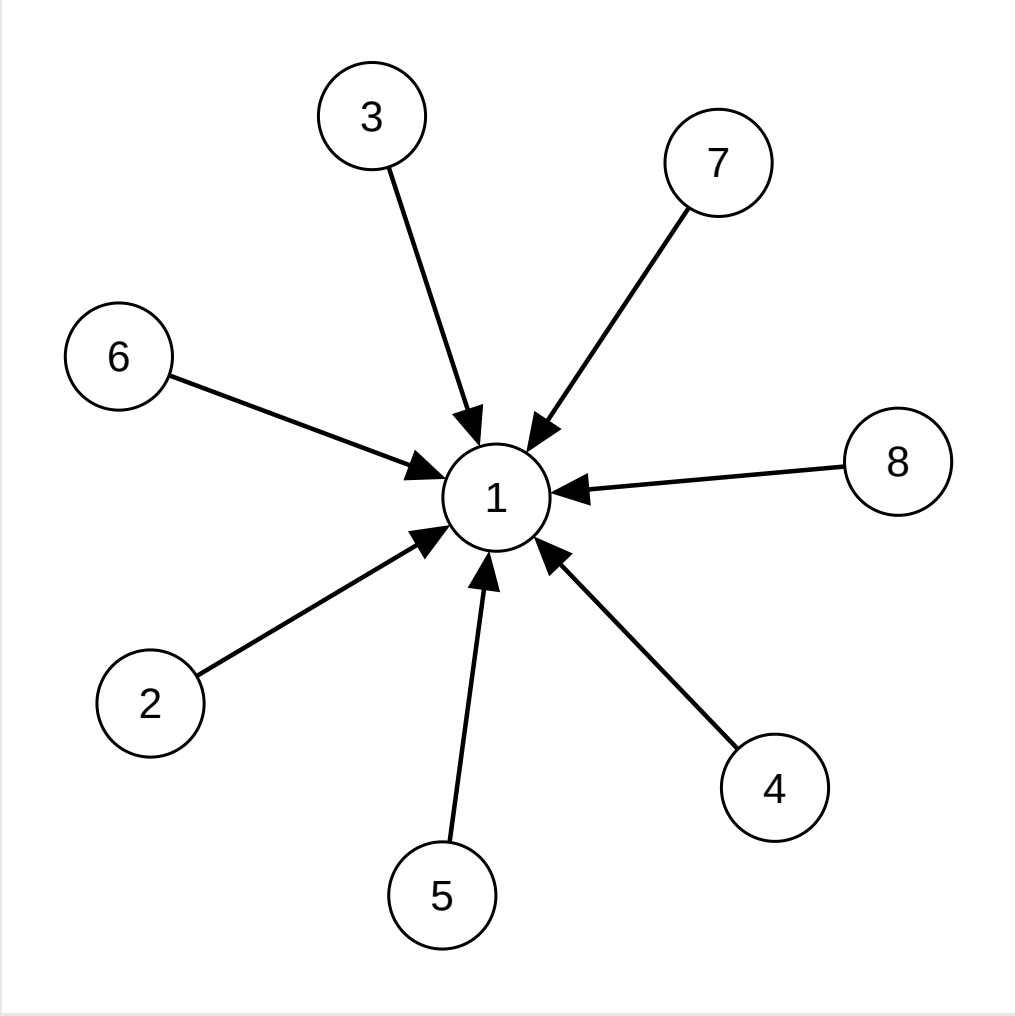
```
input2 <- structure(c(0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0
1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,
0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
0, 0, 0, 1, 0), .Dim = c(8L, 8L))

print(input2)
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
## [1,]    0    1    0    0    0    0    0    0
## [2,]    0    0    1    0    0    0    0    0
## [3,]    0    0    0    1    0    0    0    0
## [4,]    0    0    0    0    1    0    0    0
## [5,]    0    0    0    0    0    1    0    0
## [6,]    0    0    0    0    0    0    1    0
## [7,]    0    0    0    0    0    0    0    1
## [8,]    1    0    0    0    0    0    0    0
```

Weights matrices

Exercise: Create this graph



Weights matrices

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]
## [1,]    1    0    0    0    0    0    0    0
## [2,]    1    0    0    0    0    0    0    0
## [3,]    1    0    0    0    0    0    0    0
## [4,]    1    0    0    0    0    0    0    0
## [5,]    1    0    0    0    0    0    0    0
## [6,]    1    0    0    0    0    0    0    0
## [7,]    1    0    0    0    0    0    0    0
## [8,]    1    0    0    0    0    0    0    0
```

The `directed` argument

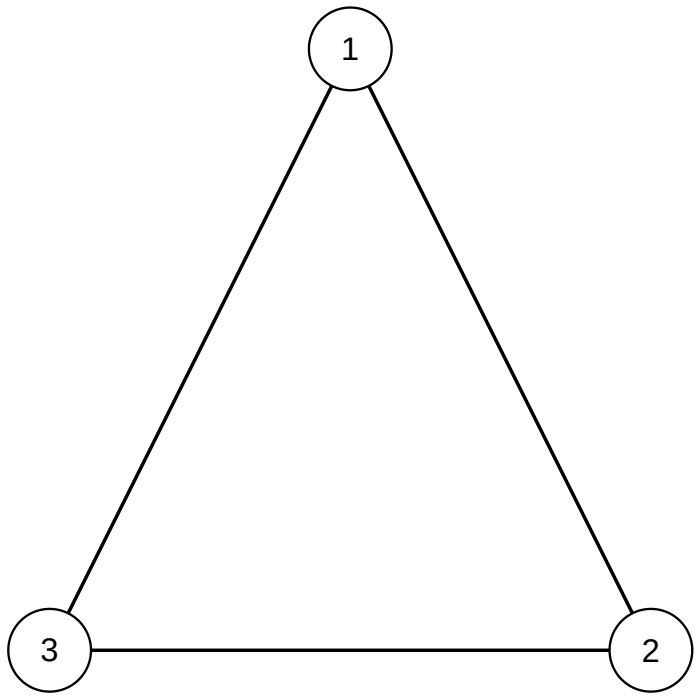
- The `directed` argument can be used to force a directed (TRUE) or undirected (FALSE) graph
- This can also be specified per edge in a matrix

The `directed` argument

```
input<- matrix(1,3,3)
print(input)

##      [,1] [,2] [,3]
## [1,]    1    1    1
## [2,]    1    1    1
## [3,]    1    1    1
```

```
qgraph(input)
```

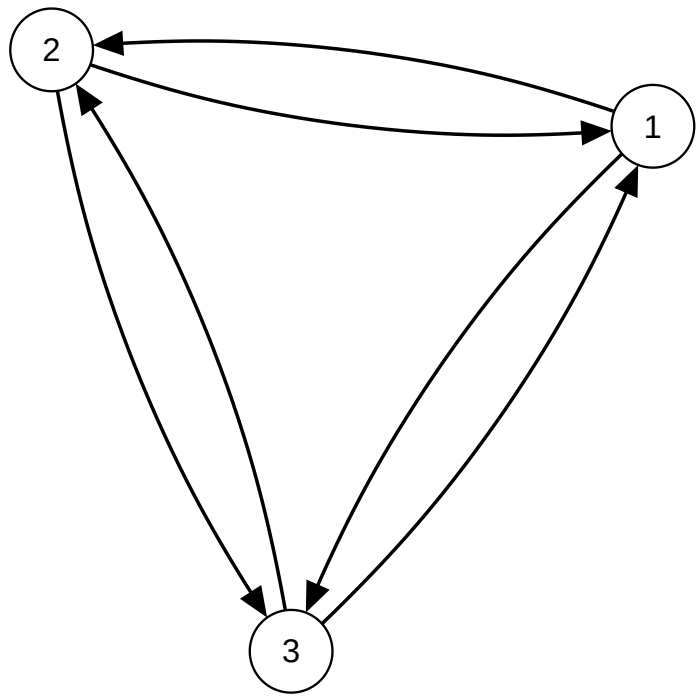


The `directed` argument

```
qgraph(input,directed=TRUE)
```

```
print(input)
```

```
##      [,1] [,2] [,3]
## [1,]    1    1    1
## [2,]    1    1    1
## [3,]    1    1    1
```



The `directed` argument

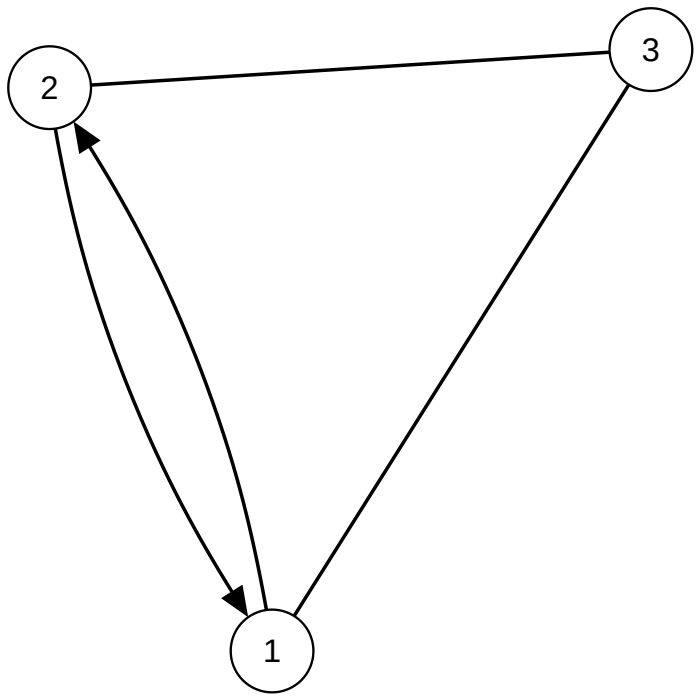
```
print(input)

##      [,1] [,2] [,3]
## [1,]    1    1    1
## [2,]    1    1    1
## [3,]    1    1    1

dir <- matrix(c(
           FALSE,TRUE,FALSE,
           TRUE,FALSE,FALSE,
           FALSE,FALSE,FALSE)
  ,3,3,byrow=TRUE)
print(dir)

##       [,1]  [,2]  [,3]
## [1,] FALSE  TRUE FALSE
## [2,]  TRUE FALSE FALSE
## [3,] FALSE FALSE FALSE
```

```
qgraph(input,directed=dir)
```



The `bidirectional` argument

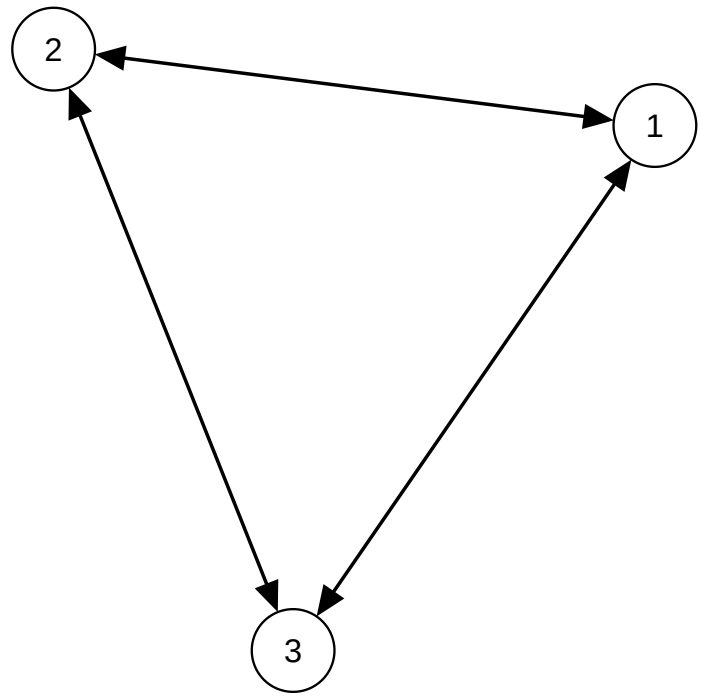
- Multiple directed edges between two nodes are curved
- To change this behavior, `bidirectional` can be set to TRUE
- Can also be a matrix

The `bidirectional` argument

```
qgraph(input,
  directed=TRUE,
  bidirectional=TRUE)
```

```
print(input)
```

```
##       [,1] [,2] [,3]
## [1,]    1    1    1
## [2,]    1    1    1
## [3,]    1    1    1
```



The `bidirectional` argument

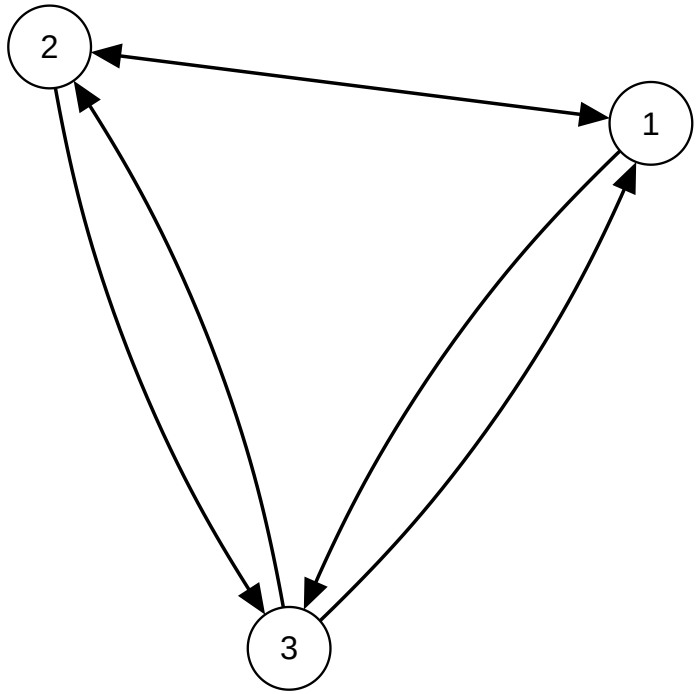
```
print(input)

##      [,1] [,2] [,3]
## [1,]    1    1    1
## [2,]    1    1    1
## [3,]    1    1    1

bidir <- matrix(c(
           FALSE,TRUE,FALSE,
           TRUE,FALSE,FALSE,
           FALSE,FALSE,FALSE)
  ,3,3,byrow=TRUE)
print(bidir)

##       [,1]  [,2]  [,3]
## [1,] FALSE  TRUE FALSE
## [2,]  TRUE FALSE FALSE
## [3,] FALSE FALSE FALSE
```

```
qgraph(input,
  directed=TRUE,
  bidirectional=bidir)
```



Arguments for directed graphs

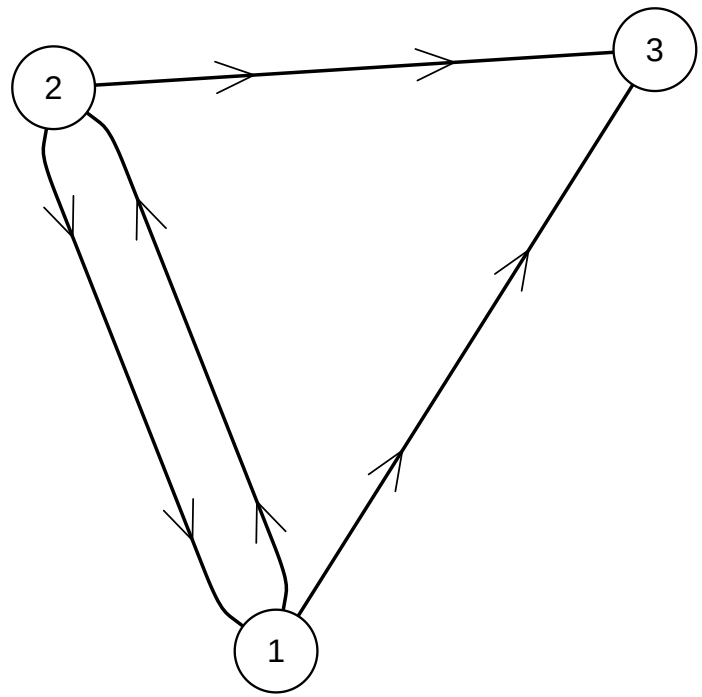
- Two other arguments can be used this way:
  - `curve` to curve each edge
  - `lty` to create dashed lines (not yet in matrix form)
- And finally a few other arguments:

Arguments for directed graphs

```
input<-matrix(c(
         0,1,1,
         1,0,1,
         0,0,0),3,3,byrow=TRUE)
print(input)
```

```
##      [,1] [,2] [,3]
## [1,]    0    1    1
## [2,]    1    0    1
## [3,]    0    0    0
```

```
qgraph(input,
  asize=10,
  arrows=2,
  open=TRUE,
  curvePivot=TRUE)
```



Weighted graphs

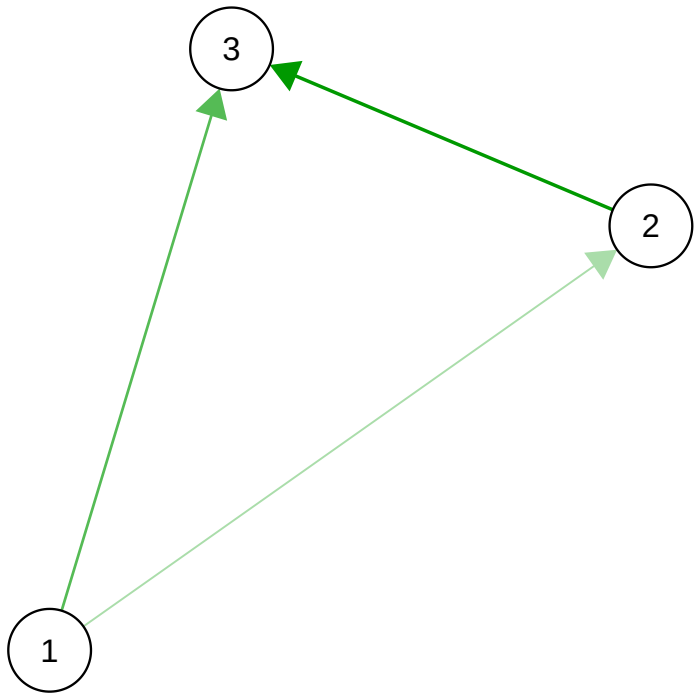
- Specify edge weights to make a graph weighted
  - In a weights matrix: simply specify other values than only zeros and ones
- An edge weigth of 0 indicates no connection
- Positive and negative edge weights must be comparable in strength
- The “length” of an edge is defined as the inverse of the weight.
  - Stronger connected nodes are closer together
  - An edge weight of 0 indicates infinite length

Weighted graphs

```
qgraph(input)
```

```
input<-matrix(c(
         0,1,2,
         0,0,3,
         0,0,0),3,3,byrow=TRUE)
print(input)
```

```
##      [,1] [,2] [,3]
## [1,]    0    1    2
## [2,]    0    0    3
## [3,]    0    0    0
```



Layout modes

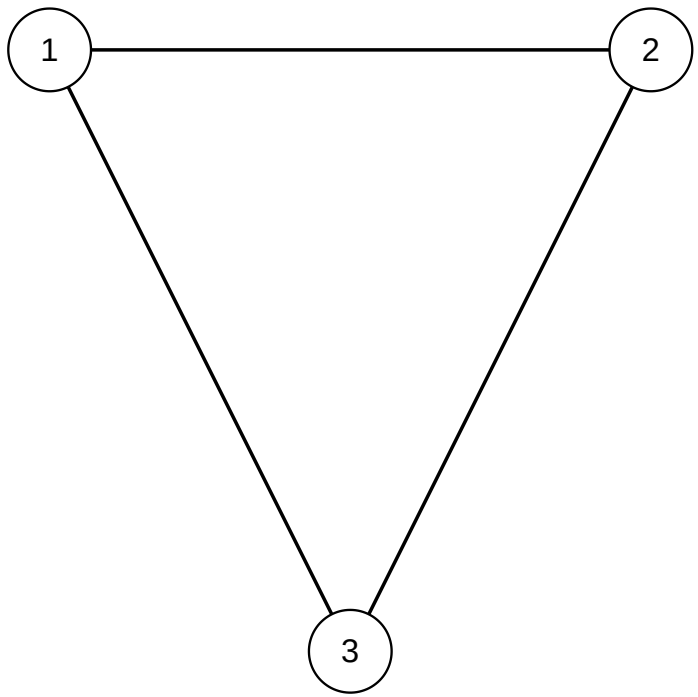
- The placement of the nodes is specified with the `layout` argument in `qgraph()`
- This can be a *n* by 2 matrix indicating the *x* and *y* position of each node
- `layout` can also be given a character indicating one of the two default layouts
  - If `layout="circular"` the nodes are placed in circles per group (if the `groups` list is specified)
  - If `layout="spring"` the Fruchterman Reingold algorithm is used for the placement
- And a final option is to specify a grid-like layout

Layout matrix

```
input <- matrix(1,3,3)
L <- matrix(c(
           0,1,
           1,1,
           0.5,0),
  ncol=2,byrow=TRUE)
print(L)

##      [,1] [,2]
## [1,]  0.0    1
## [2,]  1.0    1
## [3,]  0.5    0
```

```
qgraph(input,layout=L)
```

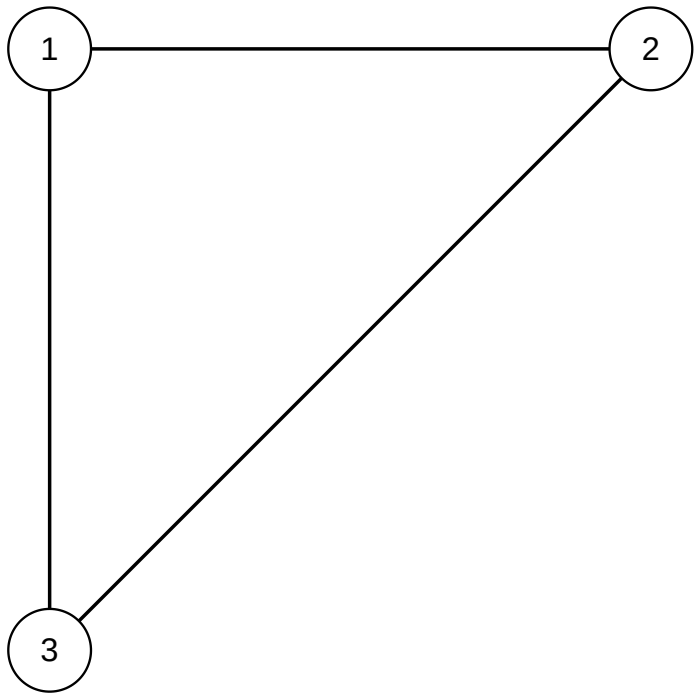


Layout matrix

```
qgraph(input,layout=L)
```

```
L <- matrix(c(
          0,1,
          1,1,
          0,0),ncol=2,byrow=TRUE)
print(L)

##      [,1] [,2]
## [1,]    0    1
## [2,]    1    1
## [3,]    0    0
```



Layout matrix

- With the layout matrix the actual layout can be specified
- The scale is not relevant
- `qgraph()` returns a list containing everything needed to make the graph
- This can be used to force another graph based on the layout of the first

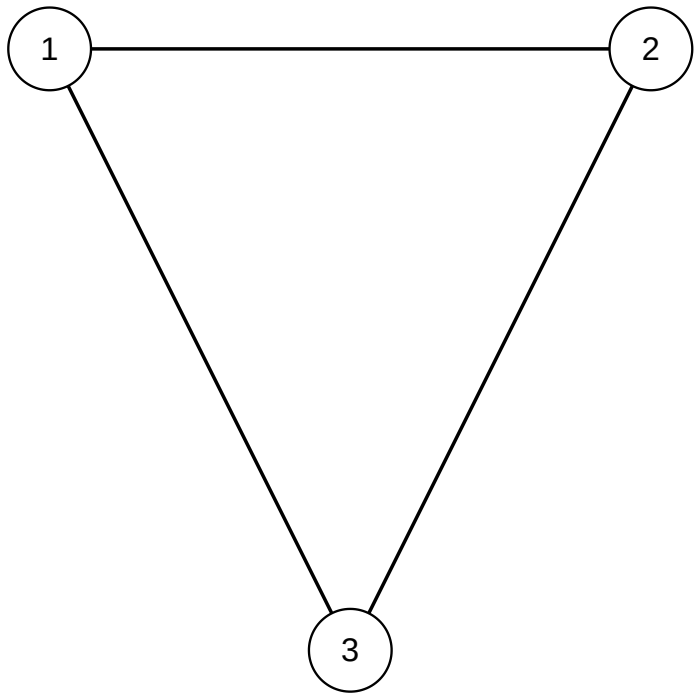
```
Q <- qgraph(input)
qgraph(input2,layout=Q$layout)
```

Grid layout

```
input <- matrix(1, 3, 3)
L <- matrix(c(
         1,0,2,
     0,0,0,
         0,3,0),
   nrow=3,byrow=TRUE)
print(L)
```

```
##      [,1] [,2] [,3]
## [1,]    1    0    2
## [2,]    0    0    0
## [3,]    0    3    0
```

```
qgraph(input,layout=L)
```

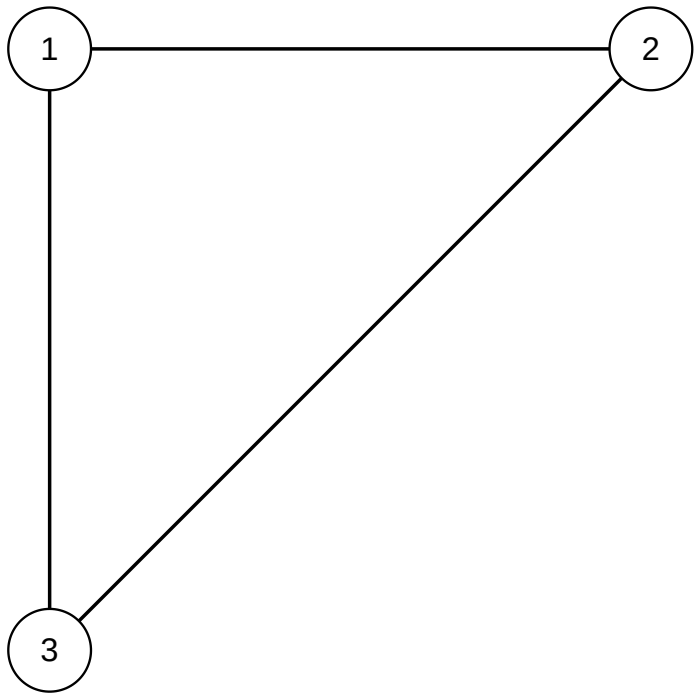


Grid layout

```
qgraph(input,layout=L)
```

```
input <- matrix(1,3,3)
L <- matrix(c(
         1,0,2,
   0,0,0,
         3,0,0),nrow=3,byrow=TRU
print(L)
```

```
##      [,1] [,2] [,3]
## [1,]    1    0    2
## [2,]    0    0    0
## [3,]    3    0    0
```



Fruchterman-Reingold layout

- `layout="spring"` uses a force-embedded algorithm (the Fruchterman-Reingold algorithm)
- This is an iterative algorithm.
- The initial layout is a circle
- Then in each iteration:
  - Each node is repulsed by all other nodes
  - Connected nodes are also attracted to each other
  - The maximum displacement weakens each iteration
- After this process the layout is rescaled to fit the -1 to 1 *xy*-plane
- The unscaled layout is returned as `layout.orig`

Big 5

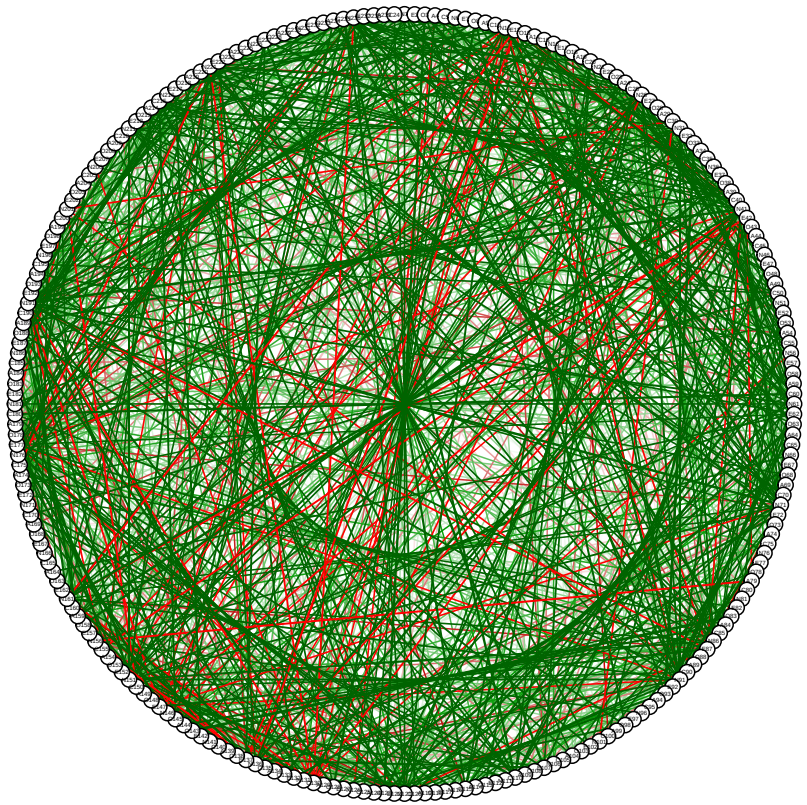
Load the big 5 dataset:

```
data(big5)
str(big5)

##  num [1:500, 1:240] 2 3 4 4 5 2 2 1 4 2 ...
##  - attr(*, "dimnames")=List of 2
##   ..$ : NULL
##   ..$ : chr [1:240] "N1" "E2" "O3" "A4" ...
```

Big 5

```
qgraph(cor(big5),minimum=0.25)
```



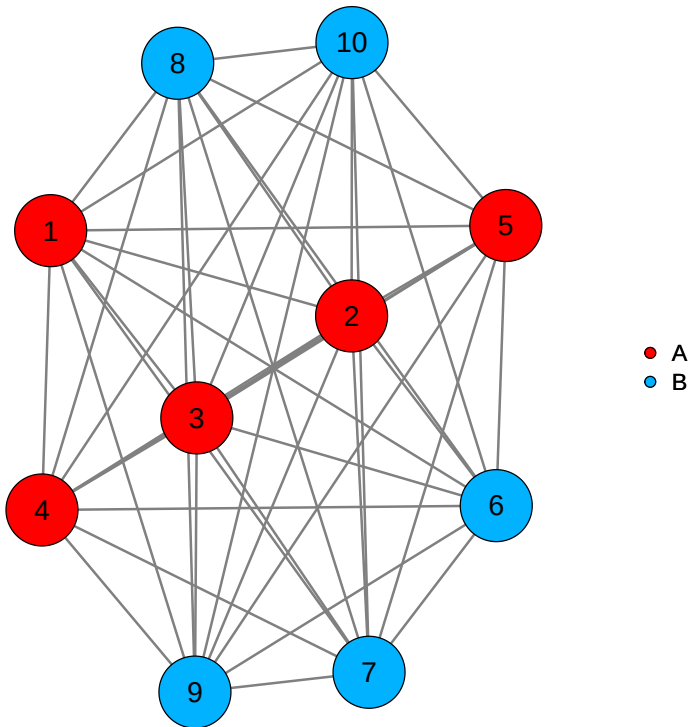
The `groups` argument

- The `groups` indicates which nodes belong together
- Nodes belonging together are...
  - placed in smaller circles (with circular layout)
  - colored in the same color (either rainbow or defined with `color`)
- Names in the `groups` can be used as legend
- `groups` can even be used to perform a oneline CFA with `qgraph.cfa()`

Either use a factor (a vector with characters) or a list in which each element is a vector containing the number of nodes that belong together

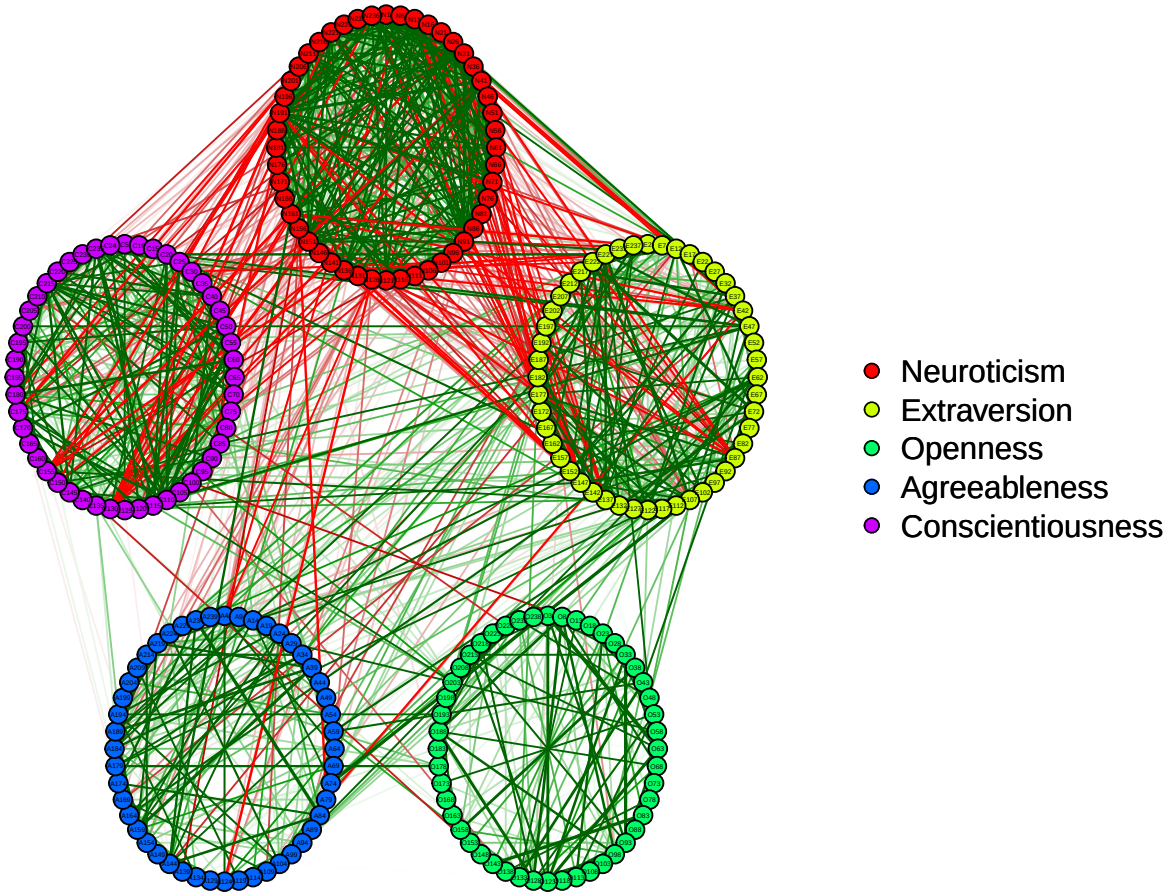
The `groups` argument

```
# List:
groups <- list(A = c(1,2,3,4,5),
               B = c(6,7,8,9,10))
# Factor:
groups <- c("A","A","A","A","A",
            "B","B","B","B","B")
# Result:
qgraph(matrix(1,10,10),groups=groups)
```



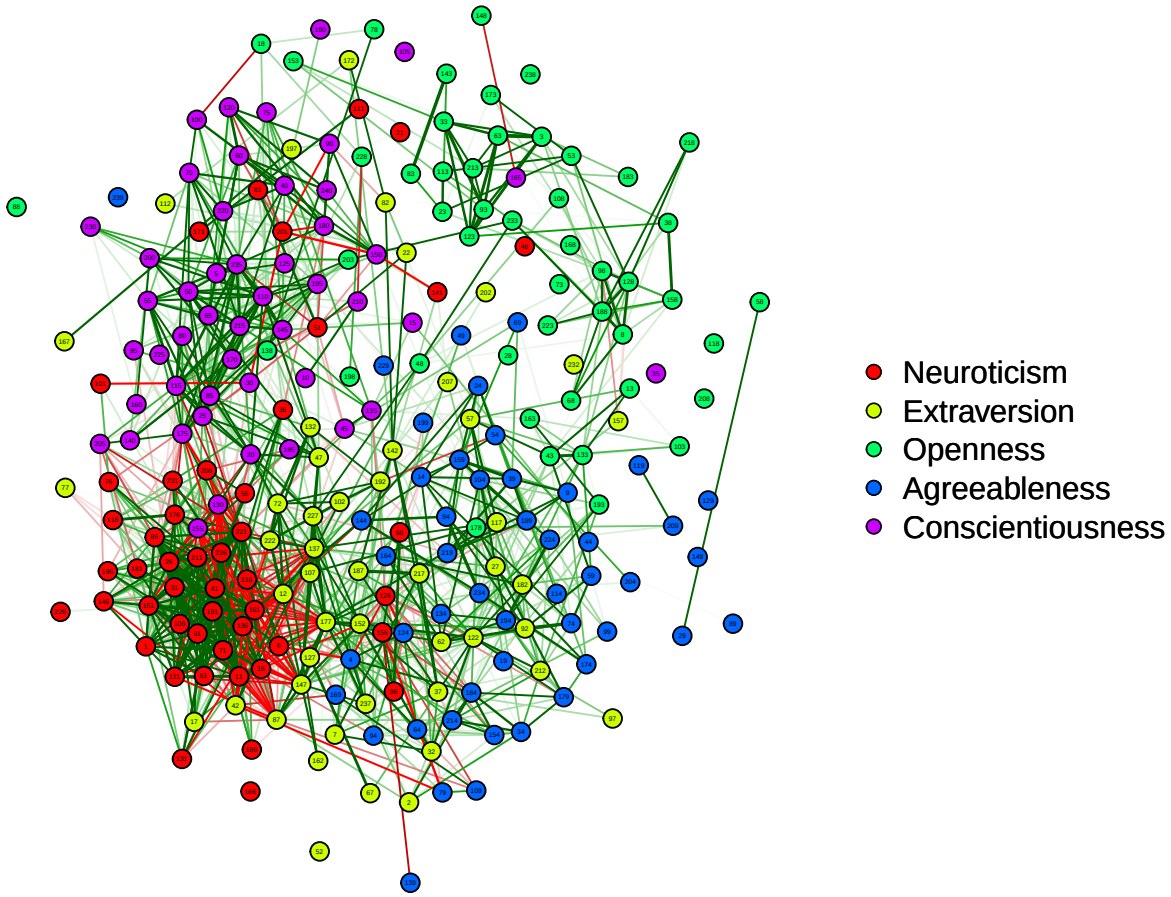
Big 5

```
data(big5groups)
big5graph <- qgraph(cor(big5),minimum=0.25,groups=big5groups)
```



Big 5

```
qgraph(big5graph,layout="spring")
```



output

qgraph graphs can **not** be manually rescaled, and hence the **RStudio** Export function can **not** be used to save **qgraph** graphs.

For the best result, save graphs in a PDF device!

Export to PDF

```
# Open a pdf device:
pdf("nameoffile.pdf")

# Plot stuff:
qgraph(1)

# Close pdf device:
dev.off()

## pdf
##   2
```

(If you get faulty output, make sure to run `dev.off()` enough times untill R returns `Null Device`)

Export to PNG

```
# Open a pdf device:
png("nameoffile.png")

# Plot stuff:
qgraph(1)

# Close pdf device:
dev.off()

## pdf
##   2
```

(If you get faulty output, make sure to run `dev.off()` enough times untill R returns `Null Device`)

Important qgraph arguments

minimum	Omits edge weights with absolute values under this argument
maximum	Sets the strongest edge to scale to
cut	Splits scaling of color and width
vsize	Sets the size of nodes
esize	Sets the size of edges
asize	Sets the size of arrows
filetype	Type of file to save the plot to
filename	Name of the file to save the plot to

Contribute to **qgraph**

The devellopmental version of **qgraph** can be found on GitHub (https://github.com/SachaEpskamp/qgraph) and can be installed using **devtools**

```
library("devtools")
install_github("qgraph","sachaepskamp")
```

If you have any ideas on concepts to implement in **qgraph** or encounter any bugs please post them on GitHub!