Simulation

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```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
```

```
## v ggplot2 3.3.6     v purrr   0.3.4
## v tibble  3.1.8     v stringr 1.4.1
## v tidyr   1.2.0     v forcats 0.5.2
## v readr   2.1.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(ggplot2)
library(mvtnorm)
library(plotly)
```

```
##
## Attaching package: 'plotly'
##
## The following object is masked from 'package:ggplot2':
##
##     last_plot
##
## The following object is masked from 'package:stats':
##
##     filter
##
## The following object is masked from 'package:graphics':
##
##     layout
```

random N(0,1) matrix

```
# matrix permutations

n = 1e2

A = matrix(rnorm(n^2), nrow = n)
B = matrix(rnorm(n^2), nrow = n)
diag(A) = 0
diag(B) = 0
sum(A*B)
```

```
## [1] 88.22046
```

```
MC = 1e4

record = data.frame(
  DIPS = rep(0, MC),
  TWOWAY = rep(0, MC),
  VEC  = rep(0, MC)
)
```

```
# DIPS permutation
record$DIPS = sapply(1:MC,
                     function(x){
                       permInd = sample(1:n)
                       sum(A * B[permInd, permInd])
                     })
```

```
# TWOWAY permutation
record$TWOWAY = sapply(1:MC,
                     function(x){
                       permInd_1 = sample(1:n)
                       permInd_2 = sample(1:n)
                       sum(A * B[permInd_1, permInd_2])
                     })
```

```
# VEC permutation
Avec = c(A)
Bvec = c(B)
record$VEC = sapply(1:MC,
                     function(x){
                       permInd = sample(1:(n^2))
                       sum(Avec * Bvec[permInd])
                     })
```

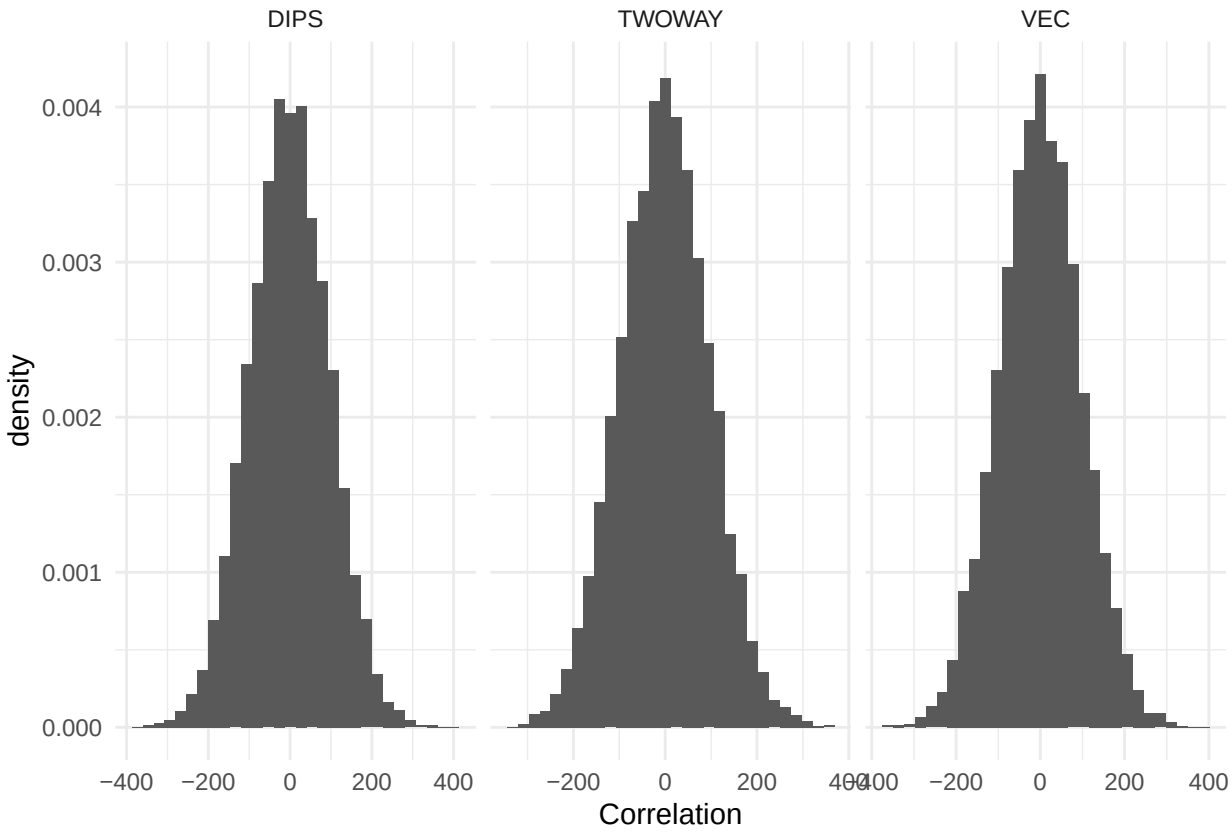
```
var(record)
```

```
##              DIPS     TWOWAY        VEC
## DIPS   9633.22619 -142.06196  -47.14638
## TWOWAY -142.06196 9534.14439  -36.75553
## VEC     -47.14638  -36.75553 9661.08254
```

```
record %>% gather(key = "PermType", value = "Correlation") %>%
  ggplot(aes(x = Correlation)) +
  geom_histogram(aes(y = ..density..)) +
  facet_wrap(vars(PermType), scales = "free_x") +
```

```
  theme_minimal()
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



matrices with heterogeneity (simulation 1)

```
# matrix permutations

n = 1e2

#A = outer(1:n/n, 1:n/n, Vectorize(function(x,y) {exp((x-y)^2)}))
#B = outer(1:n/n, 1:n/n, Vectorize(function(x,y) {exp((x-y)^2)}))

A = outer(1:n/n, 1:n/n, Vectorize(function(x,y) {sin(x*(2*pi)) + sin(y*(2*pi))}))
B = outer(1:n/n, 1:n/n, Vectorize(function(x,y) {sin(x*(2*pi)) + sin(y*(2*pi))}))

sum(A*B)
```

```
## [1] 10000
```

```
MC = 1e4

record = data.frame(
  DIPS = rep(0, MC),
  TWOWAY = rep(0, MC),
  VEC  = rep(0, MC)
)
```

```r
# DIPS permutation
record$DIPS = sapply(1:MC,
                     function(x){
                       permInd = sample(1:n)
                       sum(A * B[permInd, permInd])
                     })
```

```r
# TWOWAY permutation
record$TWOWAY = sapply(1:MC,
                     function(x){
                       permInd_1 = sample(1:n)
                       permInd_2 = sample(1:n)
                       sum(A * B[permInd_1, permInd_2])
                     })
```

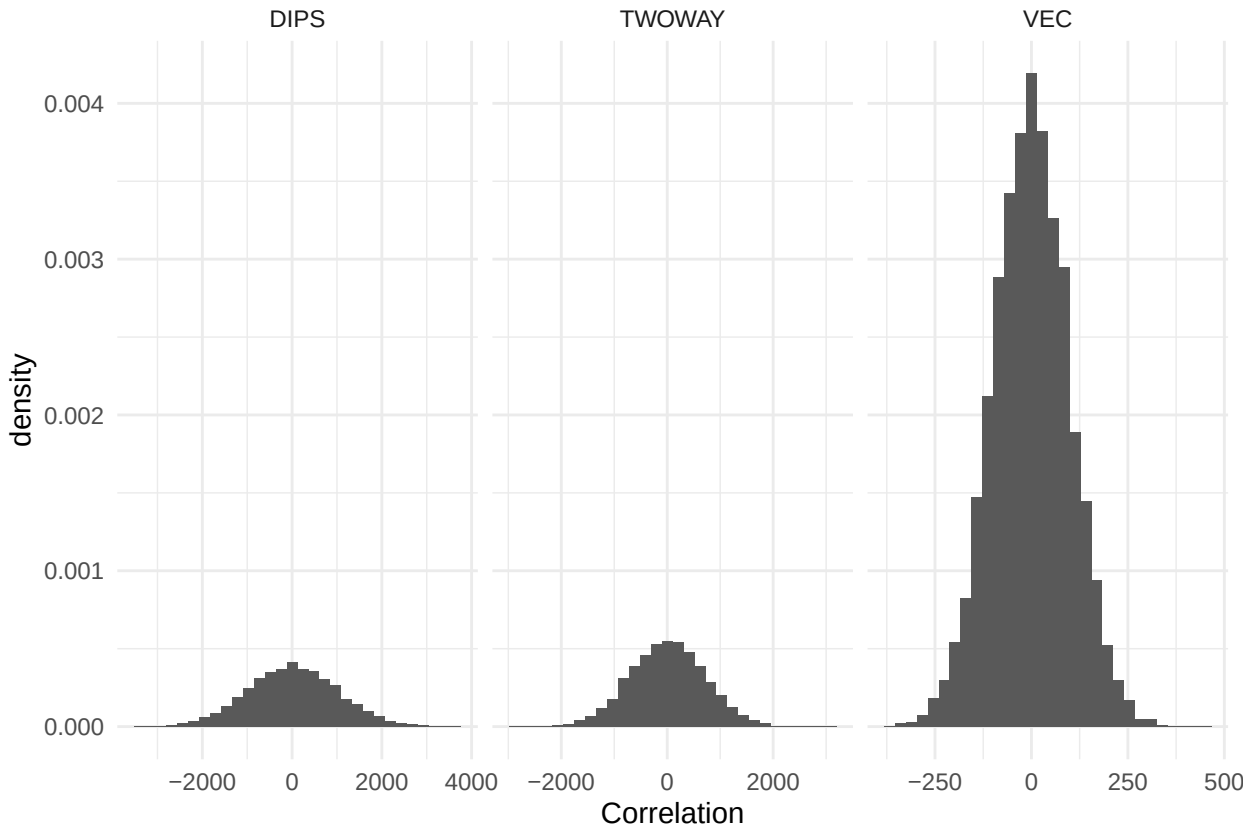
```r
# VEC permutation
Avec = c(A)
Bvec = c(B)
record$VEC = sapply(1:MC,
                     function(x){
                       permInd = sample(1:(n^2))
                       sum(Avec * Bvec[permInd])
                     })
```

```r
var(record)
```

```
##                DIPS     TWOWAY       VEC
## DIPS   1001369.1004   5356.179 -421.8247
## TWOWAY    5356.1793 506684.163 1273.2919
## VEC       -421.8247   1273.292 9845.7479
```

```r
record %>% gather(key = "PermType", value = "Correlation") %>%
  ggplot(aes(x = Correlation)) +
  geom_histogram(aes(y = ..density..)) +
  facet_wrap(vars(PermType), scales = "free_x") +
  theme_minimal()
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



matrices with heterogeneity (simulation 2)

```
# matrix permutations

n = 1e2

A = outer(1:n/n, 1:n/n, Vectorize(function(x,y) {exp((x-y)^2) - 1}))
B = outer(1:n/n, 1:n/n, Vectorize(function(x,y) {exp((x-y)^2) - 1}))

sum(A*B)
```

```
## [1] 1202.872
```

```
MC = 1e4

record = data.frame(
  DIPS = rep(0, MC),
  TWOWAY = rep(0, MC),
  VEC  = rep(0, MC)
)
```

```
# DIPS permutation
record$DIPS = sapply(1:MC,
                     function(x){
                       permInd = sample(1:n)
                       sum(A * B[permInd, permInd])
                     })
```

```r
# TWOWAY permutation
record$TWOWAY = sapply(1:MC,
                       function(x){
                         permInd_1 = sample(1:n)
                         permInd_2 = sample(1:n)
                         sum(A * B[permInd_1, permInd_2])
                       })
```

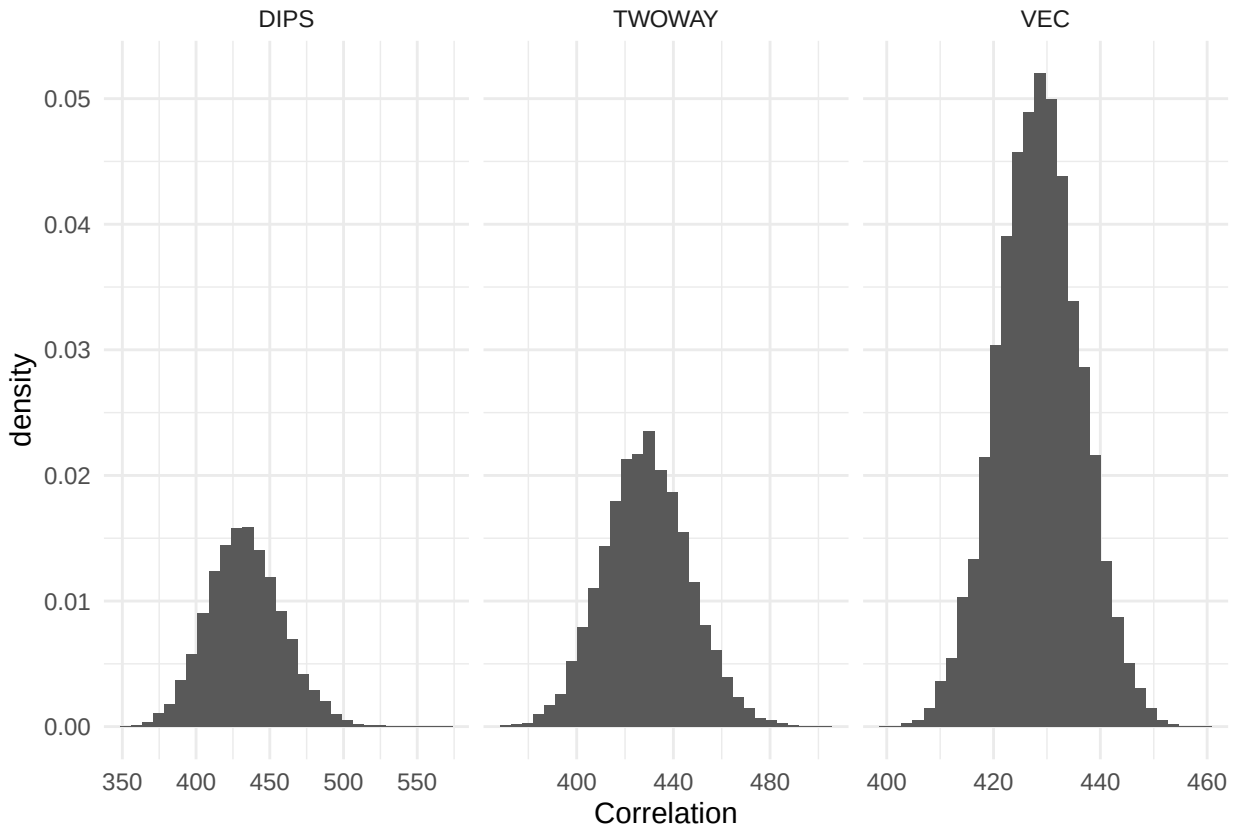
```r
# VEC permutation
Avec = c(A)
Bvec = c(B)
record$VEC = sapply(1:MC,
                       function(x){
                         permInd = sample(1:(n^2))
                         sum(Avec * Bvec[permInd])
                       })
```

```r
var(record)
```

```
##             DIPS      TWOWAY        VEC
## DIPS   636.93070  -1.3136504 -2.7524996
## TWOWAY  -1.31365 313.4260142  0.5560534
## VEC     -2.75250   0.5560534 59.6849277
```

```r
record %>% gather(key = "PermType", value = "Correlation") %>%
  ggplot(aes(x = Correlation)) +
  geom_histogram(aes(y = ..density..)) +
  facet_wrap(vars(PermType), scales = "free_x") +
  theme_minimal()
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```


DIPS
TWOWAY
VEC
density
0.05
0.04
0.03
0.02
0.01
0.00
350
400
450
500
550
400
440
480
400
420
440
460
Correlation