Appendix-2.R

sebastian_sosa

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1. Run parallel functions: to assess simulation parameter accuracy

```
options(warn = -1)
source("1.Codes/Appendix 2 parallel functions.R")
```

```
## Saving 6.5 x 4.5 in image
```

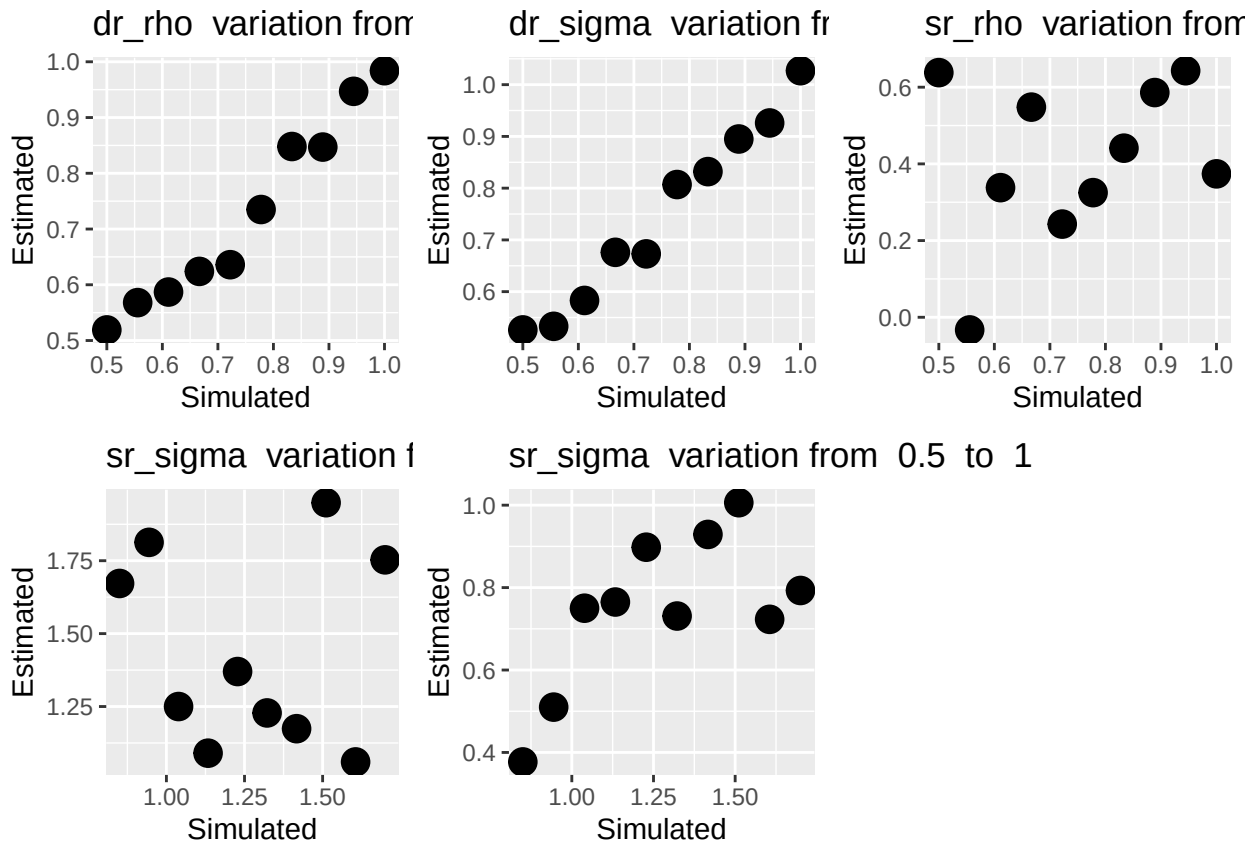
```
load("2.Results/Appendices/2/dr_rho interactions.Rdata")
p.dr_rho_interactions = plot.function(result)

load("2.Results/Appendices/2/dr_sigma interactions.Rdata")
p.dr_sigma_interactions = plot.function(result)

load("2.Results/Appendices/2/sr_rho interactions.Rdata")
p.sr_rho_interactions = plot.function(result)

load("2.Results/Appendices/2/sr_sigma interactions.Rdata")
p.sr_sigma_interactions = plot.function(result)

ggpubr::ggarrange(p.dr_rho_interactions, p.dr_sigma_interactions, p.sr_rho_interactions, p.sr_sigma_int
```



2. Testing individual characteristics on sociality, exposure, and censoring

```
N_id = 50
Hairy = matrix(rnorm(N_id, 0, 1), nrow=N_id, ncol=1)
## Run parallel functions: to assess simulation parameter accuracy..1. Individual characteristics do no
test1 = test.function(att = Hairy,
                      N_id = N_id,
                      individual_predictors=NULL, # individuals characteristics
                      individual_effects=matrix(c(0,0),ncol=1, nrow=2), # individuals characteristics o
                      exposure_predictors = NULL,
                      exposure_effects = c(0, 0), exposure_sigma = 1, # exposure effect
                      int_intercept = c(Inf,Inf), int_slope = c(Inf,Inf),#no censoring effect
                      simulate.interactions = T,
                      legend = "Figure 1. No Relationship between individuals characteristics (a) social
```

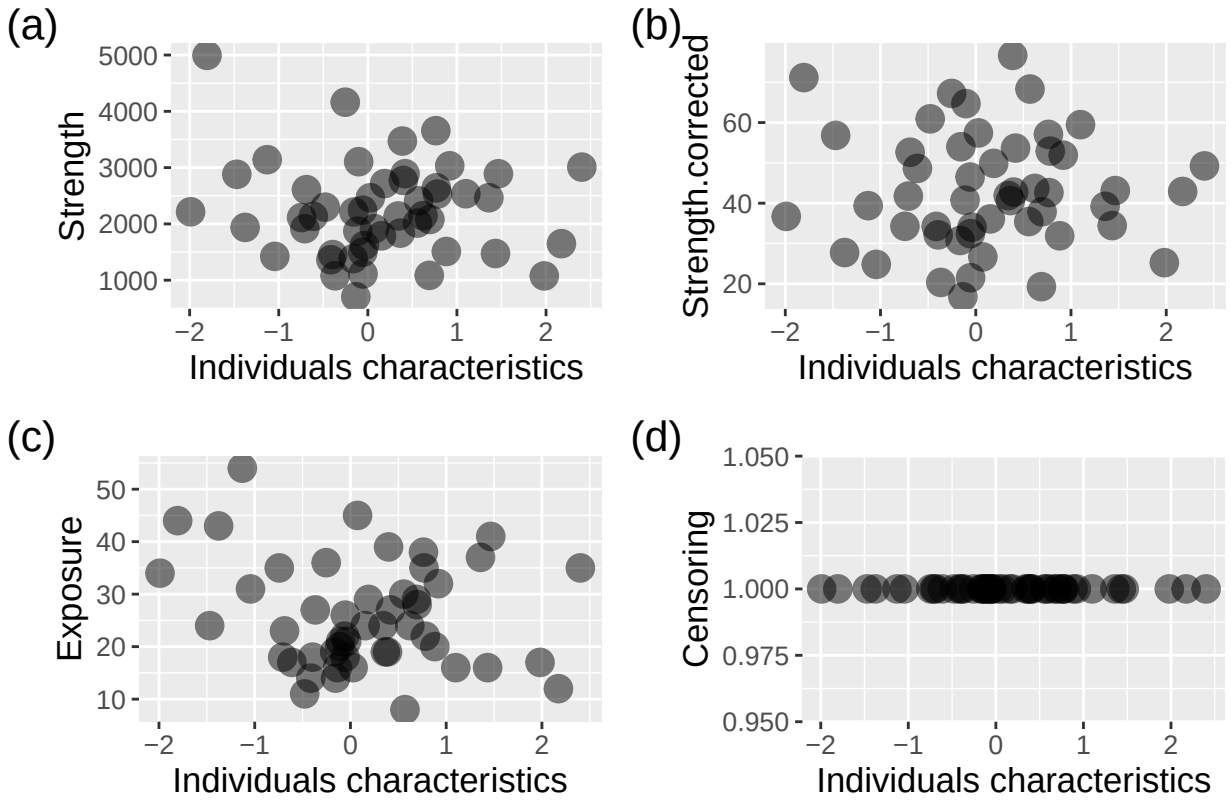
```
## Relationship between individuals characteristics and strength none corrected------------------------
##
## Call:
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1555.12  -587.03   -86.93   483.17  2572.54
```

```
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  2247.07     119.26  18.842   <2e-16
## att           -96.61     126.77  -0.762     0.45
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 833.5 on 48 degrees of freedom
## Multiple R-squared:  0.01196,    Adjusted R-squared:  -0.008628
## F-statistic: 0.5808 on 1 and 48 DF,  p-value: 0.4497
##
## Relationship between individuals characteristics and strength corrected ----------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -26.294  -8.986  -1.258   9.890  33.705
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  43.0414     2.0486  21.010   <2e-16
## att          -0.1993     2.1776  -0.092    0.927
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.32 on 48 degrees of freedom
## Multiple R-squared:  0.0001746,  Adjusted R-squared:  -0.02066
## F-statistic: 0.00838 on 1 and 48 DF,  p-value: 0.9274
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
##      Min       1Q   Median       3Q      Max
## -124.558  -41.828   -3.301   48.994  188.013
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  42.5241     1.9923  21.344   <2e-16
## att          -0.1549     2.0007  -0.077    0.939
##
```

```
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 71.29 on 48 degrees of freedom
## Multiple R-squared:  0.0001249,  Adjusted R-squared:  -0.02071
## F-statistic: 0.005996 on 1 and 48 DF,  p-value: 0.9386
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -16.919  -7.329  -2.120   6.883  25.731
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   26.042      1.441  18.074   <2e-16
## att           -1.971      1.532  -1.287    0.204
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.07 on 48 degrees of freedom
## Multiple R-squared:  0.03337,    Adjusted R-squared:  0.01323
## F-statistic: 1.657 on 1 and 48 DF,  p-value: 0.2042
##
## Relationship between individuals characteristics and censoring ---------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
##
## Residuals:
##        Min         1Q     Median         3Q
## -3.792e-15  3.950e-17  6.800e-17  1.158e-16
##        Max
##  2.376e-16
##
## Coefficients:
##               Estimate Std. Error    t value
## (Intercept)  1.000e+00  7.968e-17  1.255e+16
## att         -7.045e-17  8.470e-17 -8.320e-01
##             Pr(>|t|)
## (Intercept)   <2e-16 ***
## att             0.41
## ---
## Signif. codes:
```

```
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.569e-16 on 48 degrees of freedom
## Multiple R-squared:  0.4995, Adjusted R-squared:  0.489
## F-statistic:  47.9 on 1 and 48 DF,  p-value: 9.727e-09
```

```
test1$plots
```



ı individuals characteristics (a) sociality, (b) sociality corrected by exposure, (c) exposure, or (d) censoring.

The results of the regressions show, as expected, no significant effect in the relationship between individual characteristics, sociality, exposure, or censoring.

2.1. There is a relationship between individual characteristics and sociality, but there is no relationship between individual characteristics, observation bias, and censoring

```
test2 = test.function(att = Hairy,
                      N_id = N_id,
                      individual_predictors=Hairy, # individuals characteristics
                      individual_effects=matrix(c(0.4,0.4),ncol=1, nrow=2), # individuals characteristi
                      exposure_predictors = NULL,
                      exposure_effects = NULL,exposure_sigma = 1, #no exposure effect
                      int_intercept = c(Inf,Inf), int_slope = c(Inf,Inf), #no censoring effect
                      simulate.interactions = T,
                      legend = "Figure 2. Relationship between individuals characteristics and (a) socia
                      but no relationship betweenindividuals characteristics (c) exposure, (d) censorin
```

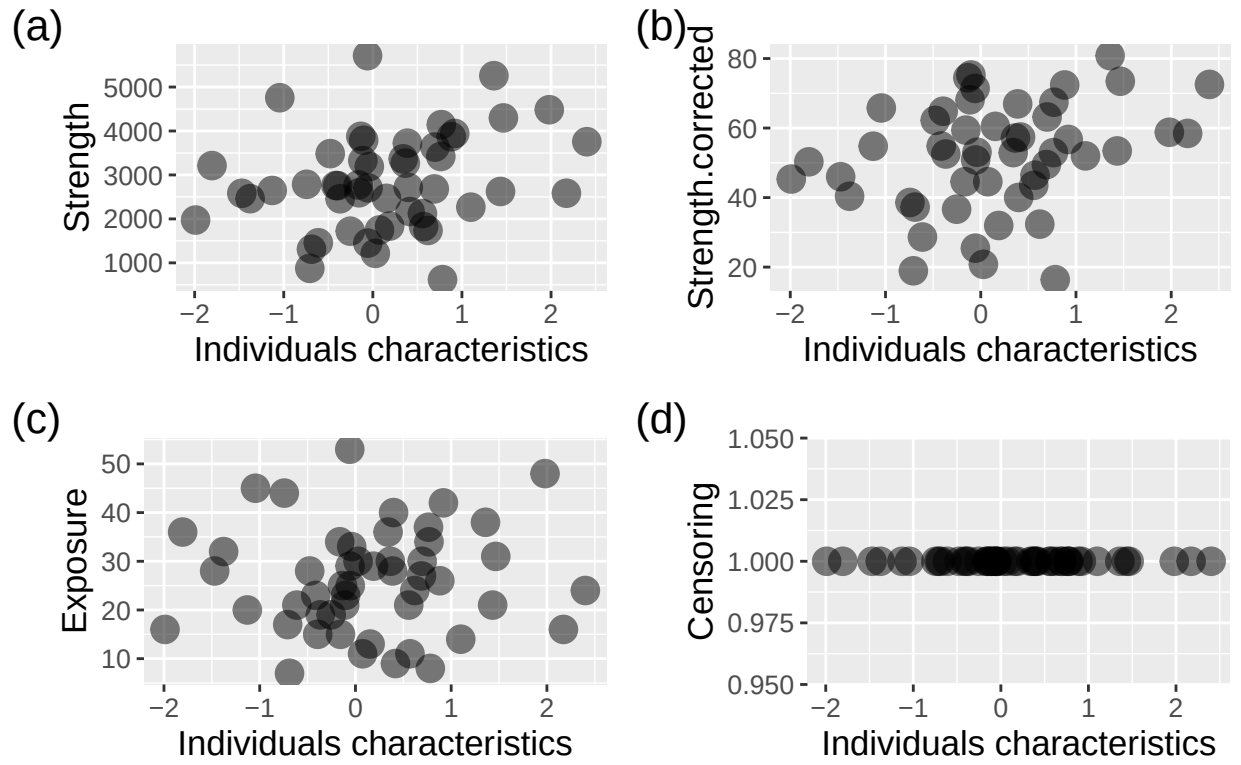
```
## Relationship between individuals characteristics and strength none corrected-------------------------
```

```
##
## Call:
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2423.60  -866.27    69.53   753.43  2926.24
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2805.6      152.8  18.360   <2e-16
## att            301.7      162.4   1.857   0.0694
##
## (Intercept) ***
## att         .
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1068 on 48 degrees of freedom
## Multiple R-squared:  0.06704,    Adjusted R-squared:  0.0476
## F-statistic: 3.449 on 1 and 48 DF,  p-value: 0.06943
##
## Relationship between individuals characteristics and strength corrected ------------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -38.775  -7.556   1.357   9.354  24.414
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   51.351      2.139  24.002   <2e-16
## att            4.881      2.274   2.147   0.0369
##
## (Intercept) ***
## att         *
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.95 on 48 degrees of freedom
## Multiple R-squared:  0.08758,    Adjusted R-squared:  0.06857
## F-statistic: 4.607 on 1 and 48 DF,  p-value: 0.03692
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
##      Min       1Q   Median       3Q      Max
```

```
## -175.613  -34.250   -0.782   40.254  138.304
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   52.714      2.079  25.356   <2e-16
## att            5.138      2.161   2.378   0.0214
##
## (Intercept) ***
## att         *
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 74.08 on 48 degrees of freedom
## Multiple R-squared:  0.1054, Adjusted R-squared:  0.08674
## F-statistic: 5.654 on 1 and 48 DF,  p-value: 0.02145
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -18.6908  -6.9008  -0.7386   6.8966  26.9845
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  26.0461     1.5513  16.790   <2e-16
## att           0.5159     1.6489   0.313    0.756
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.84 on 48 degrees of freedom
## Multiple R-squared:  0.002035,   Adjusted R-squared:  -0.01876
## F-statistic: 0.09787 on 1 and 48 DF,  p-value: 0.7558
##
## Relationship between individuals characteristics and censoring ---------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
##
## Residuals:
##        Min         1Q     Median         3Q
## -3.792e-15  3.950e-17  6.800e-17  1.158e-16
##        Max
##  2.376e-16
##
## Coefficients:
##               Estimate Std. Error    t value
```

```
## (Intercept)  1.000e+00  7.968e-17  1.255e+16
## att         -7.045e-17  8.470e-17 -8.320e-01
##             Pr(>|t|)
## (Intercept)   <2e-16 ***
## att             0.41
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.569e-16 on 48 degrees of freedom
## Multiple R-squared:  0.4995, Adjusted R-squared:  0.489
## F-statistic:  47.9 on 1 and 48 DF,  p-value: 9.727e-09
```

```
test2$plots
```



re 2. Relationship between individuals characteristics and (a) sociality, (b) sociality corrected by exposure, but no relationship betweenindividuals characteristics (c) exposure, (d) censoring, or (d) censoring.

The results of the regressions show, as expected, a significant effect in the relationship between individual characteristics and sociality, but no significant effect between individuals characteristics exposure, and censoring.

2.2. There is no relationship between individual characteristics, sociality and censoring, but there is a relationship between individual characteristics and exposure

```
test3 = test.function(att = Hairy,
                      N_id = N_id,
                      individual_predictors=Hairy, # individuals characteristics
```

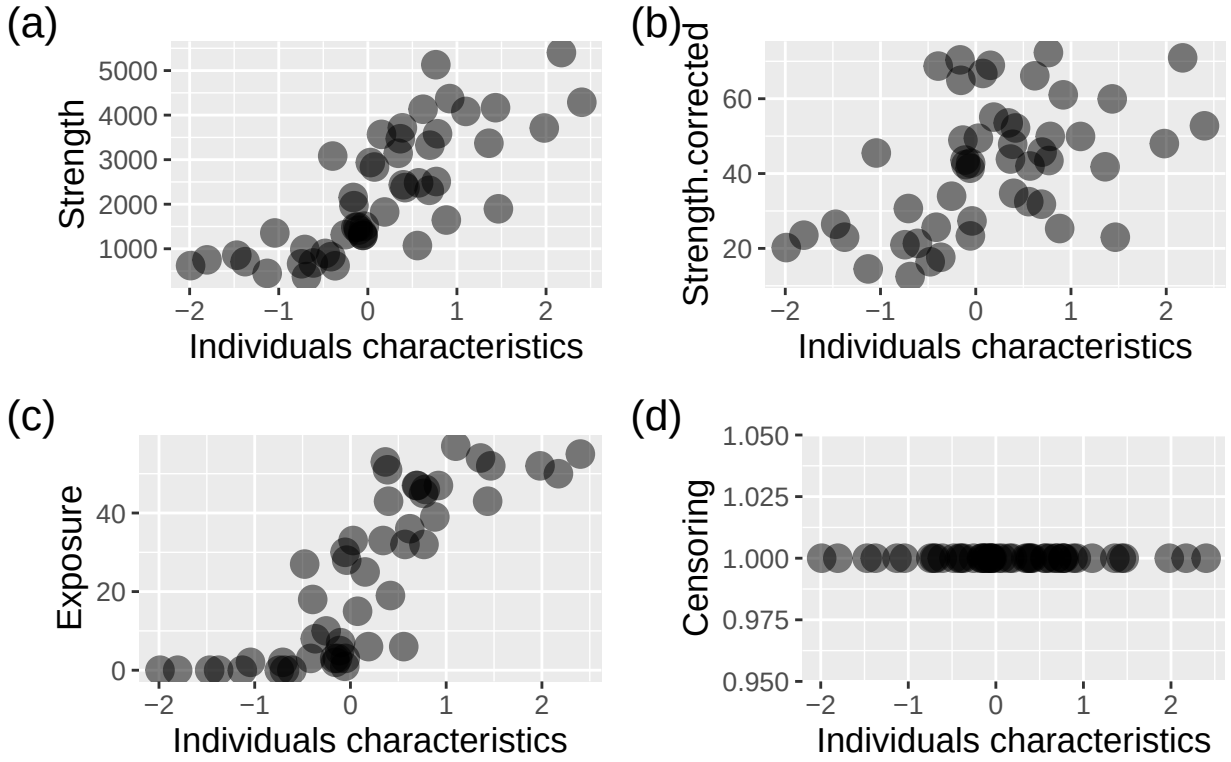
```
                    individual_effects=matrix(c(0,0),ncol=1, nrow=2), # individuals characteristics o
                    exposure_predictors = cbind(rep(1,N_id),Hairy),
                    exposure_effects = c(-1, 4), exposure_sigma = 1, # exposure effect
                    int_intercept = c(Inf,Inf), int_slope = c(Inf,Inf),#no censoring effect
                    simulate.interactions = TRUE,
                    legend = "Figure 3. No relationship between individuals characteristics and (a) s
                    but precense of relationship betweenindividuals characteristics and (c) exposure.
```

```
## Relationship between individuals characteristics and strength none corrected------------------------
##
## Call:
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1812.6  -565.0  -227.3   678.0  2202.8
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2079.2      124.1  16.761  < 2e-16
## att           1112.5      131.9   8.437 4.86e-11
##
## (Intercept) ***
## att         ***
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 867 on 48 degrees of freedom
## Multiple R-squared:  0.5972, Adjusted R-squared:  0.5888
## F-statistic: 71.18 on 1 and 48 DF,  p-value: 4.858e-11
##
## Relationship between individuals characteristics and strength corrected ----------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -30.667 -11.188  -1.074   9.275  31.594
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   40.630      2.158  18.828  < 2e-16
## att            8.891      2.294   3.876 0.000322
##
## (Intercept) ***
## att         ***
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 15.08 on 48 degrees of freedom
## Multiple R-squared:  0.2384, Adjusted R-squared:  0.2225
```

```
## F-statistic: 15.03 on 1 and 48 DF,  p-value: 0.0003215
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
##     Min      1Q  Median      3Q     Max
## -197.39  -22.85    0.00   30.80  171.93
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   42.715      3.369  12.678 1.36e-15
## att            5.220      3.097   1.686   0.0997
##
## (Intercept) ***
## att         .
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 77.13 on 40 degrees of freedom
## Multiple R-squared:  0.06632,    Adjusted R-squared:  0.04298
## F-statistic: 2.841 on 1 and 40 DF,  p-value: 0.09966
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -24.8448  -9.2760   0.4486  10.0492  25.6136
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   20.822      1.720   12.11 3.37e-16
## att           18.005      1.828    9.85 4.14e-13
##
## (Intercept) ***
## att         ***
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.02 on 48 degrees of freedom
## Multiple R-squared:  0.669,  Adjusted R-squared:  0.6621
## F-statistic: 97.02 on 1 and 48 DF,  p-value: 4.144e-13
##
## Relationship between individuals characteristics and censoring ---------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
```

```
##
## Residuals:
##        Min         1Q     Median         3Q
## -3.792e-15  3.950e-17  6.800e-17  1.158e-16
##        Max
##  2.376e-16
##
## Coefficients:
##               Estimate Std. Error    t value
## (Intercept)  1.000e+00  7.968e-17  1.255e+16
## att         -7.045e-17  8.470e-17 -8.320e-01
##             Pr(>|t|)
## (Intercept)   <2e-16 ***
## att             0.41
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.569e-16 on 48 degrees of freedom
## Multiple R-squared:  0.4995, Adjusted R-squared:  0.489
## F-statistic:  47.9 on 1 and 48 DF,  p-value: 9.727e-09
```

```
test3$plots
```



hip between individuals characteristics and (a) sociality, (b) sociality corrected by exposure, (d) censoring, but precense of relationship betweenindividuals characteristics and (c) exposure.

The results of the regressions show, as expected, a significant effect in the relationship between individual characteristics and exposure which lead to a significant effect between individuals characteristics and (a) sociality and near significant effect between individuals characteristics and (b) correct ed sociality.

2.3. There is no relationship between individual characteristics, sociality and exposure but there is a relationship between individual characteristics and censoring

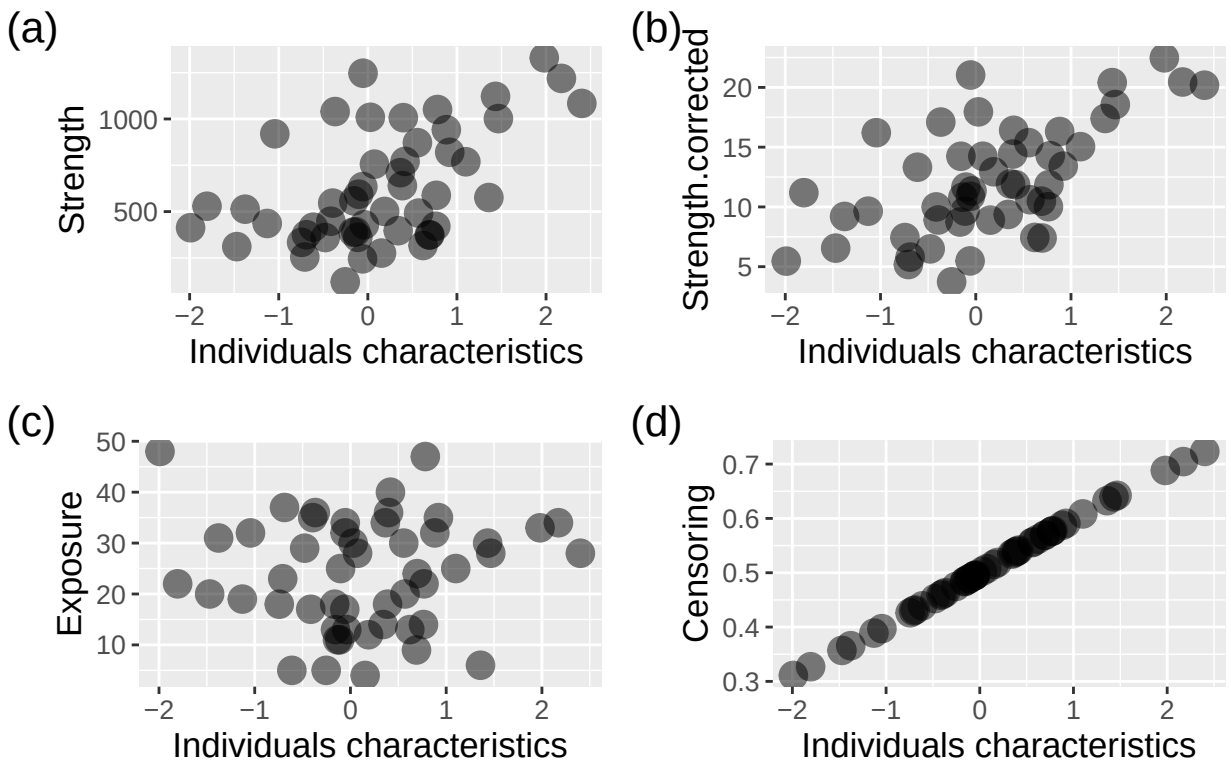
```
test4 = test.function(att = Hairy,
                      N_id = N_id,
                      individual_predictors=Hairy, # individuals characteristics
                      individual_effects=matrix(c(0,0),ncol=1, nrow=2), # individuals characteristics o
                      exposure_predictors = NULL,
                      exposure_effects = c(0, 0), exposure_sigma = 1, # exposure effect
                      int_intercept = c(0,0), int_slope = c(0.4,0.4),# censoring effect
                      simulate.interactions = T,
                      legend = "Figure 5. No relationship between individuals characteristics and (a) s
                      (c) exposure, but precense of relationship between individuals characteristics an
```

```
## Relationship between individuals characteristics and strength none corrected------------------------
##
## Call:
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -435.03 -185.02  -20.03  160.19  655.90
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   600.56      37.14  16.170  < 2e-16
## att           175.76      39.48   4.452 5.06e-05
##
## (Intercept) ***
## att         ***
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 259.6 on 48 degrees of freedom
## Multiple R-squared:  0.2923, Adjusted R-squared:  0.2775
## F-statistic: 19.82 on 1 and 48 DF,  p-value: 5.059e-05
##
## Relationship between individuals characteristics and strength corrected ----------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.2474 -2.4548 -0.2446  2.0042  9.4444
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  11.7568     0.5310  22.140  < 2e-16
## att           3.0661     0.5644   5.432 1.82e-06
##
## (Intercept) ***
```

```
## att         ***
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.711 on 48 degrees of freedom
## Multiple R-squared:  0.3807, Adjusted R-squared:  0.3678
## F-statistic: 29.51 on 1 and 48 DF,  p-value: 1.824e-06
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
##     Min      1Q  Median      3Q     Max
## -34.987 -12.581  -3.594   7.032  51.833
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  12.3184     0.5255  23.442  < 2e-16
## att           3.1889     0.5115   6.234  1.1e-07
##
## (Intercept) ***
## att         ***
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 17.97 on 48 degrees of freedom
## Multiple R-squared:  0.4474, Adjusted R-squared:  0.4359
## F-statistic: 38.87 on 1 and 48 DF,  p-value: 1.099e-07
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -19.9434  -9.2230   0.3053   8.3622  24.7791
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  23.8917     1.5794  15.127   <2e-16
## att           0.3372     1.6788   0.201    0.842
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11.04 on 48 degrees of freedom
```

```
## Multiple R-squared:  0.0008398,  Adjusted R-squared:  -0.01998
## F-statistic: 0.04034 on 1 and 48 DF,  p-value: 0.8417
##
## Relationship between individuals characteristics and censoring ---------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
##
## Residuals:
##        Min         1Q     Median         3Q
## -0.0082853 -0.0012658  0.0000215  0.0015966
##        Max
##  0.0028041
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.4999584  0.0003000  1666.6   <2e-16
## att         0.0964259  0.0003189   302.4   <2e-16
##
## (Intercept) ***
## att         ***
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.002097 on 48 degrees of freedom
## Multiple R-squared:  0.9995, Adjusted R-squared:  0.9995
## F-statistic: 9.144e+04 on 1 and 48 DF,  p-value: < 2.2e-16
```

```
test4$plots
```



5. No relationship between individuals characteristics and (a) sociality, (b) sociality corrected by exposure, (c) exposure, but precense of relationship between individuals characteristics and (d) censoring.

The results of the regressions show, as expected, a significant effect in the relationship between individual characteristics and censoring which lead to a significant effect between individuals characteristics, (a) sociality and (b) correct ed sociality.

3. Testing when the coefficient of individual characteristics (individual_effects parameter) results in a significant effect on simulated data

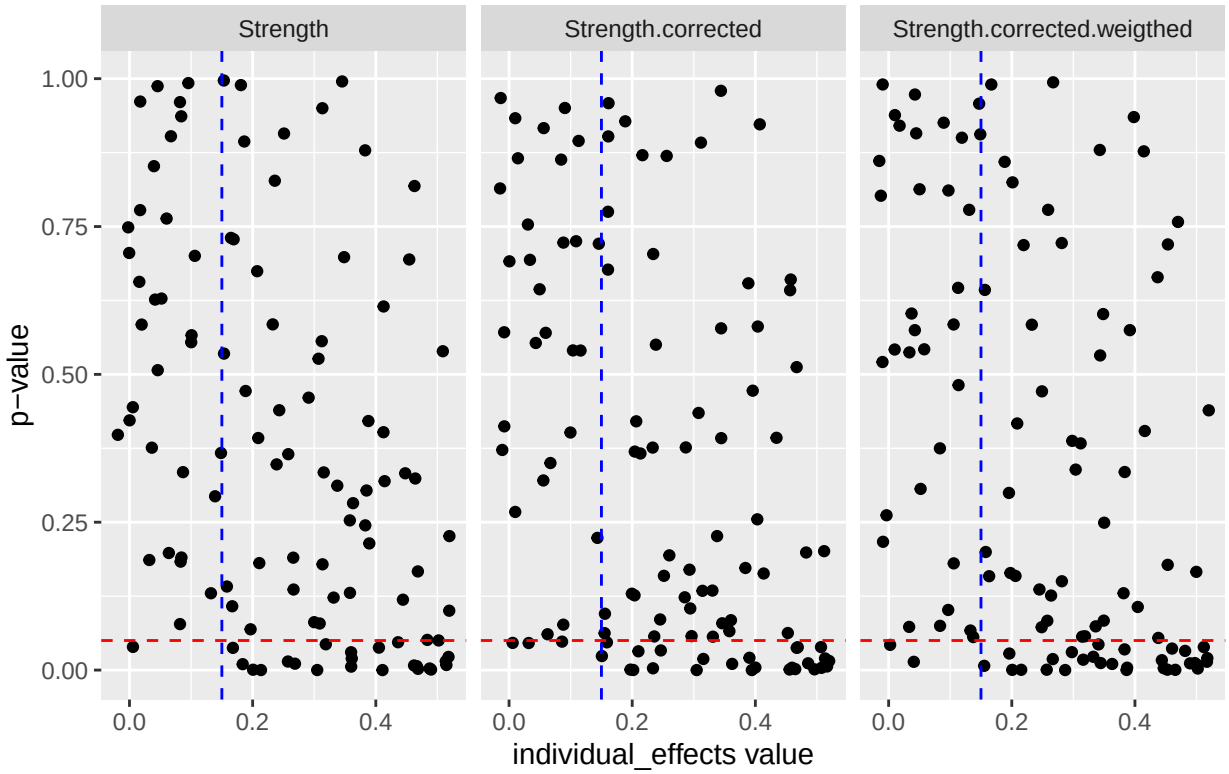
```
N_id = 30
Hairy = matrix(rnorm(N_id, 0, 1), nrow=N_id, ncol=1)
TEST = seq(from = 0, to = 0.5, by = 0.05)
length(TEST)
```

```
## [1] 11
```

```
r = NULL
a = 1
for (a in a:length(TEST)) {
  for(b in 1:10){
    r[[length(r)+1]] = test.function(att = Hairy,
                                     N_id = N_id,
                                     individual_predictors=Hairy, # individuals characteristics
                                     individual_effects=matrix(c(TEST[a],TEST[a]),ncol=1, nrow=2), # in
                                     exposure_predictors = NULL,
                                     exposure_effects = c(0, 0), exposure_sigma = 0.5, # exposure effec
```

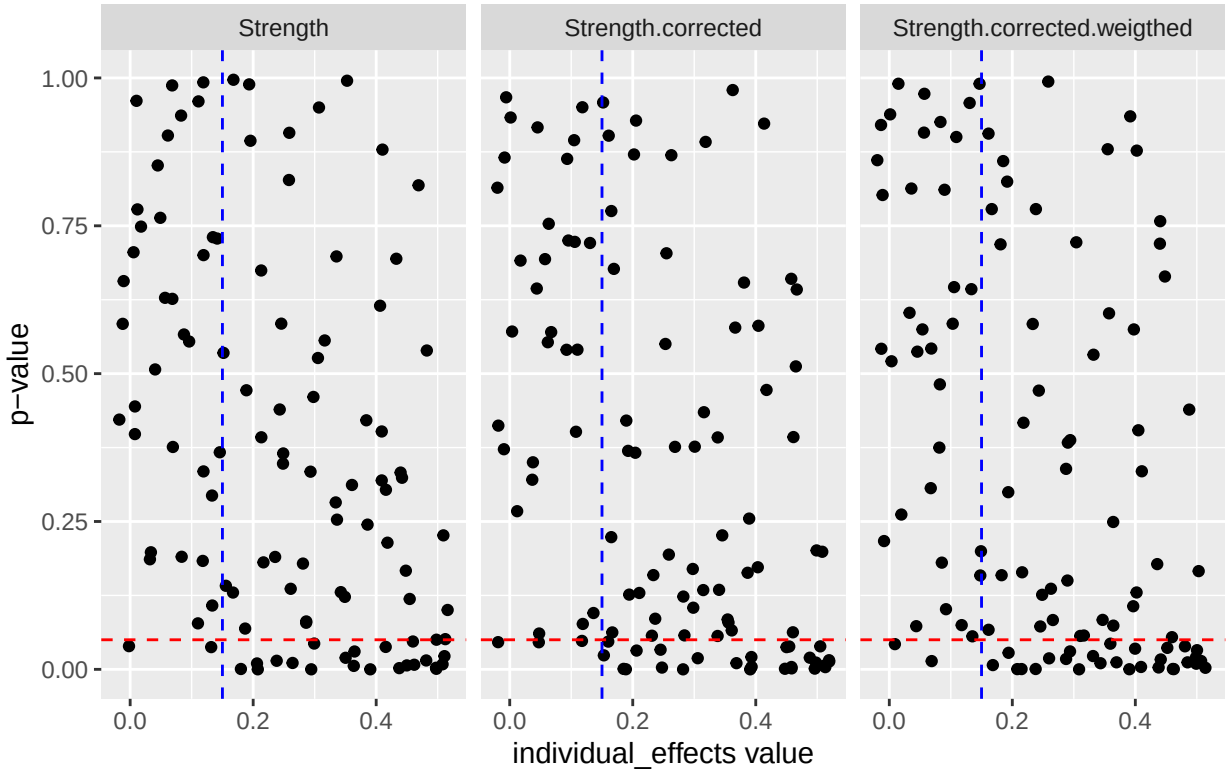
```
                                    int_intercept = c(Inf,Inf), int_slope = c(Inf,Inf),#no censoring e
                                    simulate.interactions = TRUE, print = FALSE)
  }
}
d = NULL
test = rep(TEST, each = 10)
for(a in 1: length(r)){
  for (b in 1:length(r[[a]]$result)) {
    s = summary(r[[a]]$result[[b]])
    p = s$coefficients[2,4]
    c = s$coefficients[2,1]
    d = rbind(d, data.frame('coef' = c, 'p' = p, 'effect' = test[a], 'approach' = names(r[[a]]$result)[
  }
}

error.rates(d, threshold = 0.15)
```




```
## [[1]]
##   false negatives false positives
## 1          100.00        0.000000
## 2           96.25        3.333333
## 3           72.50        3.333333
## 4           67.50       10.000000
## 5           63.75        6.666667
##                    approaches
## 1                   Censoring
```

```
## 2                     Exposure
## 3                     Strength
## 4           Strength.corrected
## 5 Strength.corrected.weigthed
##
## [[2]]
```



From a visual perspective and error rates we can see that bellow a value of 0.20 for individual_effects parameters, we obtain no or or null effects. We will use values of individual_effects ranging from 0 to 0.19 for simulations without sociality effect and values ranging 0.2 to 0.4 for simulations with sociality effect.

3.1. An example of individual_effects being equal to 0.2 in simulated data

```
N_id = 50
Hairy = matrix(rnorm(N_id, 0, 1), nrow=N_id, ncol=1)
test = test.function(att = Hairy,
                     N_id = N_id,
                     individual_predictors=Hairy, # individuals characteristics
                     individual_effects=matrix(c(0.19,0.19),ncol=1, nrow=2), # individuals characterist
                     exposure_predictors = NULL,
                     exposure_effects = c(0, 0), exposure_sigma = 1, # exposure effect
                     int_intercept = c(Inf,Inf), int_slope = c(-Inf,-Inf),
                     simulate.interactions = T) #no censoring effect
```

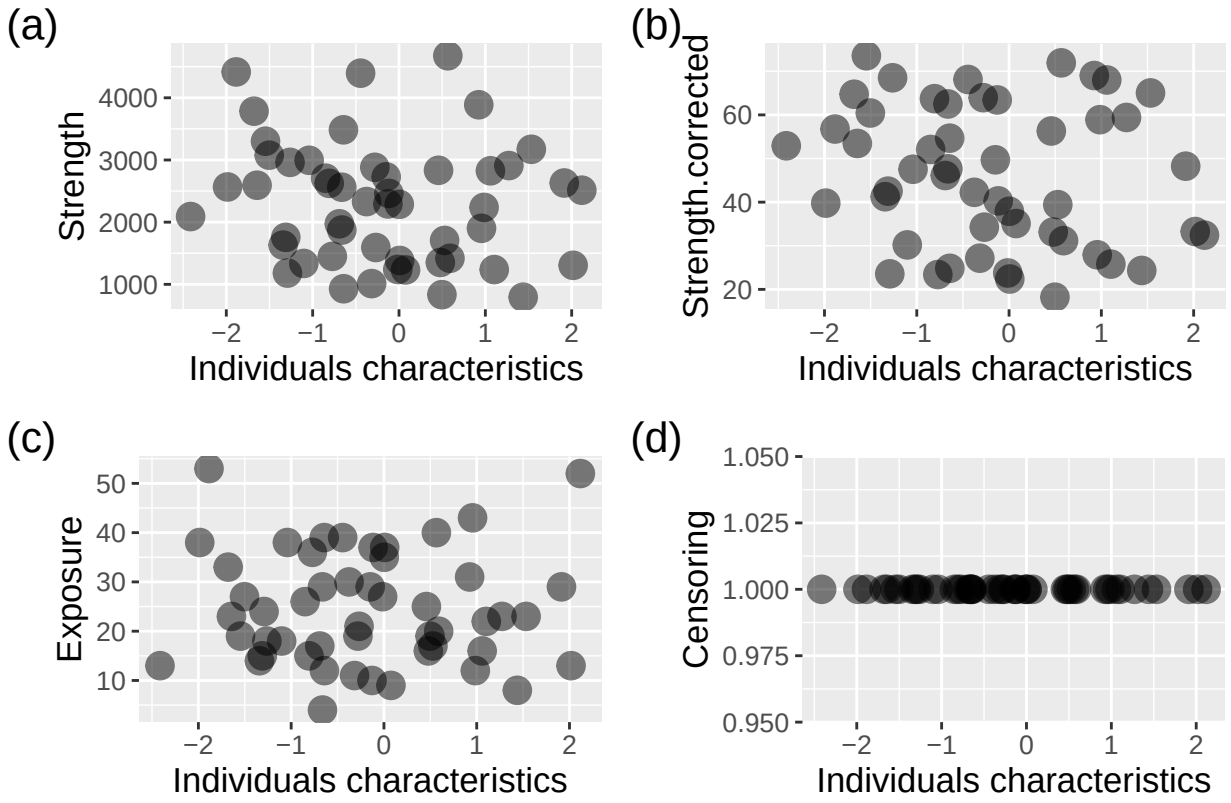
```
## Relationship between individuals characteristics and strength none corrected------------------------
##
## Call:
```

```
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1440.22  -820.80     9.77   585.96  2470.76
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2282.1      138.6  16.468   <2e-16
## att           -135.9      124.1  -1.095    0.279
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 966.2 on 48 degrees of freedom
## Multiple R-squared:  0.02435,    Adjusted R-squared:  0.004028
## F-statistic: 1.198 on 1 and 48 DF,  p-value: 0.2791
##
## Relationship between individuals characteristics and strength corrected ----------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -26.1421 -11.7765  -0.8664  15.2570  27.7550
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   45.565      2.299   19.82   <2e-16
## att           -2.450      2.059   -1.19     0.24
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.03 on 48 degrees of freedom
## Multiple R-squared:  0.02865,    Adjusted R-squared:  0.008409
## F-statistic: 1.416 on 1 and 48 DF,  p-value: 0.24
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
##      Min       1Q   Median       3Q      Max
## -145.225  -57.389   -4.952   56.704  174.703
##
```

```
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   45.705      2.274  20.101   <2e-16
## att           -2.465      1.971  -1.251    0.217
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 78.4 on 48 degrees of freedom
## Multiple R-squared:  0.03157,    Adjusted R-squared:  0.01139
## F-statistic: 1.565 on 1 and 48 DF,  p-value: 0.217
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -20.572  -8.323  -1.480   7.857  28.191
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  24.4440     1.6536  14.782   <2e-16
## att          -0.1937     1.4811  -0.131    0.896
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11.53 on 48 degrees of freedom
## Multiple R-squared:  0.0003562,  Adjusted R-squared:  -0.02047
## F-statistic: 0.01711 on 1 and 48 DF,  p-value: 0.8965
##
## Relationship between individuals characteristics and censoring ---------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
##
## Residuals:
##        Min         1Q     Median         3Q
## -3.830e-15  5.330e-17  7.920e-17  1.049e-16
##        Max
##  1.514e-16
##
## Coefficients:
##              Estimate Std. Error   t value Pr(>|t|)
## (Intercept) 1.000e+00  8.027e-17 1.246e+16   <2e-16
## att         3.272e-17  7.189e-17 4.550e-01    0.651
```

```
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.597e-16 on 48 degrees of freedom
## Multiple R-squared:  0.494,  Adjusted R-squared:  0.4835
## F-statistic: 46.87 on 1 and 48 DF,  p-value: 1.266e-08
```

```
test$plots
```



3.2. An example of individual_effects being equal to 0.4 in simulated data

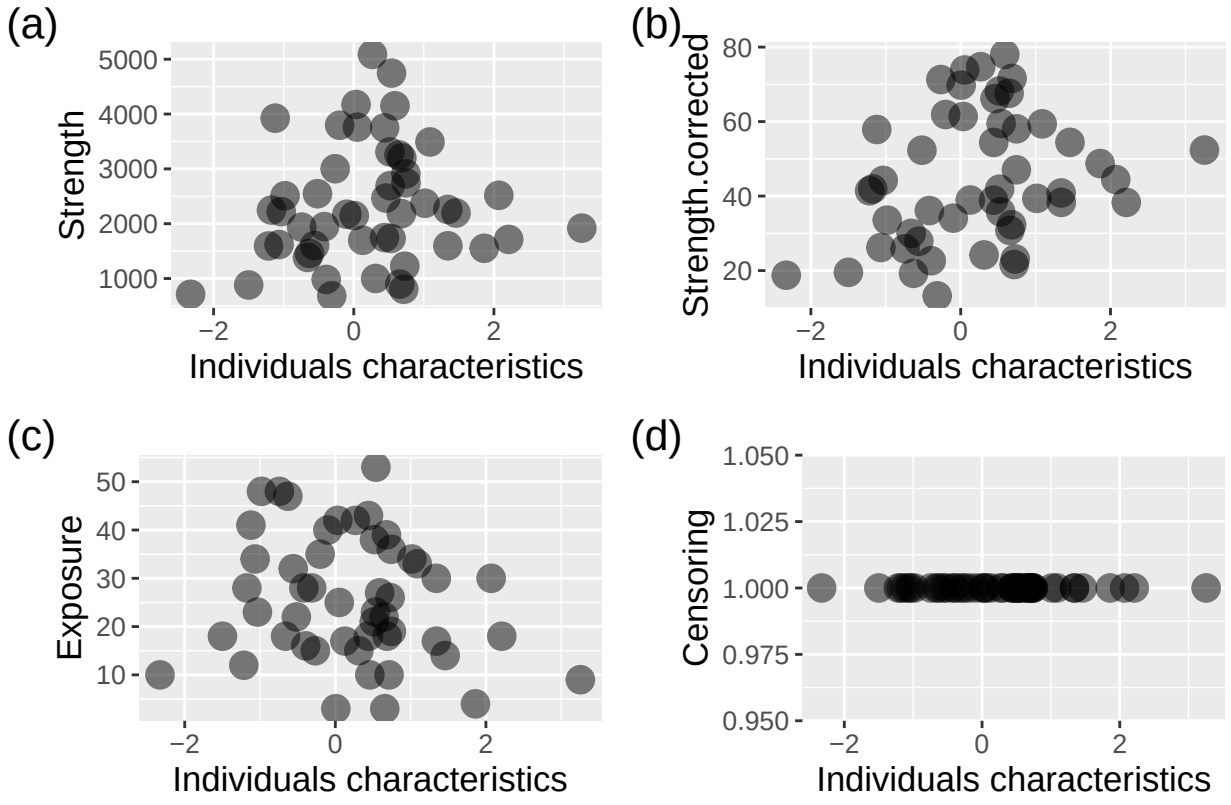
```
N_id = 50
Hairy = matrix(rnorm(N_id, 0, 1), nrow=N_id, ncol=1)
test = test.function(att = Hairy,
                     N_id = N_id,
                     individual_predictors=Hairy, # individuals characteristics
                     individual_effects=matrix(c(0.4,0.4),ncol=1, nrow=2), # individuals characteristic
                     exposure_predictors = NULL,
                     exposure_effects = c(0, 0), exposure_sigma = 1, # exposure effect
                     int_intercept = c(Inf,Inf), int_slope = c(Inf, Inf),
                     simulate.interactions = T) #no censoring effect
```

```
## Relationship between individuals characteristics and strength none corrected------------------------
##
## Call:
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1594.6  -808.2  -181.9   680.5  2750.4
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2301.0      156.3  14.720   <2e-16
## att            136.7      149.3   0.916    0.364
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1081 on 48 degrees of freedom
## Multiple R-squared:  0.01718,    Adjusted R-squared:  -0.0033
## F-statistic: 0.8388 on 1 and 48 DF,  p-value: 0.3643
##
## Relationship between individuals characteristics and strength corrected ----------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -28.864 -12.829  -5.294  12.768  31.602
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   43.601      2.463  17.704   <2e-16
## att            4.813      2.352   2.046   0.0462
##
## (Intercept) ***
## att         *
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 17.04 on 48 degrees of freedom
## Multiple R-squared:  0.08025,    Adjusted R-squared:  0.06109
## F-statistic: 4.188 on 1 and 48 DF,  p-value: 0.04621
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -152.74  -61.39  -28.80   53.44  190.00
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   43.887      2.378  18.453   <2e-16
## att            5.724      2.615   2.189   0.0335
##
## (Intercept) ***
## att         *
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 84.4 on 48 degrees of freedom
## Multiple R-squared:  0.09078,    Adjusted R-squared:  0.07183
## F-statistic: 4.792 on 1 and 48 DF,  p-value: 0.03348
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -23.134  -9.343  -1.462  10.029  28.117
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   26.150      1.832  14.278   <2e-16
## att           -2.348      1.749  -1.343    0.186
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.67 on 48 degrees of freedom
## Multiple R-squared:  0.03619,    Adjusted R-squared:  0.01611
## F-statistic: 1.802 on 1 and 48 DF,  p-value: 0.1857
##
## Relationship between individuals characteristics and censoring ---------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
##
## Residuals:
##        Min         1Q     Median         3Q
## -3.731e-15  7.300e-18  8.520e-17  1.220e-16
##        Max
##  3.608e-16
##
## Coefficients:
```

```
##                Estimate Std. Error    t value
## (Intercept)  1.000e+00  7.986e-17  1.252e+16
## att         -9.293e-17  7.626e-17 -1.218e+00
##             Pr(>|t|)
## (Intercept)   <2e-16 ***
## att            0.229
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.524e-16 on 48 degrees of freedom
## Multiple R-squared:  0.5052, Adjusted R-squared:  0.4948
## F-statistic:    49 on 1 and 48 DF,  p-value: 7.353e-09
```

```
test$plots
```



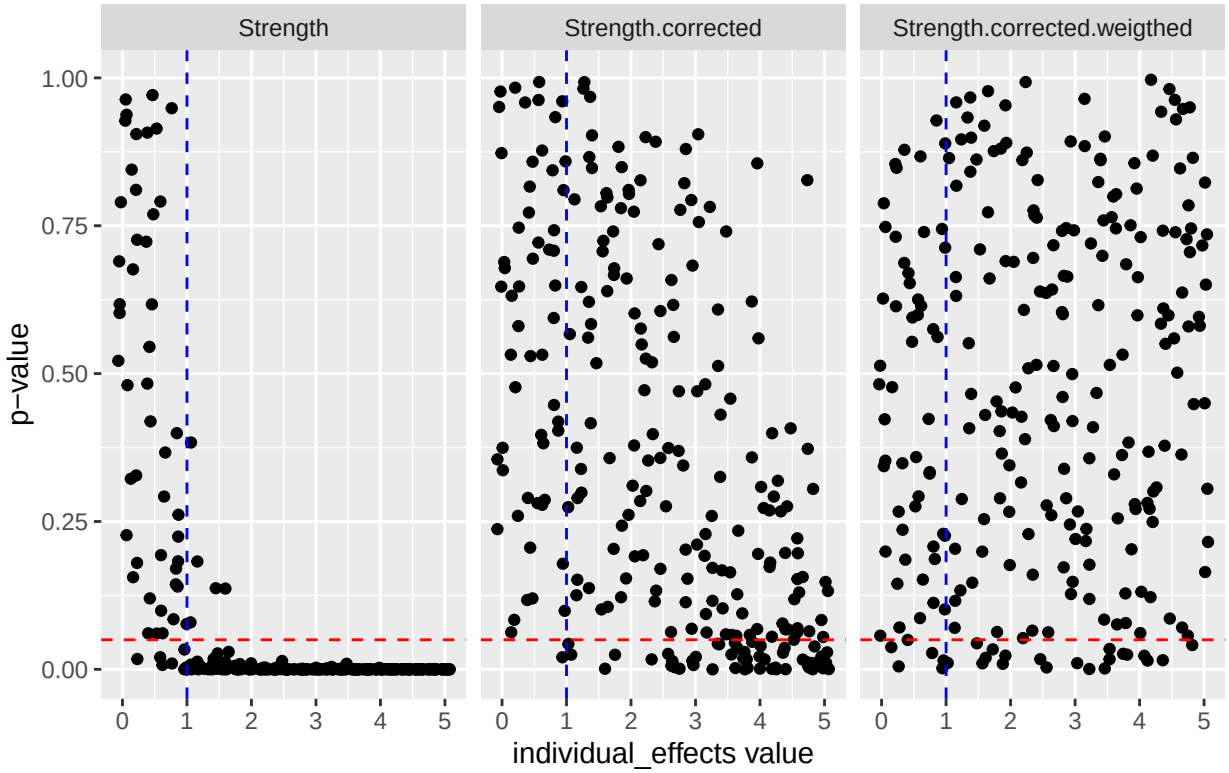
4. Testing when the coefficient of exposure (exposure_effects parameter) lead to significant effect on simulated data

```
N_id = 30
Hairy = matrix(rnorm(N_id, 0, 1), nrow=N_id, ncol=1)
TEST = seq(from = 0, to = 5, by = 0.2)
length(TEST)
```

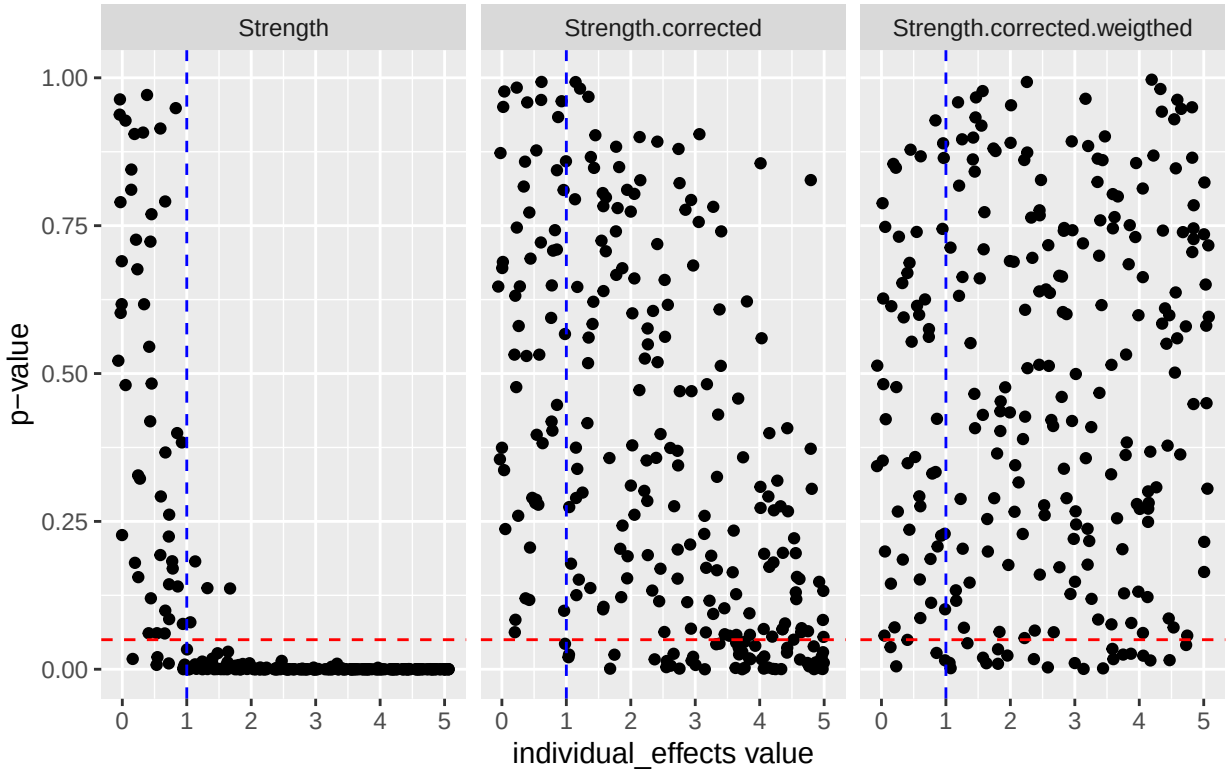
```
## [1] 26
```

```
r = NULL
a = 1
for (a in a:length(TEST)) {
  for(b in 1:10){
    r[[length(r)+1]] = test.function(att = Hairy,
                                     N_id = N_id,
                                     individual_predictors=Hairy, # individuals characteristics
                                     individual_effects=matrix(c(0,0),ncol=1, nrow=2), # individuals ch
                                     exposure_predictors = cbind(rep(1,N_id),Hairy),
                                     exposure_effects = c(-1, TEST[a]), exposure_sigma = 1, # exposure
                                     int_intercept = c(Inf,Inf), int_slope = c(Inf,Inf),#no censoring e
                                     simulate.interactions = TRUE, print = FALSE)
  }
}
d = NULL
test = rep(TEST, each = 10)
for(a in 1: length(r)){
  for (b in 1:length(r[[a]]$result)) {
    s = summary(r[[a]]$result[[b]])
    p = s$coefficients[2,4]
    c = s$coefficients[2,1]
    d = rbind(d, data.frame('coef' = c, 'p' = p, 'effect' = test[a], 'approach' = names(r[[a]]$result)[
  }
}

error.rates(d, threshold =  1)
```



```
## [[1]]
##   false negatives false positives
## 1     100.0000000         0.00000
## 2       0.4761905        38.33333
## 3       2.8571429        18.33333
## 4      75.7142857         5.00000
## 5      89.5238095        11.66667
##                      approaches
## 1                     Censoring
## 2                      Exposure
## 3                      Strength
## 4           Strength.corrected
## 5 Strength.corrected.weigthed
##
## [[2]]
```



From a visual perspective and error rates we can see that above a value of 0.30 for individual_effects parameters, we start to observe increase of false positive. We will use values of exposure_effects ranging from 0 to 0.20 for simulations without exposure bias and values ranging 0.4 to 0.6 for simulations with exposure bias.

4.1. An example of exposure_effects being equal to 0.2 in simulated data

```
N_id = 50
Hairy = matrix(rnorm(N_id, 0, 1), nrow=N_id, ncol=1)
test = test.function(att = Hairy,
```

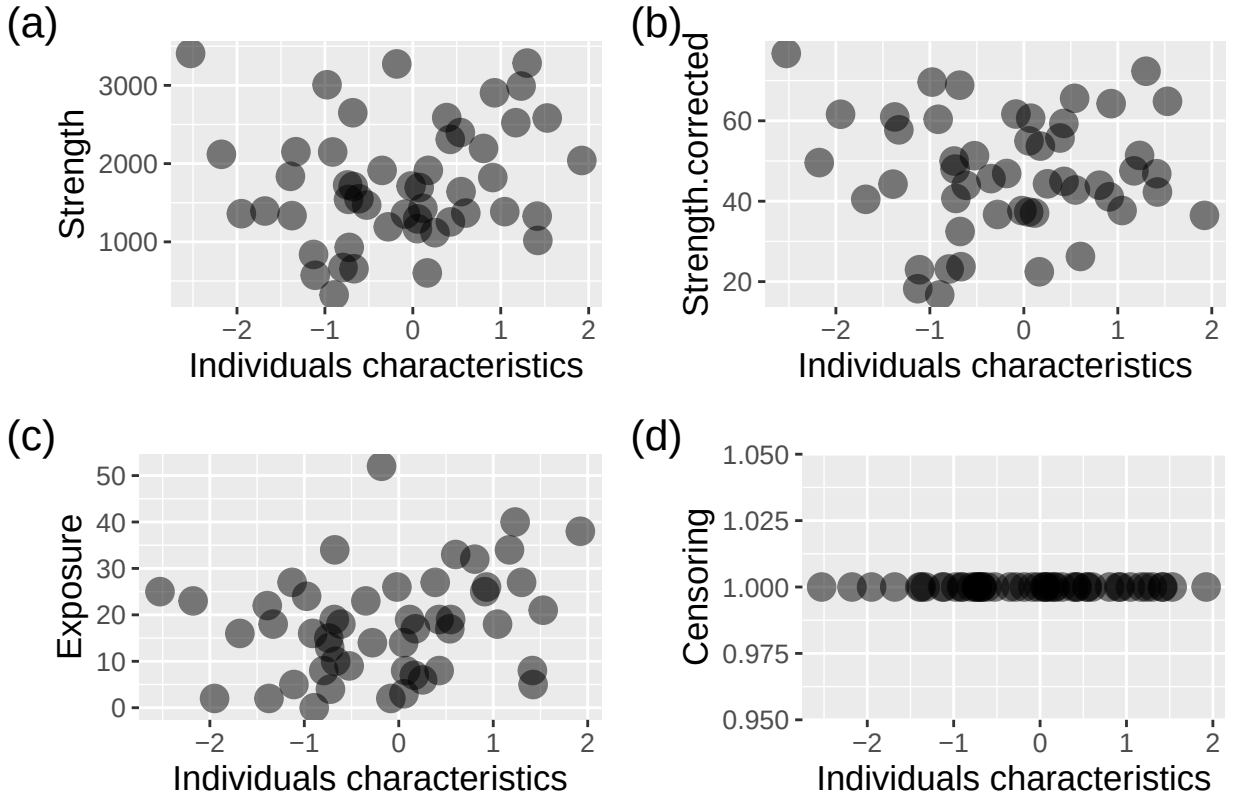
```
                    N_id = N_id,
                    individual_predictors=Hairy, # individuals characteristics
                    individual_effects=matrix(c(0,0),ncol=1, nrow=2), # individuals characteristics on
                    exposure_predictors = cbind(rep(1,N_id),Hairy),
                    exposure_effects = c(-1, 0.2), exposure_sigma = 1, # exposure effect
                    int_intercept = c(Inf,Inf), int_slope = c(Inf,Inf),
                    simulate.interactions = T) #no censoring effect
```

```
## Relationship between individuals characteristics and strength none corrected------------------------
##
## Call:
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1345.1  -535.8  -113.3   523.9  1929.1
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   1770.3      108.1  16.374   <2e-16
## att            115.3      105.4   1.094     0.28
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 757.3 on 48 degrees of freedom
## Multiple R-squared:  0.02432,    Adjusted R-squared:  0.003991
## F-statistic: 1.196 on 1 and 48 DF,  p-value: 0.2795
##
## Relationship between individuals characteristics and strength corrected ----------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -30.2805  -9.1502  -0.6431  12.0861  29.5445
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  46.8589     2.1048  22.263   <2e-16
## att          -0.1371     2.0514  -0.067    0.947
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.74 on 48 degrees of freedom
## Multiple R-squared:  9.307e-05,  Adjusted R-squared:  -0.02074
```

```
## F-statistic: 0.004468 on 1 and 48 DF,  p-value: 0.947
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
##      Min       1Q   Median       3Q      Max
## -155.917  -36.759   -2.774   28.300  138.204
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   47.544      2.018  23.563   <2e-16
## att           -0.619      1.886  -0.328    0.744
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 60.45 on 47 degrees of freedom
## Multiple R-squared:  0.002287,   Adjusted R-squared:  -0.01894
## F-statistic: 0.1077 on 1 and 47 DF,  p-value: 0.7442
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -17.509  -9.618  -0.788   7.639  34.162
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   18.369      1.577  11.648 1.36e-15
## att            2.911      1.537   1.894   0.0643
##
## (Intercept) ***
## att         .
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11.05 on 48 degrees of freedom
## Multiple R-squared:  0.06953,    Adjusted R-squared:  0.05014
## F-statistic: 3.587 on 1 and 48 DF,  p-value: 0.06428
##
## Relationship between individuals characteristics and censoring ---------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
```

```
##
## Residuals:
##        Min         1Q     Median         3Q
## -3.772e-15  2.370e-17  6.670e-17  1.235e-16
##        Max
##  2.579e-16
##
## Coefficients:
##              Estimate Std. Error   t value Pr(>|t|)
## (Intercept) 1.000e+00  7.930e-17 1.261e+16   <2e-16
## att         7.514e-17  7.729e-17 9.720e-01    0.336
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.554e-16 on 48 degrees of freedom
## Multiple R-squared:  0.5012, Adjusted R-squared:  0.4908
## F-statistic: 48.23 on 1 and 48 DF,  p-value: 8.945e-09
```

```
test$plots
```



4.2. An example of individual_effects being equal to 0.4 in simulated data

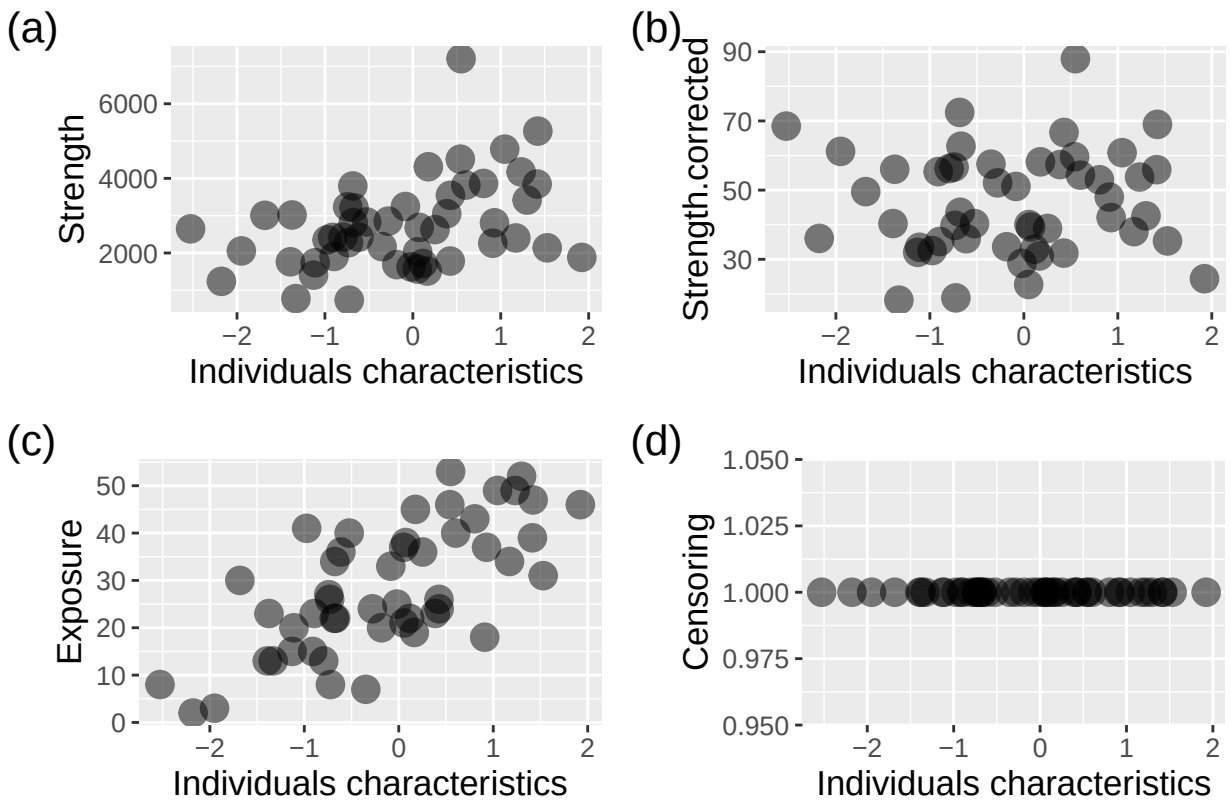
```
test = test.function(att = Hairy,
                     N_id = N_id,
                     individual_predictors=Hairy, # individuals characteristics
                     individual_effects=matrix(c(0,0),ncol=1, nrow=2), # individuals characteristics on
                     exposure_predictors = cbind(rep(1,N_id),Hairy),
                     exposure_effects = c(1,  1), exposure_sigma = 1, # exposure effect
                     int_intercept = c(Inf,Inf), int_slope = c(Inf,Inf),
                     simulate.interactions = T) #no censoring effect
```

```
## Relationship between individuals characteristics and strength none corrected-------------------------
##
## Call:
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1836.5  -847.8    -1.7   713.2  4143.6
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2804.7      157.8  17.774  < 2e-16
## att            474.9      153.8   3.088  0.00335
##
## (Intercept) ***
## att         **
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1105 on 48 degrees of freedom
## Multiple R-squared:  0.1657, Adjusted R-squared:  0.1483
## F-statistic: 9.533 on 1 and 48 DF,  p-value: 0.003348
##
## Relationship between individuals characteristics and strength corrected ----------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -27.283 -11.645  -3.447  10.752  41.314
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  46.3217     2.1469  21.576   <2e-16
## att           0.6372     2.0925   0.305    0.762
##
## (Intercept) ***
## att
## ---
```

```
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 15.04 on 48 degrees of freedom
## Multiple R-squared:  0.001928,   Adjusted R-squared:  -0.01886
## F-statistic: 0.09274 on 1 and 48 DF,  p-value: 0.762
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
##     Min      1Q  Median      3Q     Max
## -178.48  -57.03  -11.48   38.55  290.18
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   47.098      2.195  21.457   <2e-16
## att            1.874      2.309   0.811    0.421
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 80.97 on 48 degrees of freedom
## Multiple R-squared:  0.01353,    Adjusted R-squared:  -0.007021
## F-statistic: 0.6584 on 1 and 48 DF,  p-value: 0.4211
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -19.915  -7.750  -1.113   6.678  20.237
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   29.639      1.390  21.330  < 2e-16
## att            9.100      1.354   6.719 1.98e-08
##
## (Intercept) ***
## att         ***
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.733 on 48 degrees of freedom
## Multiple R-squared:  0.4847, Adjusted R-squared:  0.4739
## F-statistic: 45.15 on 1 and 48 DF,  p-value: 1.984e-08
```

```
##
## Relationship between individuals characteristics and censoring --------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
##
## Residuals:
##        Min         1Q     Median         3Q
## -3.772e-15  2.370e-17  6.670e-17  1.235e-16
##        Max
##  2.579e-16
##
## Coefficients:
##              Estimate Std. Error   t value Pr(>|t|)
## (Intercept) 1.000e+00  7.930e-17 1.261e+16   <2e-16
## att         7.514e-17  7.729e-17 9.720e-01    0.336
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.554e-16 on 48 degrees of freedom
## Multiple R-squared:  0.5012, Adjusted R-squared:  0.4908
## F-statistic: 48.23 on 1 and 48 DF,  p-value: 8.945e-09
```

```
test$plots
```



Sociality patterns observed in plot (a) are only due to exposure bias (plot (c)).

5. Testing when the coefficient of censoring (int_slope parameter) lead to significant effect on simulated data

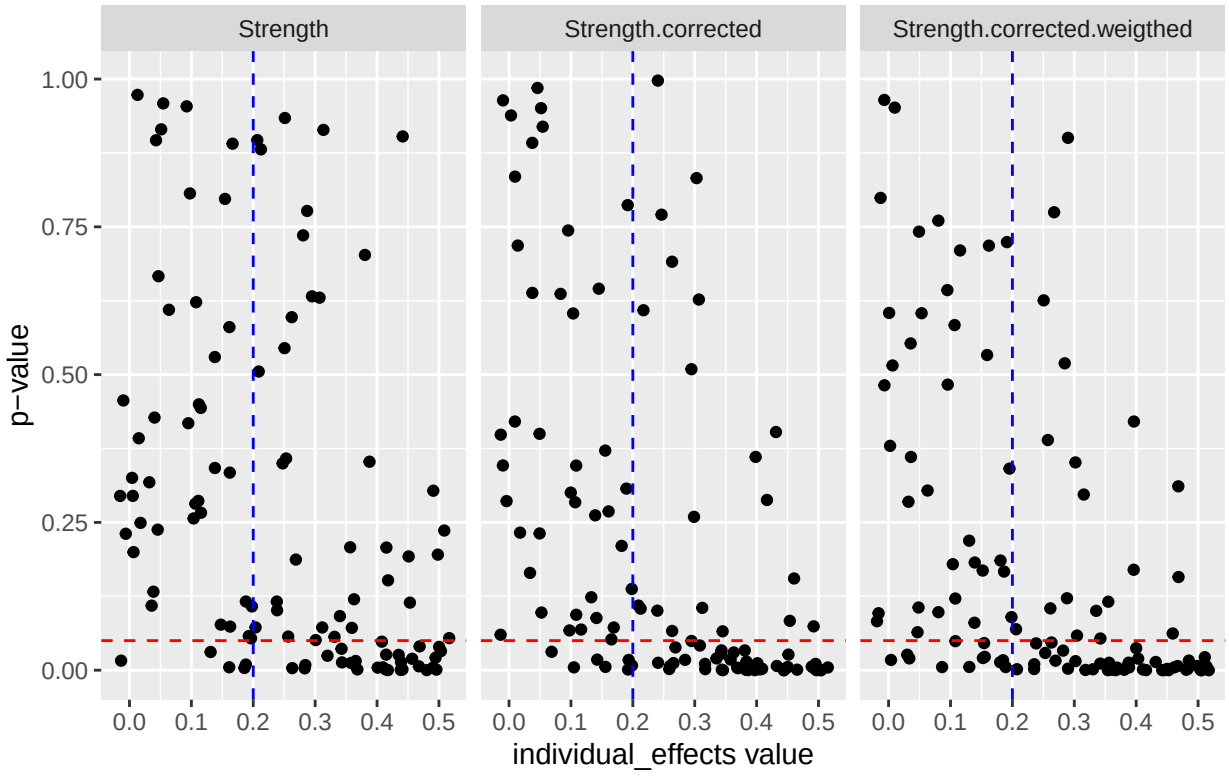
```
N_id = 30
Hairy = matrix(rnorm(N_id, 0, 1), nrow=N_id, ncol=1)
TEST = seq(from = 0, to = 0.5, by = 0.05)
length(TEST)
```

```
## [1] 11
```

```
r = NULL
a = 1
for (a in a:length(TEST)) {
  for(b in 1:10){
    r[[length(r)+1]] = test.function(att = Hairy,
                                     N_id = N_id,
                                     individual_predictors=Hairy, # individuals characteristics
                                     individual_effects=matrix(c(0,0),ncol=1, nrow=2), # individuals ch
                                     sr_mu =  c(0, 0), sr_sigma =  c(1,1), # no sender-receiver effect
                                     dr_mu = c(0,0), dr_sigma = 1, # no dyadic effect
                                     exposure_predictors = NULL,
                                     exposure_effects = c(0, 0), exposure_sigma = 1, # exposure effect
                                     int_intercept = c(TEST[a],TEST[a]), int_slope = c(TEST[a],TEST[a])
```

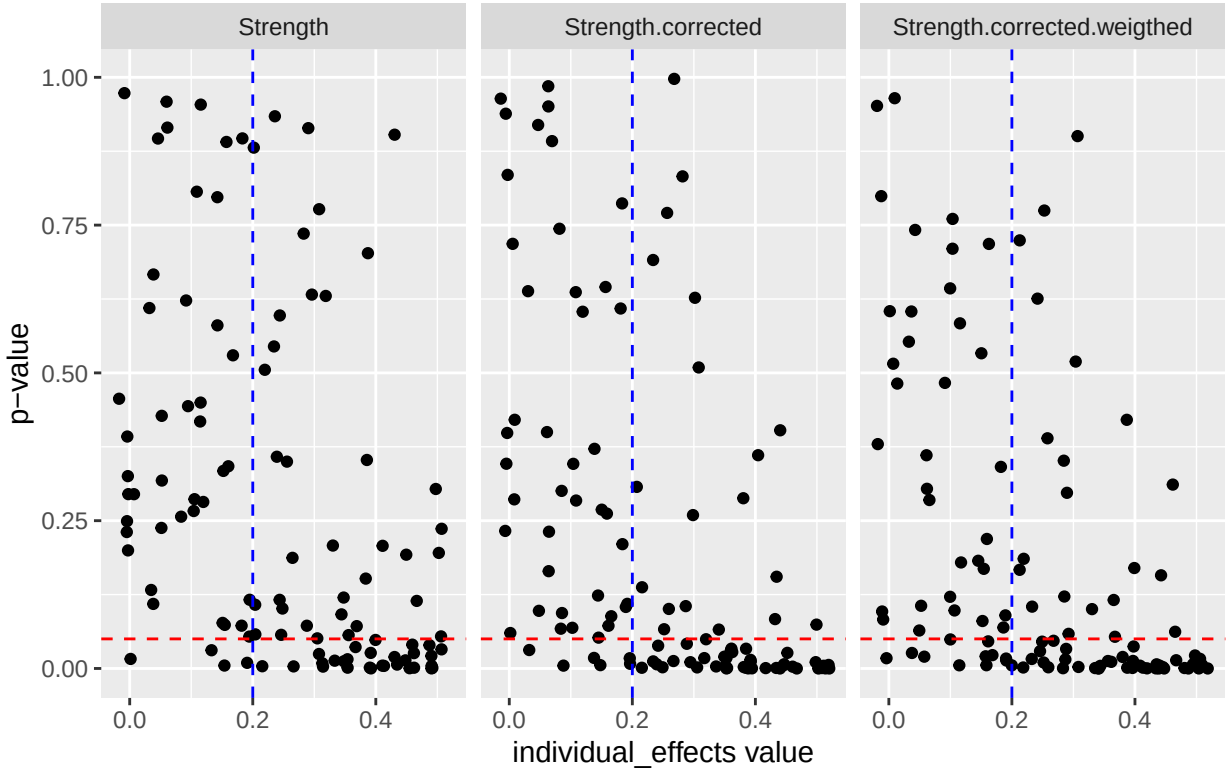
```
                                    simulate.interactions = TRUE, print = FALSE)
  }
}
d = NULL
test = rep(TEST, each = 10)
for(a in 1: length(r)){
  for (b in 1:length(r[[a]]$result)) {
    s = summary(r[[a]]$result[[b]])
    p = s$coefficients[2,4]
    c = s$coefficients[2,1]
    d = rbind(d, data.frame('coef' = c, 'p' = p, 'effect' = test[a], 'approach' = names(r[[a]]$result)[
  }
}

error.rates(d, threshold = 0.20)
```




```
## [[1]]
##   false negatives false positives
## 1         0.00000              80
## 2        95.71429              10
## 3        57.14286              10
## 4        34.28571              14
## 5        34.28571              26
##                    approaches
## 1                   Censoring
## 2                    Exposure
```

```
## 3                     Strength
## 4           Strength.corrected
## 5 Strength.corrected.weigthed
##
## [[2]]
```



From a visual perspective and error rates we can see that above a value of 0.30 for individual_effects parameters, we start to observe increase of false positive. We will use values of exposure_effects ranging from 0 to 0.20 for simulations without exposure bias and values ranging 0.4 to 0.6 for simulations with exposure bias.

5.1. An example of censoring intercept and slope are equal to 0.1 in simulated data

```
N_id = 100
Hairy = matrix(rnorm(N_id, 0, 1), nrow=N_id, ncol=1)
test = test.function(att = Hairy,
                     N_id = N_id,
                     individual_predictors=Hairy, # individuals characteristics
                     individual_effects=matrix(c(0.2,0.2),ncol=1, nrow=2), # individuals characteristic
                     exposure_predictors = NULL,
                     exposure_effects = c(0, 0), exposure_sigma = 1, # exposure effect
                     int_intercept = c(Inf,Inf), int_slope = c(Inf,Inf),
                     simulate.interactions = T) #no censoring effect
```

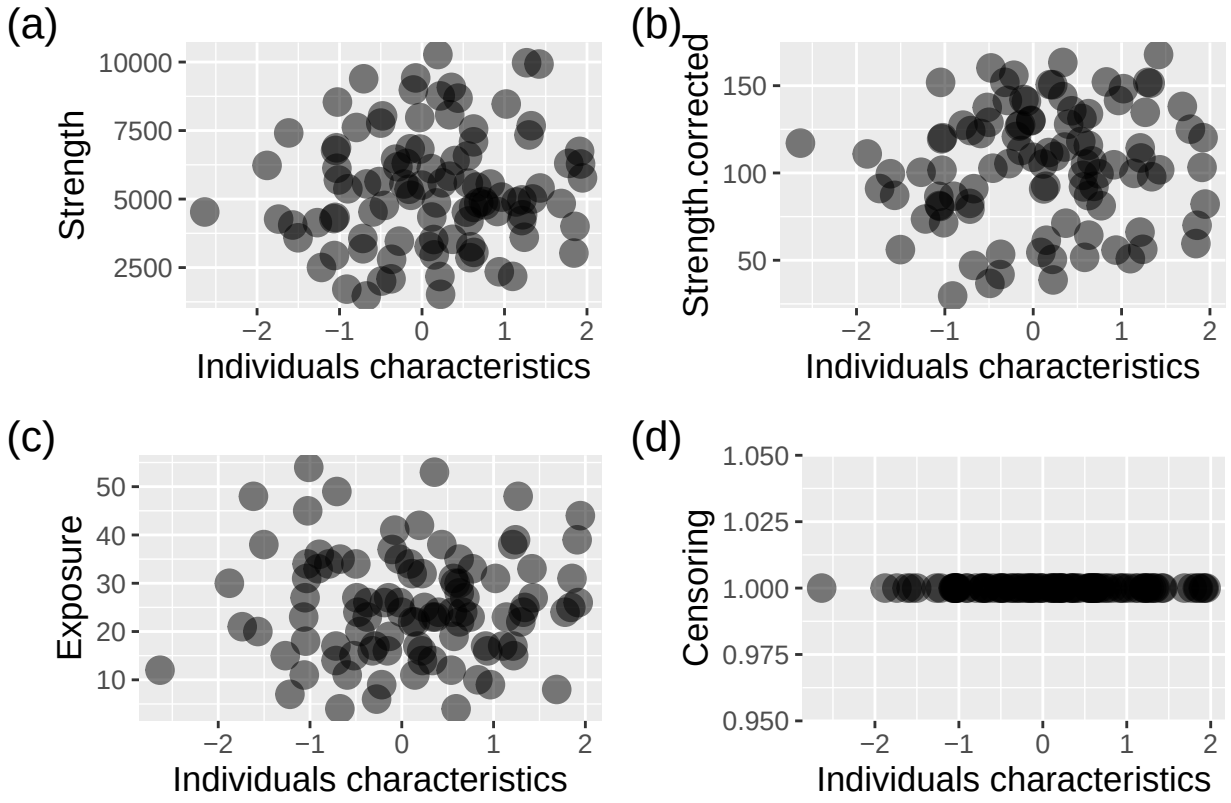
```
## Relationship between individuals characteristics and strength none corrected------------------------
```

```
##
## Call:
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3883.1 -1405.0  -213.9  1272.5  4874.0
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   5365.6      210.8  25.458   <2e-16
## att            183.9      217.3   0.846    0.399
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2091 on 98 degrees of freedom
## Multiple R-squared:  0.007255,   Adjusted R-squared:  -0.002875
## F-statistic: 0.7162 on 1 and 98 DF,  p-value: 0.3994
##
## Relationship between individuals characteristics and strength corrected ------------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -71.60 -19.44   0.70  25.85  59.14
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  104.105      3.359  30.990   <2e-16
## att            3.249      3.464   0.938    0.351
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 33.33 on 98 degrees of freedom
## Multiple R-squared:  0.008899,   Adjusted R-squared:  -0.001215
## F-statistic: 0.8799 on 1 and 98 DF,  p-value: 0.3505
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -415.08  -87.38    4.20  127.27  344.28
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  104.191      3.330  31.289   <2e-16
## att            2.630      3.368   0.781    0.437
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 165.9 on 98 degrees of freedom
## Multiple R-squared:  0.006182,   Adjusted R-squared:  -0.003959
## F-statistic: 0.6096 on 1 and 98 DF,  p-value: 0.4368
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -21.410  -8.520  -1.293   7.391  29.068
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  25.2340     1.1163  22.604   <2e-16
## att           0.2982     1.1512   0.259    0.796
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11.08 on 98 degrees of freedom
## Multiple R-squared:  0.0006842,  Adjusted R-squared:  -0.009513
## F-statistic: 0.06709 on 1 and 98 DF,  p-value: 0.7962
##
## Relationship between individuals characteristics and censoring ---------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
##
## Residuals:
##        Min         1Q     Median         3Q
## -1.861e-14  1.061e-16  1.809e-16  2.709e-16
##        Max
##  5.318e-16
##
## Coefficients:
##              Estimate Std. Error   t value Pr(>|t|)
```

```
## (Intercept) 1.000e+00  1.908e-16 5.241e+15   <2e-16
## att         1.245e-16  1.968e-16 6.330e-01    0.528
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.893e-15 on 98 degrees of freedom
## Multiple R-squared:  0.5013, Adjusted R-squared:  0.4962
## F-statistic: 98.52 on 1 and 98 DF,  p-value: < 2.2e-16
```

```
test$plots
```



5.2. An example of individual_effects being equal to 0.4 in simulated data

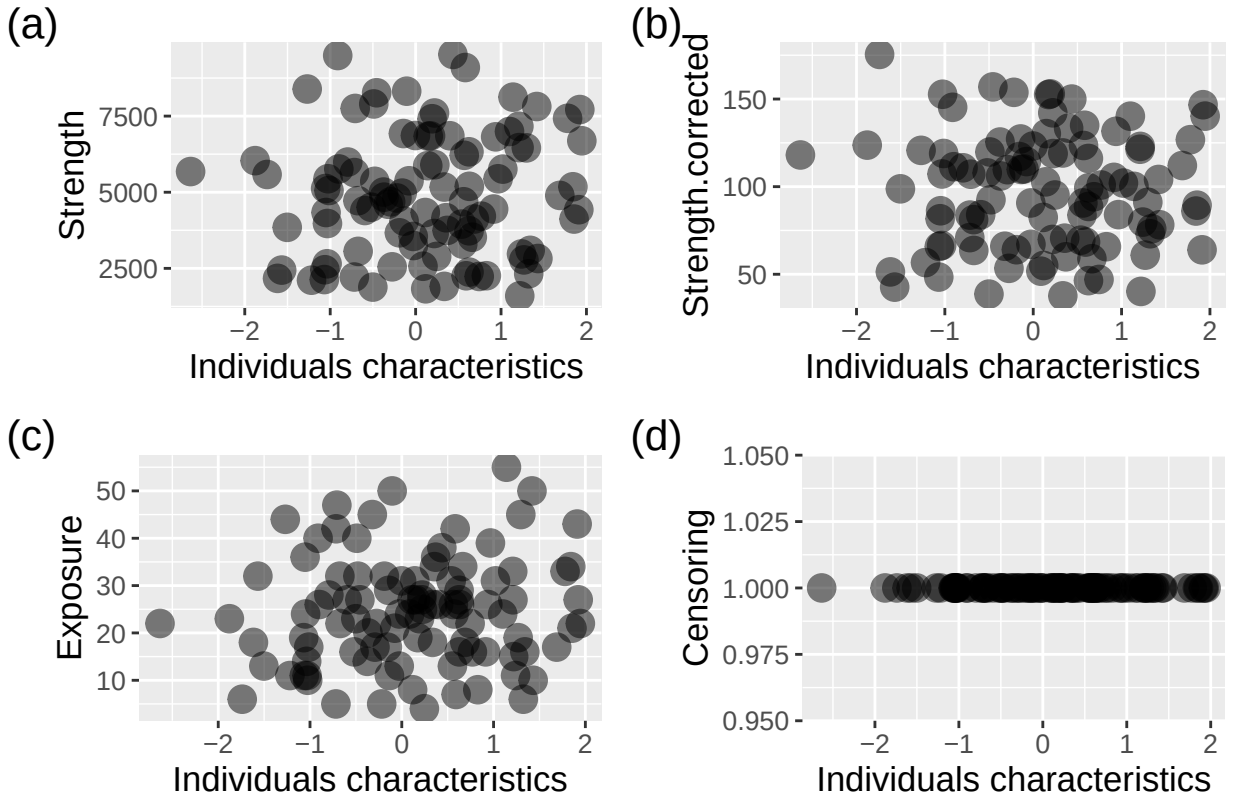
```
test = test.function(att = Hairy,
                     N_id = N_id,
                     individual_predictors=Hairy, # individuals characteristics
                     individual_effects=matrix(c(0.18,0.18),ncol=1, nrow=2), # individuals characterist
                     exposure_predictors = NULL,
                     exposure_effects = c(0, 0), exposure_sigma = 1, # exposure effect
                     int_intercept = c(Inf,Inf), int_slope = c(Inf,Inf),
                     simulate.interactions = T) #no censoring effect
```

```
## Relationship between individuals characteristics and strength none corrected------------------------
##
## Call:
## lm(formula = Strength ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3468.0 -1638.1  -104.7  1384.8  4744.7
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   4881.5      200.2  24.388   <2e-16
## att            150.5      206.4   0.729    0.468
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1986 on 98 degrees of freedom
## Multiple R-squared:  0.005395,   Adjusted R-squared:  -0.004754
## F-statistic: 0.5316 on 1 and 98 DF,  p-value: 0.4677
##
## Relationship between individuals characteristics and strength corrected ----------------------------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -59.365 -27.297   1.591  22.410  77.286
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  97.2248     3.2492  29.923   <2e-16
## att          -0.5525     3.3506  -0.165    0.869
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 32.24 on 98 degrees of freedom
## Multiple R-squared:  0.0002774,  Adjusted R-squared:  -0.009924
## F-statistic: 0.02719 on 1 and 98 DF,  p-value: 0.8694
##
## Relationship between individuals characteristics and strength corrected and lm with weigth----------
##
## Call:
## lm(formula = Strength.corrected ~ att, data = df, weights = Exposure)
##
## Weighted Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -308.74  -95.62    6.14  111.58  318.37
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   97.865      3.148  31.087   <2e-16
## att            1.065      3.249   0.328    0.744
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 153.2 on 98 degrees of freedom
## Multiple R-squared:  0.001094,   Adjusted R-squared:  -0.009099
## F-statistic: 0.1073 on 1 and 98 DF,  p-value: 0.7439
##
## Relationship between individuals characteristics and exposure ---------------------------------
##
## Call:
## lm(formula = Exposure ~ att, data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -20.6682  -8.9314   0.1515   6.5311  29.0624
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   24.318      1.136  21.412   <2e-16
## att            1.420      1.171   1.212    0.228
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11.27 on 98 degrees of freedom
## Multiple R-squared:  0.01478,    Adjusted R-squared:  0.004724
## F-statistic:  1.47 on 1 and 98 DF,  p-value: 0.2283
##
## Relationship between individuals characteristics and censoring ---------------------------------
##
## Call:
## lm(formula = Censoring ~ att, data = df)
##
## Residuals:
##        Min         1Q     Median         3Q
## -1.861e-14  1.061e-16  1.809e-16  2.709e-16
##        Max
##  5.318e-16
##
## Coefficients:
```

```
##              Estimate Std. Error   t value Pr(>|t|)
## (Intercept) 1.000e+00  1.908e-16 5.241e+15   <2e-16
## att         1.245e-16  1.968e-16 6.330e-01    0.528
##
## (Intercept) ***
## att
## ---
## Signif. codes:
## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.893e-15 on 98 degrees of freedom
## Multiple R-squared:  0.5013, Adjusted R-squared:  0.4962
## F-statistic: 98.52 on 1 and 98 DF,  p-value: < 2.2e-16
```

```
test$plots
```




```
save.image(file='2.Results/Appendices/Appendix.RData')
```