Correlations between User Variables and Attitude Ratings

Nele Albers

06 February, 2023

Contents

Introduction

The purpose of this file is to you to reproduce our results of the Bayesian analyses of the correlations between user variables and attitude ratings. These values are presented in the "Results"-section of the paper.

Authored by Nele Albers, Mark A. Neerincx, Nadyne L. Aretz, Mahira Ali, Arsen Ekinci, and Willem-Paul Brinkman.

Setup

First, we load the packages that we need.

```
library(BayesianFirstAid)  # For computing correlations
library(formatR)  # For formatting
library(ggplot2)  # For plots
library(pander)  # For table
```

Data

We load the pre-processed data.

```
df = read.csv(file = "preprocessed_data.csv")
```

Next, we need to compute indices for the ease of and motivation to do the preparatory activities. For each of these, participants rated two items on scales from -5 to 5.

```
# Multiply the difficulty rating by -1 so that we have an overall rating of ease
df$Ease = (df$MB_Easy - df$MB_Difficult)/2
```

```r
# And similarly we multiply the unmotivated rating by -1
df$Motivation = (df$MB_Motivated - df$MB_Unmotivated)/2
```

Bayesian Analysis of Correlations

We will now conduct Bayesian analyses of the Pearson correlations between user variables and attitude ratings.

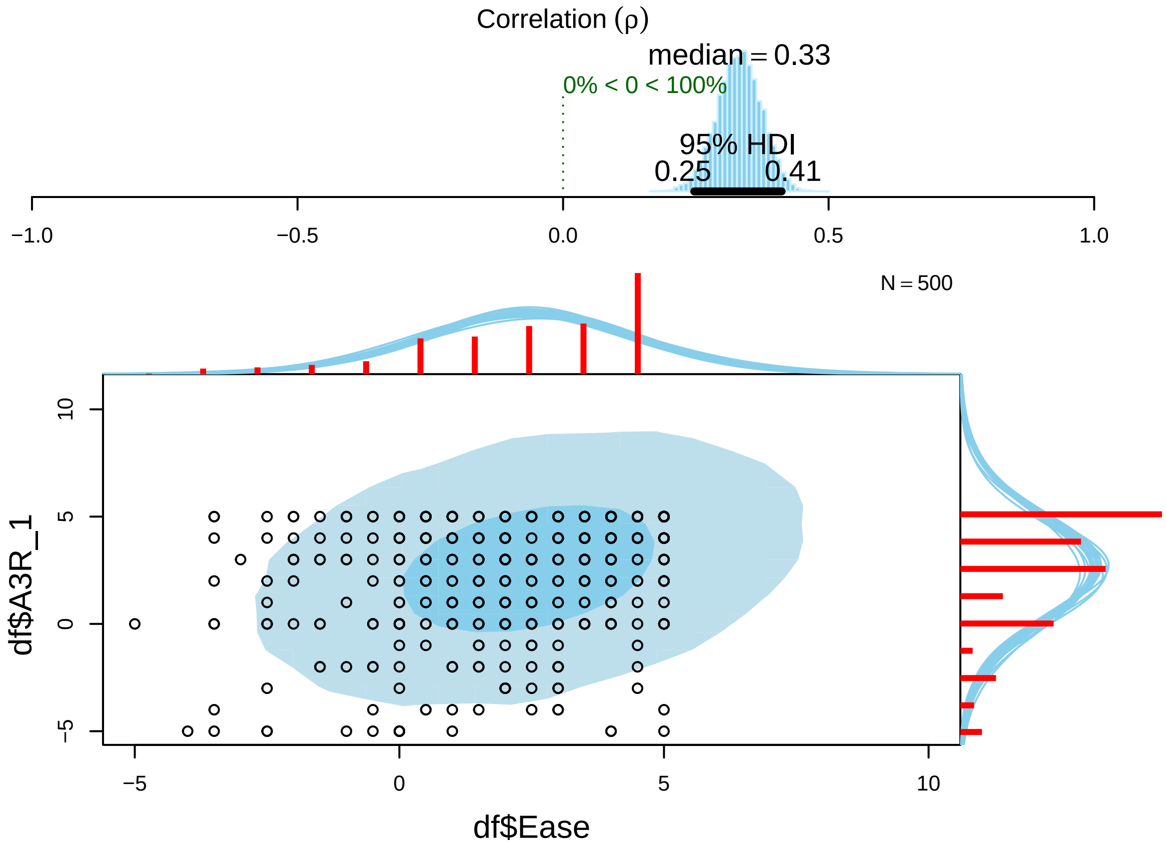
First we compute the correlation between the ease of doing the activities and the rating for "willingness to continue."

```r
set.seed(18)  # For reproducibility

fit = bayes.cor.test(df$Ease, df$A3R_1)

print(summary(fit))
```

```
##   Data
## df$Ease and df$A3R_1, n = 500
##
##   Model parameters
## rho: the correlation between df$Ease and df$A3R_1
## mu[1]: the mean of df$Ease
## sigma[1]: the scale of df$Ease , a consistent
##   estimate of SD when nu is large.
## mu[2]: the mean of df$A3R_1
## sigma[2]: the scale of df$A3R_1
## nu: the degrees-of-freedom for the bivariate t distribution
## xy_pred[1]: the posterior predictive distribution of df$Ease
## xy_pred[2]: the posterior predictive distribution of df$A3R_1
##
##   Measures
##               mean     sd  HDIlo  HDIup %<comp %>comp
## rho          0.332  0.042  0.247  0.412  0.000  1.000
## mu[1]        2.452  0.109  2.253  2.677  0.000  1.000
## mu[2]        2.563  0.134  2.306  2.832  0.000  1.000
## sigma[1]     2.053  0.083  1.884  2.211  0.000  1.000
## sigma[2]     2.544  0.108  2.333  2.753  0.000  1.000
## nu          22.875 16.305  6.570 54.749  0.000  1.000
## xy_pred[1]   2.442  2.191 -1.794  6.798  0.126  0.874
## xy_pred[2]   2.544  2.697 -2.819  7.842  0.163  0.837
##
## 'HDIlo' and 'HDIup' are the limits of a 95% HDI credible interval.
## '%<comp' and '%>comp' are the probabilities of the respective parameter being
## smaller or larger than 0.
##
##   Quantiles
##              q2.5%   q25% median   q75% q97.5%
## rho          0.247  0.304  0.332  0.360  0.412
## mu[1]        2.240  2.377  2.451  2.526  2.665
## mu[2]        2.301  2.474  2.562  2.653  2.828
## sigma[1]     1.891  1.997  2.052  2.110  2.218
## sigma[2]     2.335  2.469  2.544  2.618  2.756
## nu           8.602 13.214 18.033 26.402 68.899
```

```
## xy_pred[1] -1.820  1.010  2.434  3.864  6.784
## xy_pred[2] -2.727  0.816  2.543  4.273  7.940
##                  mean          sd HDI% comp      HDIlo     HDIup    %>comp
## rho         0.3316769  0.04209706   95    0  0.2470129  0.411584 0.9999333
## mu[1]       2.4522104  0.10891462   95    0  2.2531371  2.676688 0.9999333
## mu[2]       2.5632065  0.13397144   95    0  2.3055800  2.831898 0.9999333
## sigma[1]    2.0532468  0.08340933   95    0  1.8844121  2.210913 0.9999333
## sigma[2]    2.5438342  0.10826206   95    0  2.3327280  2.752610 0.9999333
## nu         22.8746499 16.30537570   95    0  6.5702072 54.748779 0.9999333
## xy_pred[1]  2.4424190  2.19084019   95    0 -1.7935893  6.798239 0.8739501
## xy_pred[2]  2.5435337  2.69653223   95    0 -2.8190203  7.841633 0.8373550
##                 %<comp      q2.5%       q25%     median       q75%     q97.5%
## rho        6.665778e-05  0.2473846  0.3038744  0.3319636  0.3603242  0.4121233
## mu[1]      6.665778e-05  2.2400861  2.3768778  2.4513930  2.5263412  2.6648612
## mu[2]      6.665778e-05  2.3006755  2.4739998  2.5620664  2.6530763  2.8276789
## sigma[1]   6.665778e-05  1.8907453  1.9969214  2.0518253  2.1098168  2.2177119
## sigma[2]   6.665778e-05  2.3350486  2.4689657  2.5435291  2.6175131  2.7562226
## nu         6.665778e-05  8.6015471 13.2144792 18.0325505 26.4017991 68.8993540
## xy_pred[1] 1.260499e-01 -1.8200863  1.0099904  2.4338761  3.8644576  6.7843620
## xy_pred[2] 1.626450e-01 -2.7266882  0.8159219  2.5428100  4.2732223  7.9395604
##                 mcmc_se      Rhat n_eff
## rho        0.0004750926 1.0008833  7884
## mu[1]      0.0018229827 1.0000910  3567
## mu[2]      0.0023678478 0.9998613  3260
## sigma[1]   0.0015922248 1.0002772  2772
## sigma[2]   0.0020668418 1.0002884  2769
## nu         0.5149029217 1.0158083  1051
## xy_pred[1] 0.0179092480 1.0001033 14964
## xy_pred[2] 0.0216449088 1.0000771 15551
```

```
plot(fit)
```




```r
# Mean, SD, HDI
ease_mean <- fit$stats[1, 1]
ease_SD <- fit$stats[1, 2]
ease_hdi_low <- fit$stats[1, 5]
ease_hdi_high <- fit$stats[1, 6]

# Posterior probability that correlation is
# greater than 0
post_prob_ease <- fit$stats[1, 7]

print(paste("Posterior probability that the correlation is greater than 0:",
    round(post_prob_ease, 5)))
```

```
## [1] "Posterior probability that the correlation is greater than 0: 0.99993"
```

This posterior probability can be evaluated based on the guidelines from (Chechile (2020)) and their extension to posterior probabilities below 0.5 by (Andraszewicz et al. (2015)).

```r
if (post_prob_ease < 0.0005){
  evaluation_ease = "Nearing certainty against"
}else if (post_prob_ease < 0.005){
  evaluation_ease = "Very strong bet against"
}else if (post_prob_ease < 0.01){
  evaluation_ease = "Strong bet against - irresponsible to avoid"
}else if (post_prob_ease < 0.1){
  evaluation_ease = "A promising but risky bet against"
}else if (post_prob_ease < 0.25){
  evaluation_ease = "Only a casual bet against"
```

```r
}else if (post_prob_ease < 0.5){
  evaluation_ease = "Not worth betting against"
}else if (post_prob_ease < 0.75){
  evaluation_ease = "Not worth betting on"
}else if (post_prob_ease < 0.9){
  evaluation_ease = "Only a casual bet"
}else if (post_prob_ease < 0.95){
  evaluation_ease = "A promising but risky bet"
}else if (post_prob_ease < 0.99){
  evaluation_ease = "Good bet - too good to disregard"
}else if (post_prob_ease < 0.995){
  evaluation_ease = "Strong bet - irresponsible to avoid"
}else if (post_prob_ease < 0.9995){
  evaluation_ease = "Very strong bet"
}else if (post_prob_ease < 0.99995){
  evaluation_ease = "Nearing certainty"
}else{
  evaluation_ease = "Virtually certain"
}

evaluation_ease
```

```
## [1] "Nearing certainty"
```

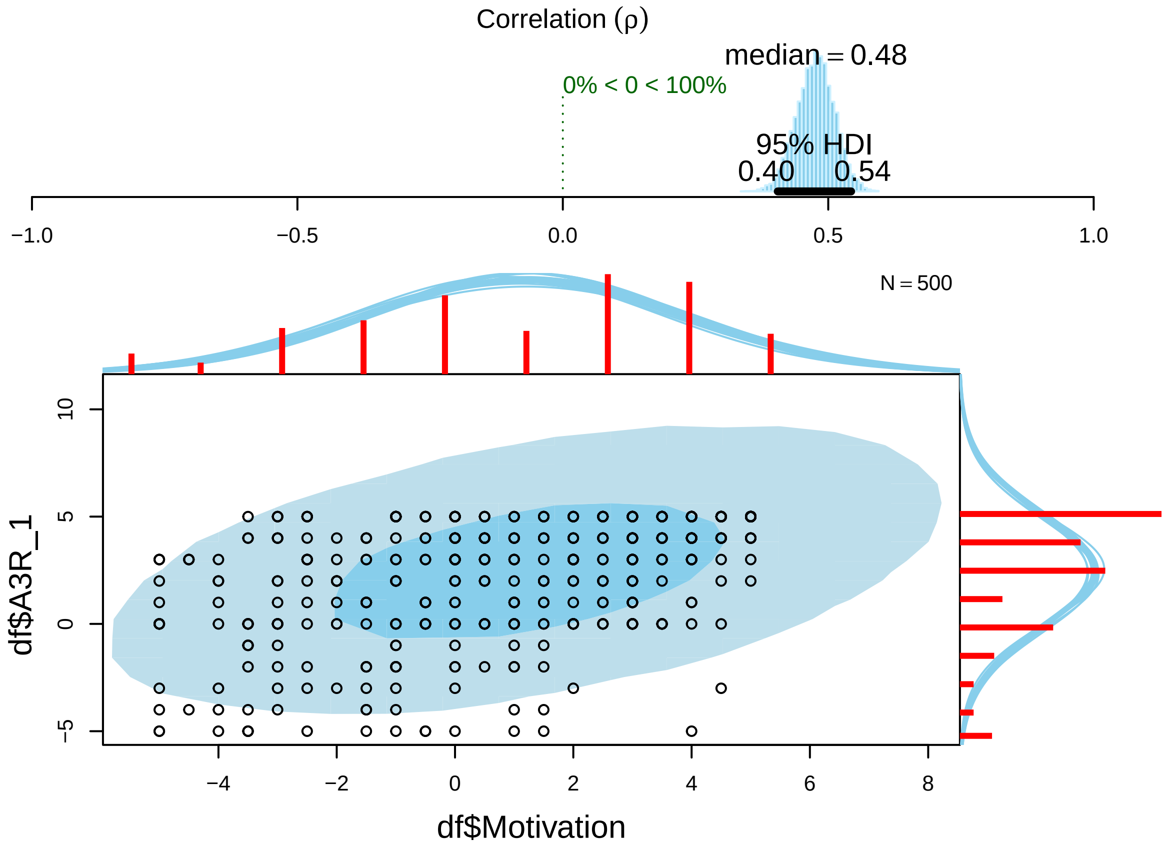
Next we compute the correlation between the motivation to do the activities and the rating for "willingness to continue."

```r
set.seed(18)  # For reproducibility

fit = bayes.cor.test(df$Motivation, df$A3R_1)

print(summary(fit))
```

```
##   Data
## df$Motivation and df$A3R_1, n = 500
##
##   Model parameters
## rho: the correlation between df$Motivation and df$A3R_1
## mu[1]: the mean of df$Motivation
## sigma[1]: the scale of df$Motivation , a consistent
##   estimate of SD when nu is large.
## mu[2]: the mean of df$A3R_1
## sigma[2]: the scale of df$A3R_1
## nu: the degrees-of-freedom for the bivariate t distribution
## xy_pred[1]: the posterior predictive distribution of df$Motivation
## xy_pred[2]: the posterior predictive distribution of df$A3R_1
##
##   Measures
##               mean     sd  HDIlo   HDIup %<comp %>comp
## rho          0.476  0.035  0.405   0.543  0.000  1.000
## mu[1]        1.207  0.130  0.962   1.466  0.000  1.000
## mu[2]        2.479  0.124  2.236   2.720  0.000  1.000
## sigma[1]     2.754  0.092  2.577   2.940  0.000  1.000
## sigma[2]     2.644  0.092  2.468   2.825  0.000  1.000
## nu          60.250 33.119 13.106 126.245  0.000  1.000
```

```
## xy_pred[1]  1.200  2.862 -4.571   6.659  0.333  0.667
## xy_pred[2]  2.493  2.722 -2.891   7.980  0.173  0.827
##
## 'HDIlo' and 'HDIup' are the limits of a 95% HDI credible interval.
## '%<comp' and '%>comp' are the probabilities of the respective parameter being
## smaller or larger than 0.
##
##   Quantiles
##             q2.5%   q25% median   q75%  q97.5%
## rho         0.406  0.452  0.477  0.500   0.545
## mu[1]       0.954  1.120  1.206  1.294   1.460
## mu[2]       2.238  2.396  2.479  2.561   2.722
## sigma[1]    2.579  2.691  2.751  2.815   2.943
## sigma[2]    2.468  2.582  2.644  2.706   2.826
## nu         18.928 36.321 52.477 75.934 145.514
## xy_pred[1] -4.474 -0.678  1.208  3.132   6.764
## xy_pred[2] -2.962  0.729  2.487  4.255   7.910
##                  mean          sd HDI% comp      HDIlo       HDIup    %>comp
## rho         0.4760307  0.03548331   95    0  0.4049008   0.5431083 0.9999333
## mu[1]       1.2068797  0.12966276   95    0  0.9619609   1.4656785 0.9999333
## mu[2]       2.4788748  0.12380552   95    0  2.2363070   2.7203090 0.9999333
## sigma[1]    2.7536671  0.09249617   95    0  2.5768140   2.9396572 0.9999333
## sigma[2]    2.6443602  0.09166592   95    0  2.4677732   2.8254241 0.9999333
## nu         60.2495164 33.11936342   95    0 13.1061732 126.2450739 0.9999333
## xy_pred[1]  1.1997940  2.86230125   95    0 -4.5710943   6.6589270 0.6672444
## xy_pred[2]  2.4928115  2.72217398   95    0 -2.8911189   7.9800782 0.8272897
##                  %<comp       q2.5%        q25%     median       q75%     q97.5%
## rho        6.665778e-05  0.4060514  0.4523706  0.4768253  0.4999526   0.544663
## mu[1]      6.665778e-05  0.9539587  1.1200080  1.2058986  1.2939497   1.459935
## mu[2]      6.665778e-05  2.2380227  2.3959264  2.4791775  2.5613239   2.722232
## sigma[1]   6.665778e-05  2.5786035  2.6907845  2.7509644  2.8145938   2.942519
## sigma[2]   6.665778e-05  2.4681866  2.5818573  2.6442309  2.7055190   2.826010
## nu         6.665778e-05 18.9281475 36.3206773 52.4771810 75.9339953 145.514154
## xy_pred[1] 3.327556e-01 -4.4740988 -0.6777344  1.2084371  3.1324716   6.764372
## xy_pred[2] 1.727103e-01 -2.9618956  0.7288366  2.4869985  4.2547478   7.910244
##                 mcmc_se      Rhat n_eff
## rho        0.0004369683 1.0009404  6687
## mu[1]      0.0018703304 1.0007332  4806
## mu[2]      0.0017282920 1.0008454  5153
## sigma[1]   0.0012060670 1.0006297  6001
## sigma[2]   0.0012075829 1.0003648  5782
## nu         0.5226830032 1.0062635  4041
## xy_pred[1] 0.0237671016 1.0002600 14523
## xy_pred[2] 0.0219271988 0.9999298 15417
```

```
plot(fit)
```




```r
# Mean, SD, HDI
motiv_mean <- fit$stats[1, 1]
motiv_SD <- fit$stats[1, 2]
motiv_hdi_low <- fit$stats[1, 5]
motiv_hdi_high <- fit$stats[1, 6]

# Posterior probability that correlation is
# greater than 0
post_prob_motiv <- fit$stats[1, 7]

print(paste("Posterior probability that the correlation is greater than 0:",
    round(post_prob_motiv, 5)))
```

```
## [1] "Posterior probability that the correlation is greater than 0: 0.99993"
```

This posterior probability can be evaluated based on the guidelines from (Chechile (2020)) and their extension to posterior probabilities below 0.5 by (Andraszewicz et al. (2015)).

```r
if (post_prob_motiv < 0.0005){
  evaluation_motiv = "Nearing certainty against"
}else if (post_prob_motiv < 0.005){
  evaluation_motiv = "Very strong bet against"
}else if (post_prob_motiv < 0.01){
  evaluation_motiv = "Strong bet against - irresponsible to avoid"
}else if (post_prob_motiv < 0.1){
  evaluation_motiv = "A promising but risky bet against"
}else if (post_prob_motiv < 0.25){
  evaluation_motiv = "Only a casual bet against"
```

```r
}else if (post_prob_motiv < 0.5){
  evaluation_motiv = "Not worth betting against"
}else if (post_prob_motiv < 0.75){
  evaluation_motiv = "Not worth betting on"
}else if (post_prob_motiv < 0.9){
  evaluation_motiv = "Only a casual bet"
}else if (post_prob_motiv < 0.95){
  evaluation_motiv = "A promising but risky bet"
}else if (post_prob_motiv < 0.99){
  evaluation_motiv = "Good bet - too good to disregard"
}else if (post_prob_motiv < 0.995){
  evaluation_motiv = "Strong bet - irresponsible to avoid"
}else if (post_prob_motiv < 0.9995){
  evaluation_motiv = "Very strong bet"
}else if (post_prob_motiv < 0.99995){
  evaluation_motiv = "Nearing certainty"
}else{
  evaluation_motiv = "Virtually certain"
}

evaluation_motiv
```

```
## [1] "Nearing certainty"
```

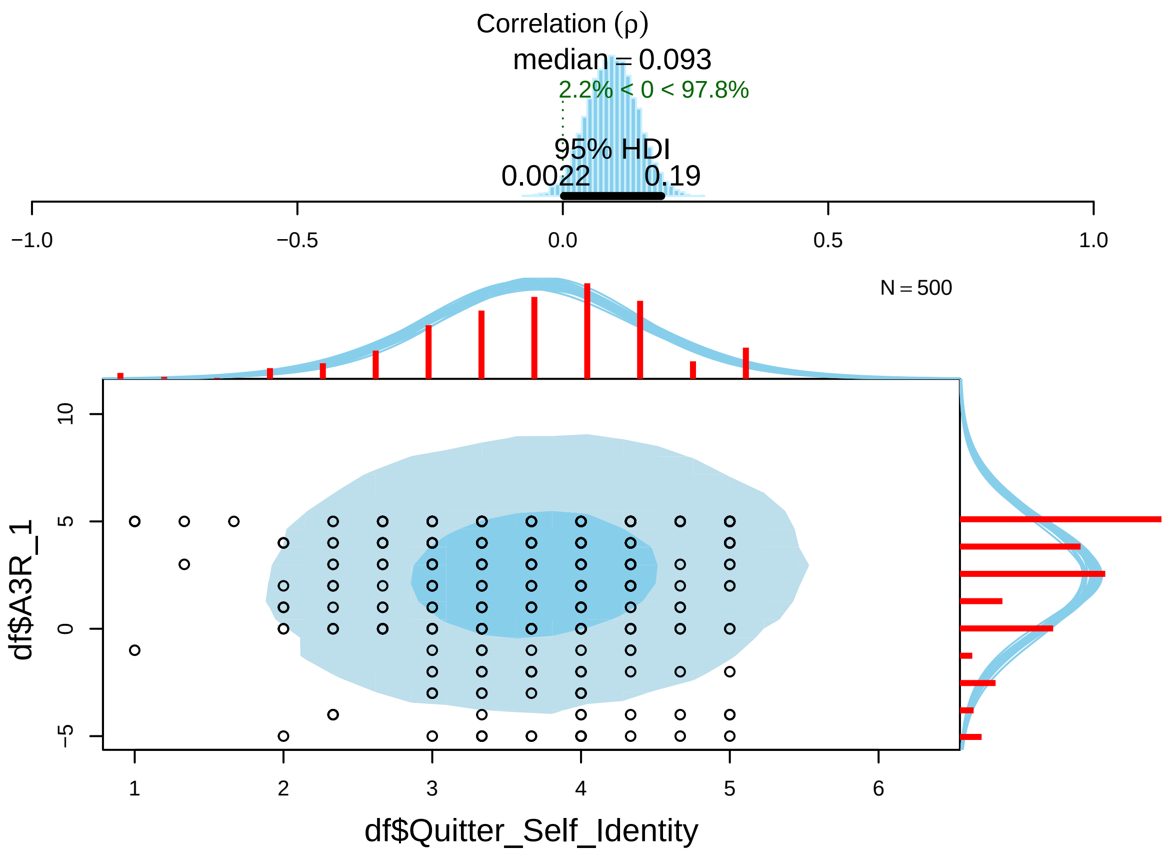
Now we calculate the correlation between quitter self-identity and the rating for "willingness to continue."

```r
set.seed(18)  # For reproducibility

fit = bayes.cor.test(df$Quitter_Self_Identity, df$A3R_1)

print(summary(fit))
```

```
##   Data
## df$Quitter_Self_Identity and df$A3R_1, n = 500
##
##   Model parameters
## rho: the correlation between df$Quitter_Self_Identity and df$A3R_1
## mu[1]: the mean of df$Quitter_Self_Identity
## sigma[1]: the scale of df$Quitter_Self_Identity , a consistent
##   estimate of SD when nu is large.
## mu[2]: the mean of df$A3R_1
## sigma[2]: the scale of df$A3R_1
## nu: the degrees-of-freedom for the bivariate t distribution
## xy_pred[1]: the posterior predictive distribution of df$Quitter_Self_Identity
## xy_pred[2]: the posterior predictive distribution of df$A3R_1
##
##   Measures
##               mean     sd  HDIlo  HDIup %<comp %>comp
## rho          0.093  0.047  0.002  0.185  0.022  0.978
## mu[1]        3.686  0.033  3.623  3.752  0.000  1.000
## mu[2]        2.558  0.131  2.306  2.813  0.000  1.000
## sigma[1]     0.711  0.029  0.654  0.767  0.000  1.000
## sigma[2]     2.543  0.107  2.326  2.748  0.000  1.000
## nu          20.400 12.185  6.854 42.981  0.000  1.000
## xy_pred[1]   3.676  0.754  2.183  5.147  0.000  1.000
```

```
## xy_pred[2]  2.555  2.706 -2.783  7.878  0.166  0.834
##
## 'HDIlo' and 'HDIup' are the limits of a 95% HDI credible interval.
## '%<comp' and '%>comp' are the probabilities of the respective parameter being
## smaller or larger than 0.
##
##   Quantiles
##             q2.5%   q25% median   q75% q97.5%
## rho         0.003  0.061  0.093  0.125  0.186
## mu[1]       3.621  3.663  3.686  3.709  3.751
## mu[2]       2.303  2.470  2.558  2.646  2.811
## sigma[1]    0.656  0.690  0.710  0.731  0.770
## sigma[2]    2.330  2.473  2.544  2.615  2.753
## nu          8.656 12.914 16.909 23.800 50.924
## xy_pred[1]  2.185  3.187  3.677  4.169  5.152
## xy_pred[2] -2.803  0.809  2.562  4.274  7.873
##                  mean          sd HDI% comp        HDIlo      HDIup    %>comp
## rho         0.0934430  0.04701486   95    0  0.002189648  0.1854029 0.9778030
## mu[1]       3.6862472  0.03347483   95    0  3.622921593  3.7522262 0.9999333
## mu[2]       2.5581636  0.13054866   95    0  2.305807593  2.8130587 0.9999333
## sigma[1]    0.7108535  0.02923348   95    0  0.654173382  0.7673809 0.9999333
## sigma[2]    2.5430111  0.10693696   95    0  2.326481303  2.7479707 0.9999333
## nu         20.4003752 12.18492038   95    0  6.853844955 42.9810161 0.9999333
## xy_pred[1]  3.6755762  0.75423254   95    0  2.182526451  5.1465316 0.9999333
## xy_pred[2]  2.5545915  2.70599257   95    0 -2.782894789  7.8776205 0.8338222
##                  %<comp        q2.5%        q25%      median       q75%
## rho        2.219704e-02  0.002538719  0.06118693  0.09337381  0.1253303
## mu[1]      6.665778e-05  3.621327874  3.66349191  3.68617529  3.7085740
## mu[2]      6.665778e-05  2.302611557  2.46950662  2.55779586  2.6461468
## sigma[1]   6.665778e-05  0.656185328  0.69037160  0.71024090  0.7309898
## sigma[2]   6.665778e-05  2.329814306  2.47268945  2.54371816  2.6149587
## nu         6.665778e-05  8.655873325 12.91378312 16.90897553 23.7995788
## xy_pred[1] 6.665778e-05  2.185140823  3.18720456  3.67701773  4.1692892
## xy_pred[2] 1.661778e-01 -2.803142623  0.80926032  2.56214711  4.2736655
##                 q97.5%      mcmc_se     Rhat n_eff
## rho         0.1860244 0.0005083177 1.000184  8598
## mu[1]       3.7509872 0.0003739524 1.000789  8046
## mu[2]       2.8112726 0.0018448916 1.002481  5005
## sigma[1]    0.7698032 0.0004845776 1.000126  3672
## sigma[2]    2.7526654 0.0017830102 1.000130  3603
## nu         50.9239292 0.3438086725 1.016007  1406
## xy_pred[1]  5.1521319 0.0062595509 1.000308 14555
## xy_pred[2]  7.8727133 0.0225261584 1.000177 14461
```

```
plot(fit)
```




```
# Mean, SD, HDI
qi_mean <- fit$stats[1, 1]
qi_SD <- fit$stats[1, 2]
qi_hdi_low <- fit$stats[1, 5]
qi_hdi_high <- fit$stats[1, 6]

# Posterior probability that correlation is
# greater than 0
post_prob_qi <- fit$stats[1, 7]

print(paste("Posterior probability that the correlation is greater than 0:",
    round(post_prob_qi, 2)))
```

```
## [1] "Posterior probability that the correlation is greater than 0: 0.98"
```

This posterior probability can be evaluated based on the guidelines from (Chechile (2020)) and their extension to posterior probabilities below 0.5 by (Andraszewicz et al. (2015)).

```
if (post_prob_qi < 0.0005){
  evaluation_qi = "Nearing certainty against"
}else if (post_prob_qi < 0.005){
  evaluation_qi = "Very strong bet against"
}else if (post_prob_qi < 0.01){
  evaluation_qi = "Strong bet against - irresponsible to avoid"
}else if (post_prob_qi < 0.1){
  evaluation_qi = "A promising but risky bet against"
}else if (post_prob_qi < 0.25){
  evaluation_qi = "Only a casual bet against"
```

```r
}else if (post_prob_qi < 0.5){
  evaluation_qi = "Not worth betting against"
}else if (post_prob_qi < 0.75){
  evaluation_qi = "Not worth betting on"
}else if (post_prob_qi < 0.9){
  evaluation_qi = "Only a casual bet"
}else if (post_prob_qi < 0.95){
  evaluation_qi = "A promising but risky bet"
}else if (post_prob_qi < 0.99){
  evaluation_qi = "Good bet - too good to disregard"
}else if (post_prob_qi < 0.995){
  evaluation_qi = "Strong bet - irresponsible to avoid"
}else if (post_prob_qi < 0.9995){
  evaluation_qi = "Very strong bet"
}else if (post_prob_qi < 0.99995){
  evaluation_qi = "Nearing certainty"
}else{
  evaluation_qi = "Virtually certain"
}

evaluation_qi
```

```
## [1] "Good bet - too good to disregard"
```

Summary

Below we print a summary of the correlations.

```r
tab <- rbind(c("Ease of doing activities", "Willingness to continue",
    paste(round(ease_mean, 2), "(", round(ease_SD, 2), ")"),
    paste("[", round(ease_hdi_low, 2), ",", round(ease_hdi_high,
        2), "]"), round(post_prob_ease, 5), evaluation_ease))

tab <- rbind(tab, c("Motivation to do activities", "Willingness to continue",
    paste(round(motiv_mean, 2), "(", round(motiv_SD, 2), ")"),
    paste("[", round(motiv_hdi_low, 2), ",", round(motiv_hdi_high,
        2), "]"), round(post_prob_motiv, 5), evaluation_motiv))

tab <- rbind(tab, c("Quitter self-identity", "Willingness to continue",
    paste(round(qi_mean, 2), "(", round(qi_SD, 2), ")"), paste("[",
        round(qi_hdi_low, 2), ",", round(qi_hdi_high, 2), "]"),
    round(post_prob_qi, 2), evaluation_qi))

colnames(tab) = c("User variable", "Attitude question", "Mean (SD)",
    "95% CI", "Post > 0", "Evaluation")

pander(tab, caption = "Results of Bayesian analyses of Pearson correlations between user variables and a
```

Table 1: Results of Bayesian analyses of Pearson correlations between user variables and attitude ratings. (continued below)

User variable	Attitude question	Mean (SD)
Ease of doing activities	Willingness to continue	0.33 (0.04)

User variable	Attitude question	Mean (SD)
Motivation to do activities	Willingness to continue	0.48 (0.04)
Quitter self-identity	Willingness to continue	0.09 (0.05)

95% CI	Post > 0	Evaluation
[0.25 , 0.41]	0.99993	Nearing certainty
[0.4 , 0.54]	0.99993	Nearing certainty
[0 , 0.19]	0.98	Good bet - too good to disregard

References

Andraszewicz, Sandra, Benjamin Scheibehenne, Jörg Rieskamp, Raoul Grasman, Josine Verhagen, and Eric-Jan Wagenmakers. 2015. "An Introduction to Bayesian Hypothesis Testing for Management Research." *Journal of Management* 41 (2): 521–43.

Chechile, Richard A. 2020. *Bayesian Statistics for Experimental Scientists: A General Introduction Using Distribution-Free Methods.* MIT Press.