MileStone 2

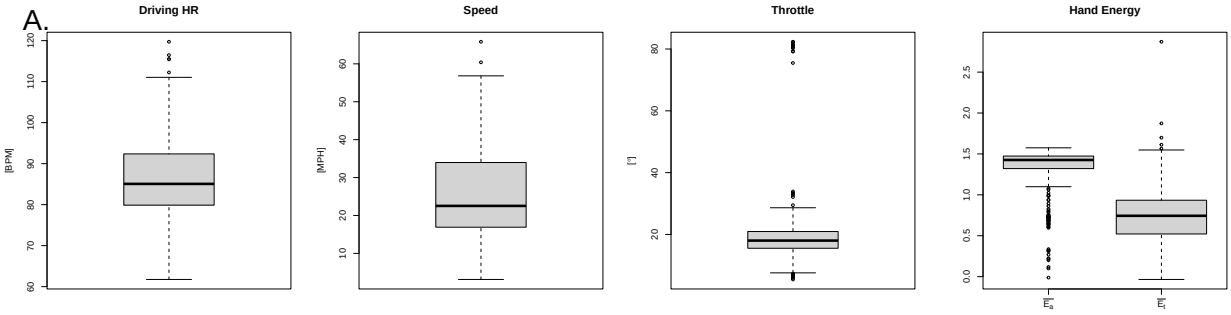
Team 19

2023-04-30

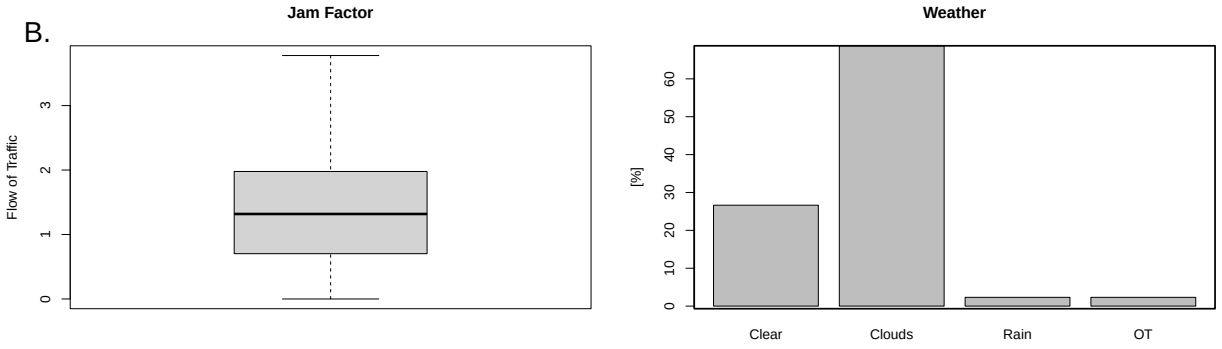
Contents

Exploratory Plots

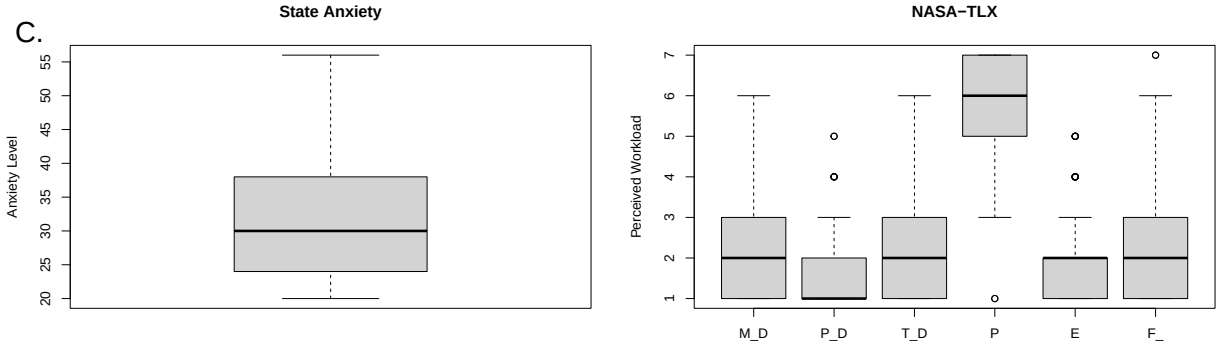
A.



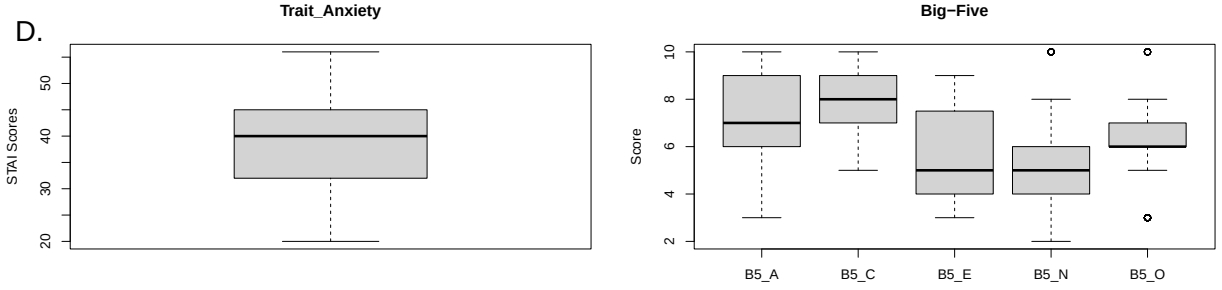
B.



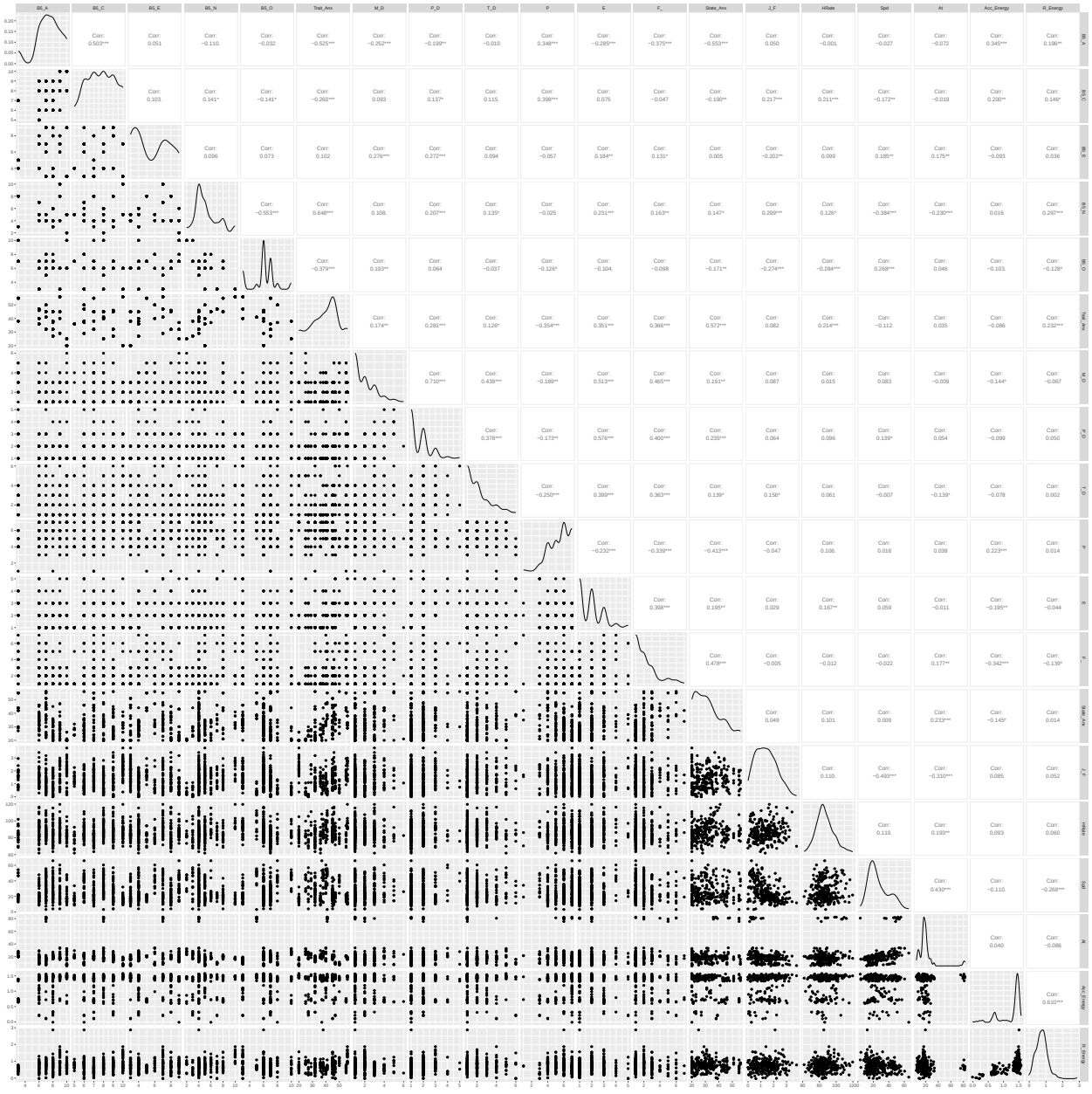
C.



D.



Correlation Matrix

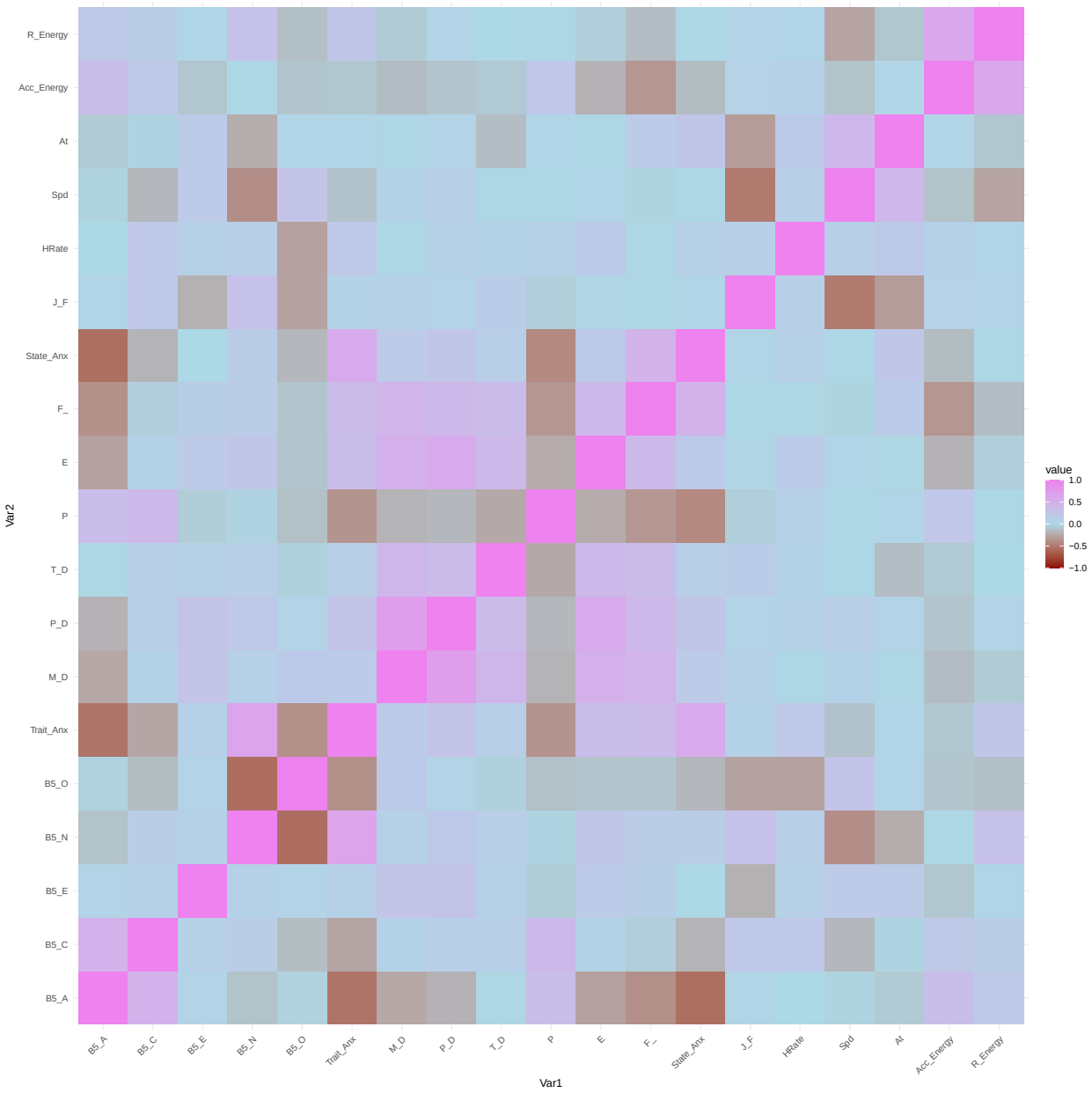


Observations:

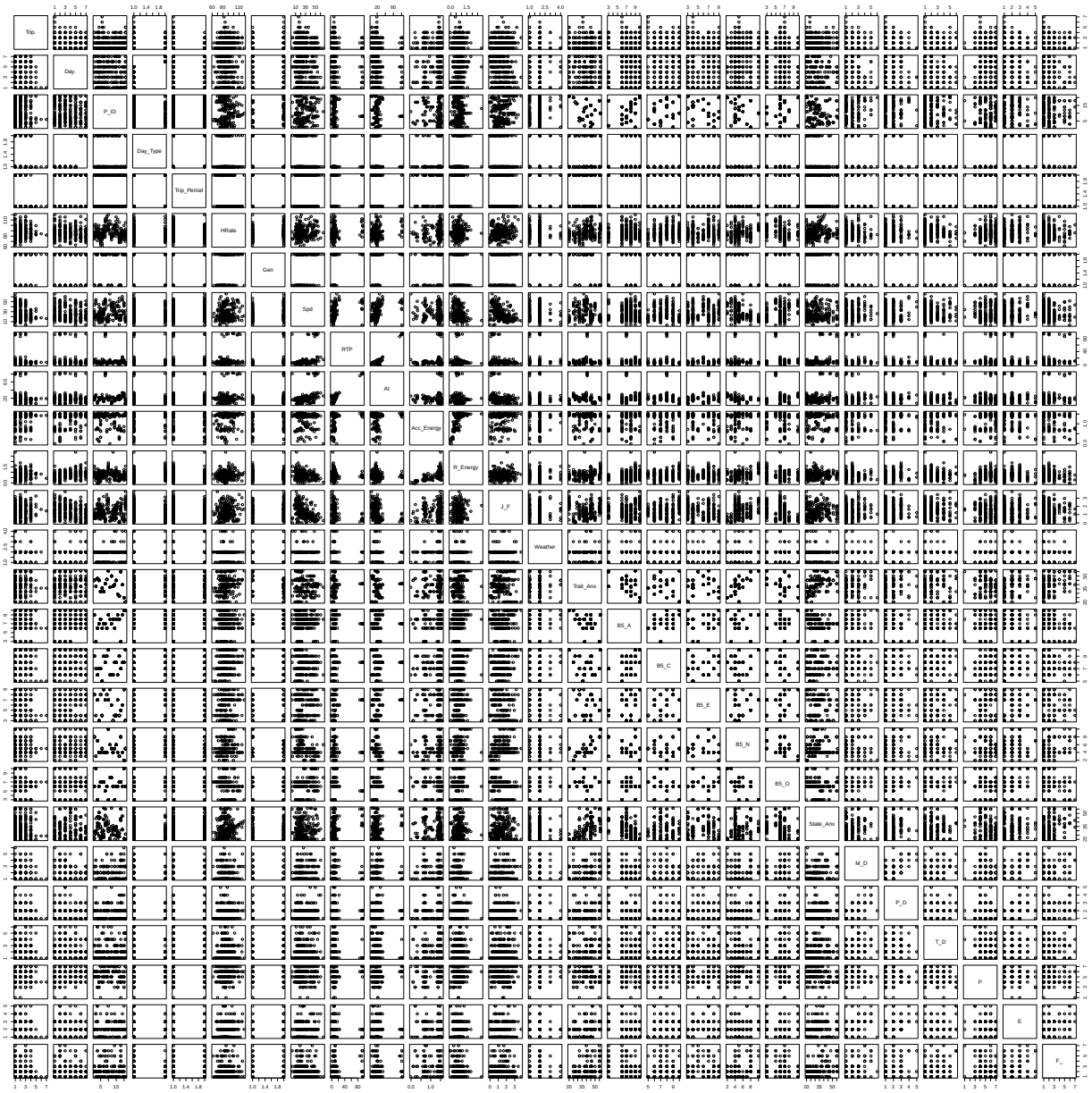
From the above matrix, Since all the correlation values are less than 0.8, we can observe that there is no high collinearity between any two of the predictor variables.

```
##                  B5_A        B5_C         B5_E        B5_N        B5_O
## B5_A        1.000000000  0.50300889  0.051164352 -0.11030233 -0.03236693
## B5_C        0.503008890  1.00000000  0.103072553  0.14103529 -0.14122393
## B5_E        0.051164352  0.10307255  1.000000000  0.09632856  0.07272798
## B5_N       -0.110302328  0.14103529  0.096328558  1.00000000 -0.55335787
## B5_O       -0.032366930 -0.14122393  0.072727975 -0.55335787  1.00000000
## Trait_Anx  -0.525168024 -0.25968369  0.102285943  0.64782385 -0.37862438
## M_D        -0.251854536  0.08278050  0.275611107  0.10753681  0.19281439
## P_D        -0.199478004  0.13723573  0.271692010  0.20749769  0.06369622
## T_D        -0.010486704  0.11452966  0.094039760  0.13504107 -0.03667249
## P           0.348092873  0.39841750 -0.056983033 -0.02536895 -0.12554655
## E          -0.284809387  0.07546857  0.184131658  0.23062362 -0.10386185
## F_         -0.374695606 -0.04744760  0.131051467  0.16347435 -0.09757263
## State_Anx  -0.552791759 -0.19048529  0.004846024  0.14659268 -0.17136585
## J_F         0.050077262  0.21709413 -0.202018288  0.29881973 -0.27448705
## HRate      -0.001227037  0.21083499  0.098784340  0.12646252 -0.28393943
## Spd        -0.026501916 -0.17224791  0.184611381 -0.38418816  0.26841389
## At         -0.071803282 -0.01906093  0.175245743 -0.22954836  0.04607272
## Acc_Energy  0.345191628  0.19990519 -0.092836805  0.01644709 -0.10278978
## R_Energy    0.195586773  0.14621130  0.036297087  0.29651275 -0.12768455
##               Trait_Anx          M_D         P_D          T_D           P
## B5_A       -0.52516802 -0.251854536 -0.19947800 -0.010486704  0.34809287
## B5_C       -0.25968369  0.082780499  0.13723573  0.114529661  0.39841750
## B5_E        0.10228594  0.275611107  0.27169201  0.094039760 -0.05698303
## B5_N        0.64782385  0.107536812  0.20749769  0.135041071 -0.02536895
## B5_O       -0.37862438  0.192814394  0.06369622 -0.036672485 -0.12554655
## Trait_Anx   1.00000000  0.174419237  0.28095545  0.126424966 -0.35414445
## M_D         0.17441924  1.000000000  0.70994880  0.439487825 -0.18893859
## P_D         0.28095545  0.709948802  1.00000000  0.377599185 -0.17337346
## T_D         0.12642497  0.439487825  0.37759918  1.000000000 -0.24966032
## P          -0.35414445 -0.188938590 -0.17337346 -0.249660320  1.00000000
## E           0.35105711  0.513132754  0.57636938  0.399047757 -0.23196271
## F_          0.36584590  0.464882859  0.39973998  0.362626740 -0.33887158
## State_Anx   0.57206087  0.190758448  0.23475050  0.139299681 -0.41271375
## J_F         0.08235347  0.087084045  0.06402500  0.155991502 -0.04728379
## HRate       0.21409124  0.015295874  0.09609649  0.061451587  0.10559866
## Spd        -0.11199563  0.082844014  0.13929716 -0.006687623  0.01623625
## At          0.03546549 -0.008874941  0.05409371 -0.138825853  0.03805085
## Acc_Energy -0.08638242 -0.143753681 -0.09947562 -0.077977115  0.22285574
## R_Energy    0.23248040 -0.067020151  0.05033977  0.001585467  0.01421644
##                     E           F_    State_Anx          J_F        HRate
## B5_A       -0.28480939 -0.374695606 -0.552791759  0.050077262 -0.001227037
## B5_C        0.07546857 -0.047447598 -0.190485293  0.217094133  0.210834988
## B5_E        0.18413166  0.131051467  0.004846024 -0.202018288  0.098784340
## B5_N        0.23062362  0.163474346  0.146592678  0.298819734  0.126462522
## B5_O       -0.10386185 -0.097572626 -0.171365852 -0.274487052 -0.283939429
## Trait_Anx   0.35105711  0.365845900  0.572060872  0.082353466  0.214091240
## M_D         0.51313275  0.464882859  0.190758448  0.087084045  0.015295874
## P_D         0.57636938  0.399739983  0.234750501  0.064025003  0.096096486
## T_D         0.39904776  0.362626740  0.139299681  0.155991502  0.061451587
## P          -0.23196271 -0.338871584 -0.412713751 -0.047283787  0.105598662
## E           1.00000000  0.398252470  0.194673245  0.029356403  0.166709102
## F_          0.39825247  1.000000000  0.477933300 -0.004886311 -0.011663093
## State_Anx   0.19467325  0.477933300  1.000000000  0.048576104  0.100521468
```

```
## J_F         0.02935640 -0.004886311  0.048576104  1.000000000  0.109595992
## HRate       0.16670910 -0.011663093  0.100521468  0.109595992  1.000000000
## Spd         0.05908156 -0.021980654  0.009163098 -0.493083406  0.118759239
## At         -0.01145117  0.176666989  0.232918061 -0.310166861  0.193102574
## Acc_Energy -0.19479627 -0.341679800 -0.145244351  0.085152654  0.093402828
## R_Energy   -0.04387630 -0.139071119  0.014360029  0.051851883  0.059829959
##                    Spd           At  Acc_Energy     R_Energy
## B5_A       -0.026501916 -0.071803282  0.34519163  0.195586773
## B5_C       -0.172247912 -0.019060932  0.19990519  0.146211297
## B5_E        0.184611381  0.175245743 -0.09283680  0.036297087
## B5_N       -0.384188161 -0.229548361  0.01644709  0.296512747
## B5_O        0.268413894  0.046072724 -0.10278978 -0.127684549
## Trait_Anx  -0.111995634  0.035465490 -0.08638242  0.232480398
## M_D         0.082844014 -0.008874941 -0.14375368 -0.067020151
## P_D         0.139297163  0.054093710 -0.09947562  0.050339766
## T_D        -0.006687623 -0.138825853 -0.07797712  0.001585467
## P           0.016236253  0.038050852  0.22285574  0.014216439
## E           0.059081565 -0.011451166 -0.19479627 -0.043876304
## F_         -0.021980654  0.176666989 -0.34167980 -0.139071119
## State_Anx   0.009163098  0.232918061 -0.14524435  0.014360029
## J_F        -0.493083406 -0.310166861  0.08515265  0.051851883
## HRate       0.118759239  0.193102574  0.09340283  0.059829959
## Spd         1.000000000  0.430479141 -0.10971389 -0.268140485
## At          0.430479141  1.000000000  0.04007207 -0.086079949
## Acc_Energy -0.109713888  0.040072069  1.00000000  0.610030384
## R_Energy   -0.268140485 -0.086079949  0.61003038  1.000000000
```


R_Energy
Acc_Energy
At
Spd
HRate
J_F
State_Anx
F_
E
P
T_D
P_D
M_D
Trait_Anx
B5_O
B5_N
B5_E
B5_C
B5_A
Var2
B5_A
B5_C
B5_E
B5_N
B5_O
Trait_Anx
M_D
P_D
T_D
P
E
F_
State_Anx
J_F
HRate
Spd
At
Acc_Energy
R_Energy
Var1
value
1.0
0.5
0.0
−0.5
−1.0

Cross-Correlation plots



Full Model

Full Model Summary

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: HRate ~ Day_Type + Trip_Period + Gen + RTP + Spd + At + Acc_Energy +
##     R_Energy + J_F + Weather + Trait_Anx + B5_A + B5_C + B5_N +
##     B5_E + B5_O + State_Anx + M_D + P_D + T_D + P + E + F_ +      (1 | P_ID)
##    Data: df
##
##      AIC      BIC   logLik deviance df.resid
##   1849.5   1941.9   -898.7   1797.5      233
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.6396 -0.6161 -0.0960  0.5153  3.2729
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  P_ID     (Intercept) 10.43    3.229
##  Residual             55.04    7.419
## Number of obs: 259, groups:  P_ID, 21
##
## Fixed effects:
##                     Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         43.44125   14.07558  16.91851   3.086 0.006728 **
## Day_TypeWeekEnd     -2.65257    1.28442 245.85140  -2.065 0.039954 *
## Trip_PeriodMorning  -4.49480    1.04975 245.27907  -4.282 2.66e-05 ***
## GenMale              9.56436    2.33952  15.39472   4.088 0.000922 ***
## RTP                 -0.22941    0.13048  43.20360  -1.758 0.085789 .
## Spd                  0.09063    0.05860 217.85323   1.546 0.123438
## At                   0.28802    0.16791  39.61290   1.715 0.094094 .
## Acc_Energy          -0.75715    2.19488 258.96488  -0.345 0.730404
## R_Energy            -1.55529    2.06032 252.99148  -0.755 0.451025
## J_F                  0.12937    0.87067 245.97917   0.149 0.881998
## Weather             -0.88962    0.84905 252.49383  -1.048 0.295737
## Trait_Anx            0.65212    0.18125  16.16209   3.598 0.002377 **
## B5_A                 0.28030    0.68950  18.11046   0.407 0.689116
## B5_C                 2.65232    0.76948  17.36210   3.447 0.003002 **
## B5_N                -0.83675    0.81149  14.22125  -1.031 0.319701
## B5_E                 0.05693    0.46615  12.32750   0.122 0.904768
## B5_O                -0.72197    0.71295  16.73361  -1.013 0.325647
## State_Anx           -0.00755    0.07921 256.80422  -0.095 0.924141
## M_D                 -0.16673    0.76368 258.10245  -0.218 0.827353
## P_D                 -0.64278    0.95523 253.31613  -0.673 0.501621
## T_D                 -0.24372    0.48896 253.28159  -0.498 0.618602
## P                    0.06990    0.58414 218.07412   0.120 0.904861
## E                    0.08637    0.76823 254.05502   0.112 0.910568
## F_                  -0.40975    0.52383 254.47435  -0.782 0.434806
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

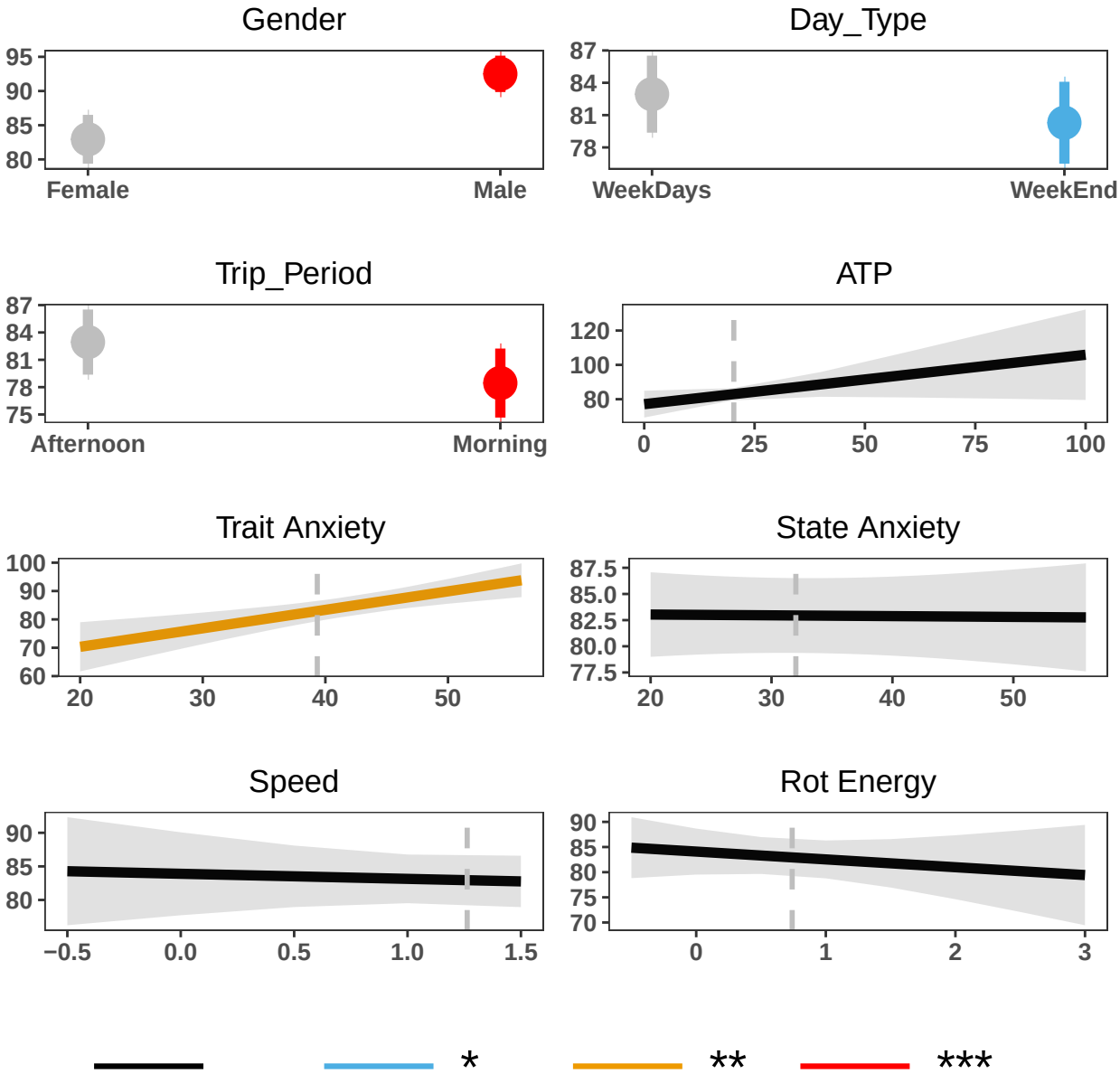
```
## Linear mixed model fit by maximum likelihood  ['lmerModLmerTest']
## Formula: HRate ~ Day_Type + Trip_Period + Gen + RTP + Spd + At + Acc_Energy +
##     R_Energy + J_F + Weather + Trait_Anx + B5_A + B5_C + B5_N +
##     B5_E + B5_O + State_Anx + M_D + P_D + T_D + P + E + F_ +      (1 | P_ID)
##    Data: df
##       AIC       BIC    logLik  deviance  df.resid
## 1849.4629 1941.9405 -898.7315 1797.4629       233
## Random effects:
##  Groups   Name        Std.Dev.
##  P_ID     (Intercept) 3.229
##  Residual             7.419
## Number of obs: 259, groups:  P_ID, 21
## Fixed Effects:
##        (Intercept)     Day_TypeWeekEnd  Trip_PeriodMorning             GenMale
##           43.44125            -2.65257            -4.49480             9.56436
##                RTP                 Spd                  At          Acc_Energy
##           -0.22941             0.09063             0.28802            -0.75715
##           R_Energy                 J_F             Weather           Trait_Anx
##           -1.55529             0.12937            -0.88962             0.65211
##               B5_A                B5_C                B5_N                B5_E
##            0.28030             2.65232            -0.83675             0.05693
##               B5_O           State_Anx                 M_D                 P_D
##           -0.72197            -0.00755            -0.16673            -0.64278
##                T_D                   P                   E                  F_
##           -0.24372             0.06990             0.08638            -0.40975
```

Full Model AIC

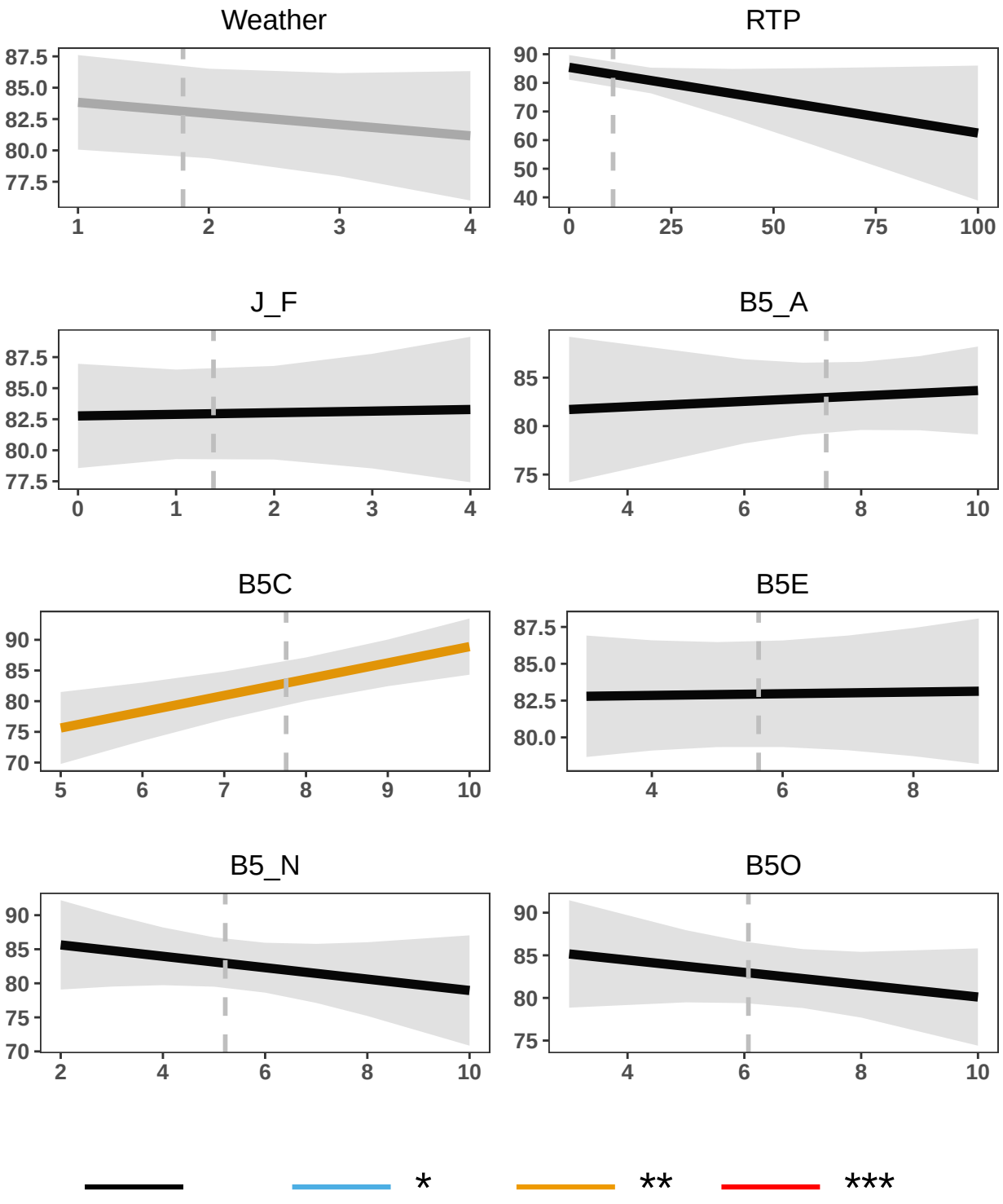
```
## full Model AIC: 1849.463
```

Full Model Plots

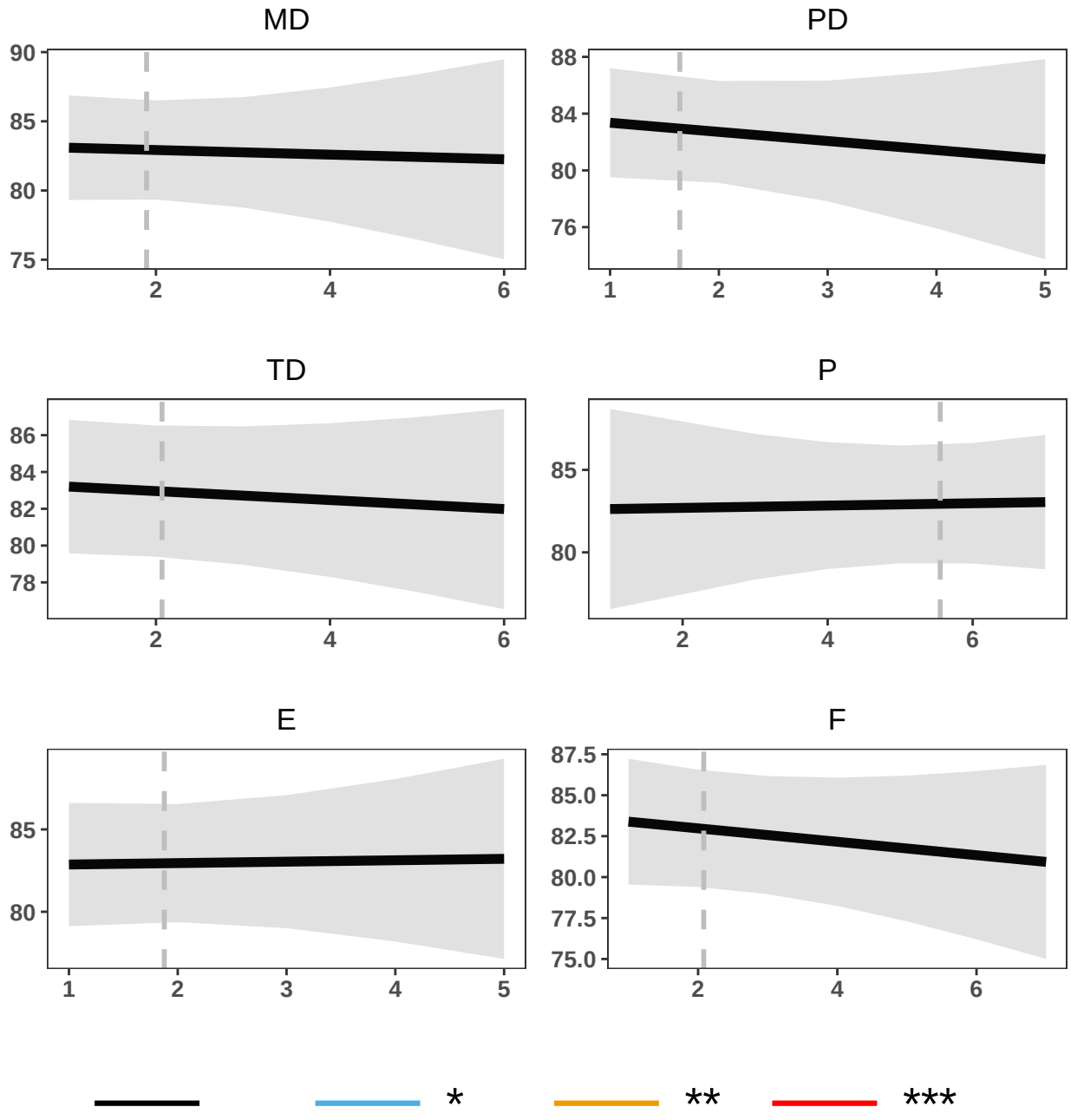
Plots for Gender, Day Type, Trip Period, ATP, Trait Anxiety, State Anxiety



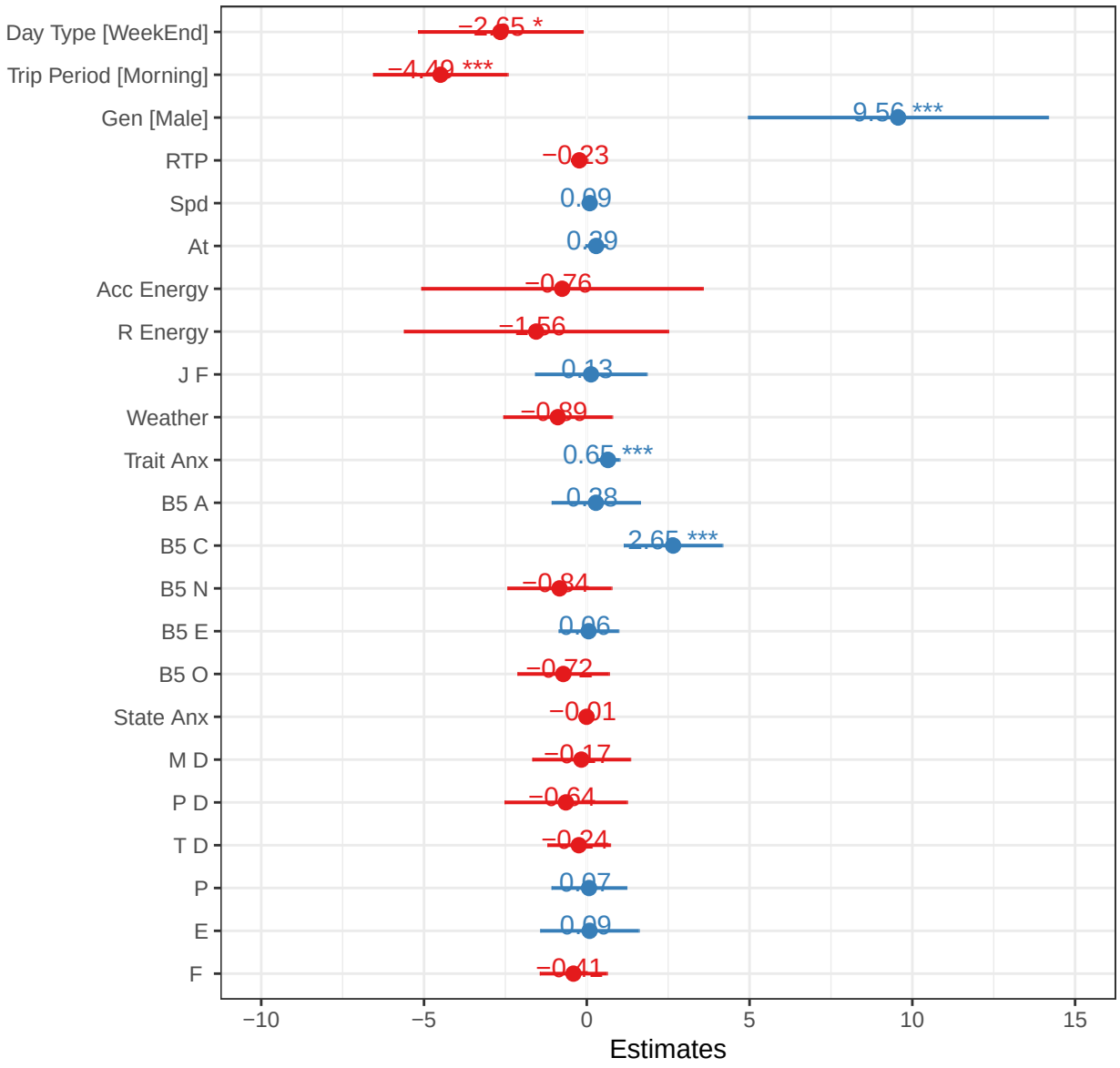
Plots for Weather, JF, B5A, B5C, B5E, B5N, B5O



Plots for MD, PD, TD, P, E, F

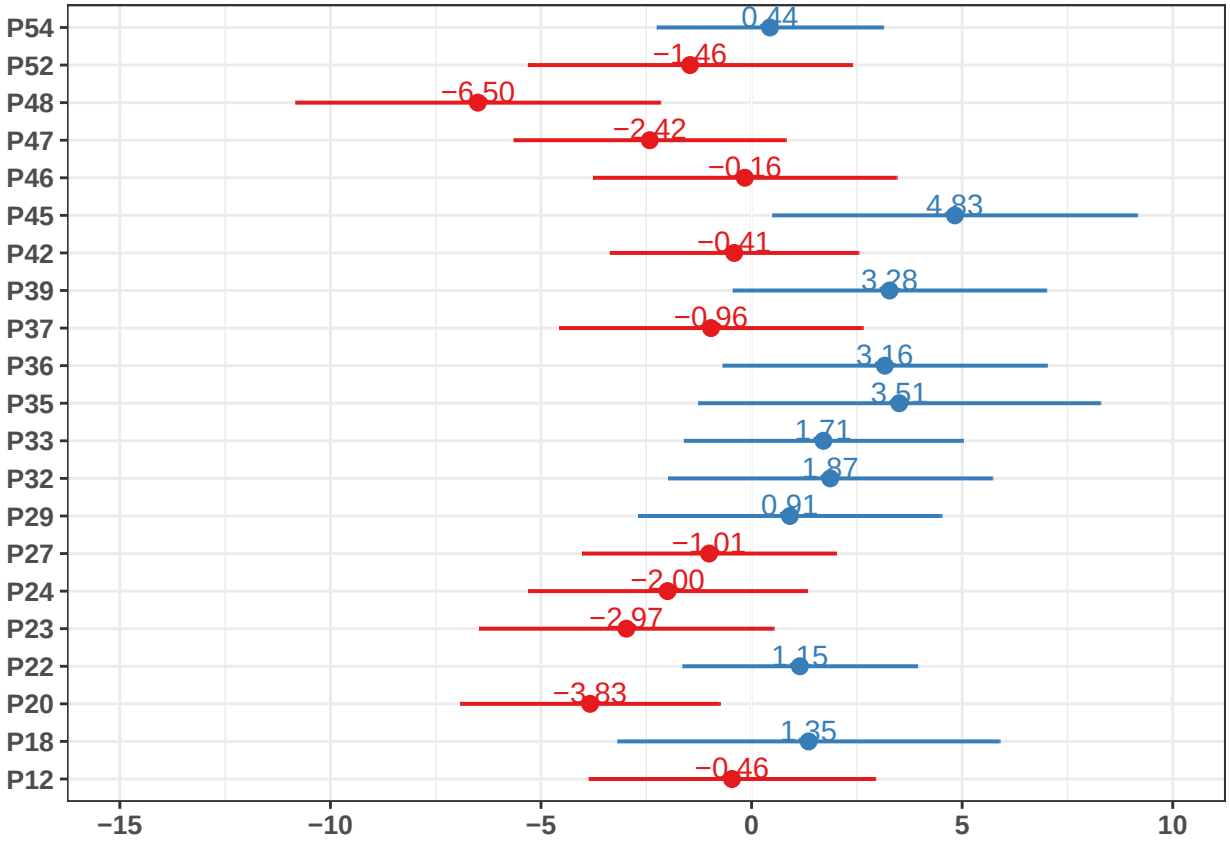


Full Model Predictor Plots



OBSERVATIONS The fixed effects include several variables, such as Day_Type, Trip_Period, Gen, Spd, At, Acc_Energy, R_Energy, J_F, Weather, Trait_Anx, and various personality traits (B5_A, B5_C, B5_N, B5_E, and B5_O). It shows the estimated coefficients for the variables in the model. For example, we can see that the estimated coefficient for Day_TypeWeekEnd is -2.823072, indicating that on average, heart rate is lower on weekends compared to weekdays. Similarly, the coefficient for GenMale is 9.261192, indicating that, on average, males have higher heart rates compared to females.

Full Model Random Effects Plot



Full Model Observations:

This model has groups with a total of 259 Observations.

It includes information about the fixed effects (i.e., the coefficients and standard errors for each predictor variable), the random effects (i.e., the variance of the random intercepts for each participant), and model fit statistics (e.g., AIC, BIC).

The random effects section of the output shows the estimated variance components for the random effects. In this model, there is one random effect, (1|P_ID), which accounts for the variation in heart rate between individuals. The estimated standard deviation of the random intercept is 3.199.

The model also includes a random intercept for each participant, indicating that there is variability in heart rate between participants that is not accounted for by the fixed effects. The variance of the random intercepts is estimated to be 10.24, with a standard deviation of 3.199, indicating that there is considerable individual-level variation in heart rate.

Based on the p-values provided in the output, we can see that several predictor variables are ***SIGNIFICANTLY ASSOCIATED*** with heart rate ($p<0.05$): ***Day_TypeWeekEnd***, ***Trip_PeriodMorning***, ***GenMale***, ***Trait_Anx***, ***B5_C***. This means that individuals who are male, have higher levels of trait anxiety, and travel during weekday mornings have higher heart rates compared to others in this sample. On weekends, heart rates tend to be lower compared to weekdays.

However, other predictor variables, such as Spd, At, Acc_Energy, R_Energy, J_F, Weather, B5_A, B5_N, B5_E, B5_O, State_Anx, M_D, P_D, T_D, P, E, F_ are ***NOT SIGNIFICANTLY*** associated with "Heart rate". Overall, this model suggests that several factors, including individual differences and contextual factors, are associated with heart rate.

Elimination Types including Observations

Backward Elimination Steps

```
## Backward reduced random-effect table:
##
##            Eliminated npar  logLik    AIC    LRT Df Pr(>Chisq)
## <none>                  26 -898.73 1849.5
## (1 | P_ID)          0   25 -901.57 1853.2 5.6838  1    0.01712 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Backward reduced fixed-effect table:
## Degrees of freedom method: Satterthwaite
##
##              Eliminated  Sum Sq Mean Sq NumDF   DenDF F value    Pr(>F)
## State_Anx             1    0.50    0.50     1 256.804  0.0091 0.9241414
## B5_E                  2    0.89    0.89     1  13.082  0.0162 0.9006376
## E                     3    0.93    0.93     1 251.523  0.0169 0.8967681
## P                     4    0.66    0.66     1 214.990  0.0121 0.9126782
## J_F                   5    0.77    0.77     1 233.299  0.0140 0.9060216
## M_D                   6    1.72    1.72     1 258.642  0.0312 0.8598774
## Acc_Energy            7    7.94    7.94     1 257.295  0.1445 0.7041564
## B5_A                  8   10.81   10.81     1  18.776  0.1968 0.6624203
## T_D                   9   15.77   15.77     1 256.597  0.2874 0.5923335
## B5_N                 10   44.86   44.86     1  15.229  0.8161 0.3804030
## B5_O                 11   44.45   44.45     1  21.437  0.8122 0.3774759
## F_                   12   61.23   61.23     1 257.901  1.1199 0.2909396
## Weather              13   58.70   58.70     1 252.369  1.0680 0.3023864
## R_Energy             14   53.04   53.04     1 254.936  0.9602 0.3280698
## P_D                  15  158.14  158.14     1 258.913  2.8512 0.0925105 .
## RTP                  16  159.37  159.37     1  47.114  2.8462 0.0982021 .
## At                   17   14.04   14.04     1  21.011  0.2483 0.6234166
## Day_Type              0  294.81  294.81     1 249.058  5.2056 0.0233582 *
## Trip_Period           0 1079.88 1079.88     1 246.839 19.0679 1.857e-05 ***
## Gen                   0 1098.06 1098.06     1  17.116 19.3890 0.0003827 ***
## Spd                   0  312.97  312.97     1 204.870  5.5262 0.0196836 *
## Trait_Anx             0 1019.45 1019.45     1  16.557 18.0008 0.0005787 ***
## B5_C                  0  695.24  695.24     1  17.136 12.2762 0.0026948 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Model found:
## HRate ~ Day_Type + Trip_Period + Gen + Spd + Trait_Anx + B5_C + (1 | P_ID)
```

Suggested Model by Backward Elimination

Backward model summary

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: HRate ~ Day_Type + Trip_Period + Gen + Spd + Trait_Anx + B5_C +
##     (1 | P_ID)
##    Data: df
##
##      AIC      BIC   logLik deviance df.resid
##   1826.8   1858.8   -904.4   1808.8      250
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.2351 -0.5903 -0.1093  0.4775  3.3613
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  P_ID     (Intercept) 14.04    3.747
##  Residual             56.63    7.526
## Number of obs: 259, groups:  P_ID, 21
##
## Fixed effects:
##                     Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         42.31026    8.57109  19.82364   4.936 8.15e-05 ***
## Day_TypeWeekEnd     -2.74980    1.20522 249.05783  -2.282 0.023358 *
## Trip_PeriodMorning  -4.44547    1.01804 246.83918  -4.367 1.86e-05 ***
## GenMale              9.87560    2.24278  17.11566   4.403 0.000383 ***
## Spd                  0.11290    0.04802 204.87005   2.351 0.019684 *
## Trait_Anx            0.47565    0.11211  16.55697   4.243 0.000579 ***
## B5_C                 2.45979    0.70205  17.13606   3.504 0.002695 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Dy_TWE Trp_PM GenMal Spd    Trt_An
## Dy_TypWkEnd -0.039
## Trp_PrdMrnn -0.079  0.121
## GenMale     -0.471  0.083 -0.008
## Spd         -0.262  0.005 -0.075 -0.090
## Trait_Anx   -0.726  0.024  0.039  0.401  0.081
## B5_C        -0.779 -0.037  0.032  0.171  0.128  0.203
```

Backward model AIC value

```
## backward Model AIC: 1826.779
```

Forward Elimination Steps

```
## Backward reduced random-effect table:
##
##            Eliminated npar  logLik    AIC    LRT Df Pr(>Chisq)
## <none>                  26 -898.73 1849.5
## (1 | P_ID)          0   25 -901.57 1853.2 5.6838  1    0.01712 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Backward reduced fixed-effect table:
## Degrees of freedom method: Satterthwaite
##
##             Eliminated  Sum Sq Mean Sq NumDF   DenDF F value    Pr(>F)
## State_Anx            1    0.50    0.50     1 256.804  0.0091 0.9241414
## B5_E                 2    0.89    0.89     1  13.082  0.0162 0.9006376
## E                    3    0.93    0.93     1 251.523  0.0169 0.8967681
## P                    4    0.66    0.66     1 214.990  0.0121 0.9126782
## J_F                  5    0.77    0.77     1 233.299  0.0140 0.9060216
## M_D                  6    1.72    1.72     1 258.642  0.0312 0.8598774
## Acc_Energy           7    7.94    7.94     1 257.295  0.1445 0.7041564
## B5_A                 8   10.81   10.81     1  18.776  0.1968 0.6624203
## T_D                  9   15.77   15.77     1 256.597  0.2874 0.5923335
## B5_N                10   44.86   44.86     1  15.229  0.8161 0.3804030
## B5_O                11   44.45   44.45     1  21.437  0.8122 0.3774759
## F_                  12   61.23   61.23     1 257.901  1.1199 0.2909396
## Weather             13   58.70   58.70     1 252.369  1.0680 0.3023864
## R_Energy            14   53.04   53.04     1 254.936  0.9602 0.3280698
## P_D                 15  158.14  158.14     1 258.913  2.8512 0.0925105 .
## RTP                 16  159.37  159.37     1  47.114  2.8462 0.0982021 .
## At                  17   14.04   14.04     1  21.011  0.2483 0.6234166
## Day_Type             0  294.81  294.81     1 249.058  5.2056 0.0233582 *
## Trip_Period          0 1079.88 1079.88     1 246.839 19.0679 1.857e-05 ***
## Gen                  0 1098.06 1098.06     1  17.116 19.3890 0.0003827 ***
## Spd                  0  312.97  312.97     1 204.870  5.5262 0.0196836 *
## Trait_Anx            0 1019.45 1019.45     1  16.557 18.0008 0.0005787 ***
## B5_C                 0  695.24  695.24     1  17.136 12.2762 0.0026948 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Model found:
## HRate ~ Day_Type + Trip_Period + Gen + Spd + Trait_Anx + B5_C + (1 | P_ID)
```

Suggested Model by Forward Elimination

Forward model summary

```
## Linear mixed model fit by maximum likelihood  ['lmerModLmerTest']
## Formula: HRate ~ Day_Type + Trip_Period + Gen + Spd + Trait_Anx + B5_C +
##     (1 | P_ID)
##    Data: df
##       AIC       BIC    logLik  deviance  df.resid
## 1826.7793 1858.7907 -904.3896 1808.7793       250
## Random effects:
##  Groups   Name        Std.Dev.
##  P_ID     (Intercept) 3.747
##  Residual             7.526
## Number of obs: 259, groups:  P_ID, 21
## Fixed Effects:
##        (Intercept)     Day_TypeWeekEnd  Trip_PeriodMorning             GenMale
##            42.3103             -2.7498             -4.4455              9.8756
##                Spd           Trait_Anx               B5_C
##             0.1129              0.4756              2.4598
```

Forward model AIC value

```
## forward Model AIC: 1826.779
```

Both Direction stepwise Elimination

```
## Backward reduced random-effect table:
##
##            Eliminated npar  logLik    AIC    LRT Df Pr(>Chisq)
## <none>                  26 -898.73 1849.5
## (1 | P_ID)          0   25 -901.57 1853.2 5.6838  1    0.01712 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Backward reduced fixed-effect table:
## Degrees of freedom method: Satterthwaite
##
##             Eliminated  Sum Sq Mean Sq NumDF   DenDF F value    Pr(>F)
## State_Anx            1    0.50    0.50     1 256.804  0.0091 0.9241414
## B5_E                 2    0.89    0.89     1  13.082  0.0162 0.9006376
## E                    3    0.93    0.93     1 251.523  0.0169 0.8967681
## P                    4    0.66    0.66     1 214.990  0.0121 0.9126782
## J_F                  5    0.77    0.77     1 233.299  0.0140 0.9060216
## M_D                  6    1.72    1.72     1 258.642  0.0312 0.8598774
## Acc_Energy           7    7.94    7.94     1 257.295  0.1445 0.7041564
## B5_A                 8   10.81   10.81     1  18.776  0.1968 0.6624203
## T_D                  9   15.77   15.77     1 256.597  0.2874 0.5923335
## B5_N                10   44.86   44.86     1  15.229  0.8161 0.3804030
## B5_O                11   44.45   44.45     1  21.437  0.8122 0.3774759
## F_                  12   61.23   61.23     1 257.901  1.1199 0.2909396
## Weather             13   58.70   58.70     1 252.369  1.0680 0.3023864
## R_Energy            14   53.04   53.04     1 254.936  0.9602 0.3280698
## P_D                 15  158.14  158.14     1 258.913  2.8512 0.0925105 .
## RTP                 16  159.37  159.37     1  47.114  2.8462 0.0982021 .
## At                  17   14.04   14.04     1  21.011  0.2483 0.6234166
## Day_Type             0  294.81  294.81     1 249.058  5.2056 0.0233582 *
## Trip_Period          0 1079.88 1079.88     1 246.839 19.0679 1.857e-05 ***
## Gen                  0 1098.06 1098.06     1  17.116 19.3890 0.0003827 ***
## Spd                  0  312.97  312.97     1 204.870  5.5262 0.0196836 *
## Trait_Anx            0 1019.45 1019.45     1  16.557 18.0008 0.0005787 ***
## B5_C                 0  695.24  695.24     1  17.136 12.2762 0.0026948 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Model found:
## HRate ~ Day_Type + Trip_Period + Gen + Spd + Trait_Anx + B5_C + (1 | P_ID)
```

Suggested Model by Stepwise Direction

Stepwise Direction Model summary

```
## Linear mixed model fit by maximum likelihood  ['lmerModLmerTest']
## Formula: HRate ~ Day_Type + Trip_Period + Gen + Spd + Trait_Anx + B5_C +
##     (1 | P_ID)
##    Data: df
##       AIC       BIC    logLik  deviance  df.resid
## 1826.7793 1858.7907 -904.3896 1808.7793       250
## Random effects:
##  Groups   Name        Std.Dev.
##  P_ID     (Intercept) 3.747
##  Residual             7.526
## Number of obs: 259, groups:  P_ID, 21
## Fixed Effects:
##        (Intercept)     Day_TypeWeekEnd  Trip_PeriodMorning             GenMale
##            42.3103             -2.7498             -4.4455              9.8756
##                Spd           Trait_Anx               B5_C
##             0.1129              0.4756              2.4598
```

Stepwise direction Model AIC value

```
## Stepwise Model AIC: 1826.779
```

Observations and Conclusions

We can see that all three types of Elimination process gave the same results.

From the results, we can see that several variables were eliminated in the elimination process and got the same for three types of elimination processes. The "Day_Type" and "Trip_Period" variables were the only two that were statistically significant at the 0.05 level, with p-values of 0.022471 and 1.845e-05, respectively. This suggests that these two variables are important predictors of the response variable.

The other variables that were eliminated during the selection process were not statistically significant at the 0.05 level, indicating that they did not have a significant impact on the response variable.

Significant variables:

Day_Type ($p = 0.02335$): The type of day (weekday or weekend) has a significant effect on the outcome.

Trip_Period ($p < 0.0001$): The time of day when the trip is taken has a significant effect on the outcome.

Gen ($p = 0.00038$): The gender of the driver has a significant effect on the outcome.

Spd ($p = 0.01968$): The speed of the vehicle has a significant effect on the outcome.

Trait_Anx ($p = 0.00057$): The driver's level of trait anxiety has a significant effect on the outcome.

B5_C ($p = 0.0026$): The driver's level of agreeableness (B5_C) has a significant effect on the outcome.

Non-significant variables:

M_D, J_F, B5_E, State_Anx, P, E, B5_A, At, Acc_Energy, B5_O, B5_N, T_D, Weather, F_, R_Energy, P_D.

Optimal Model including Observations and Conclusions

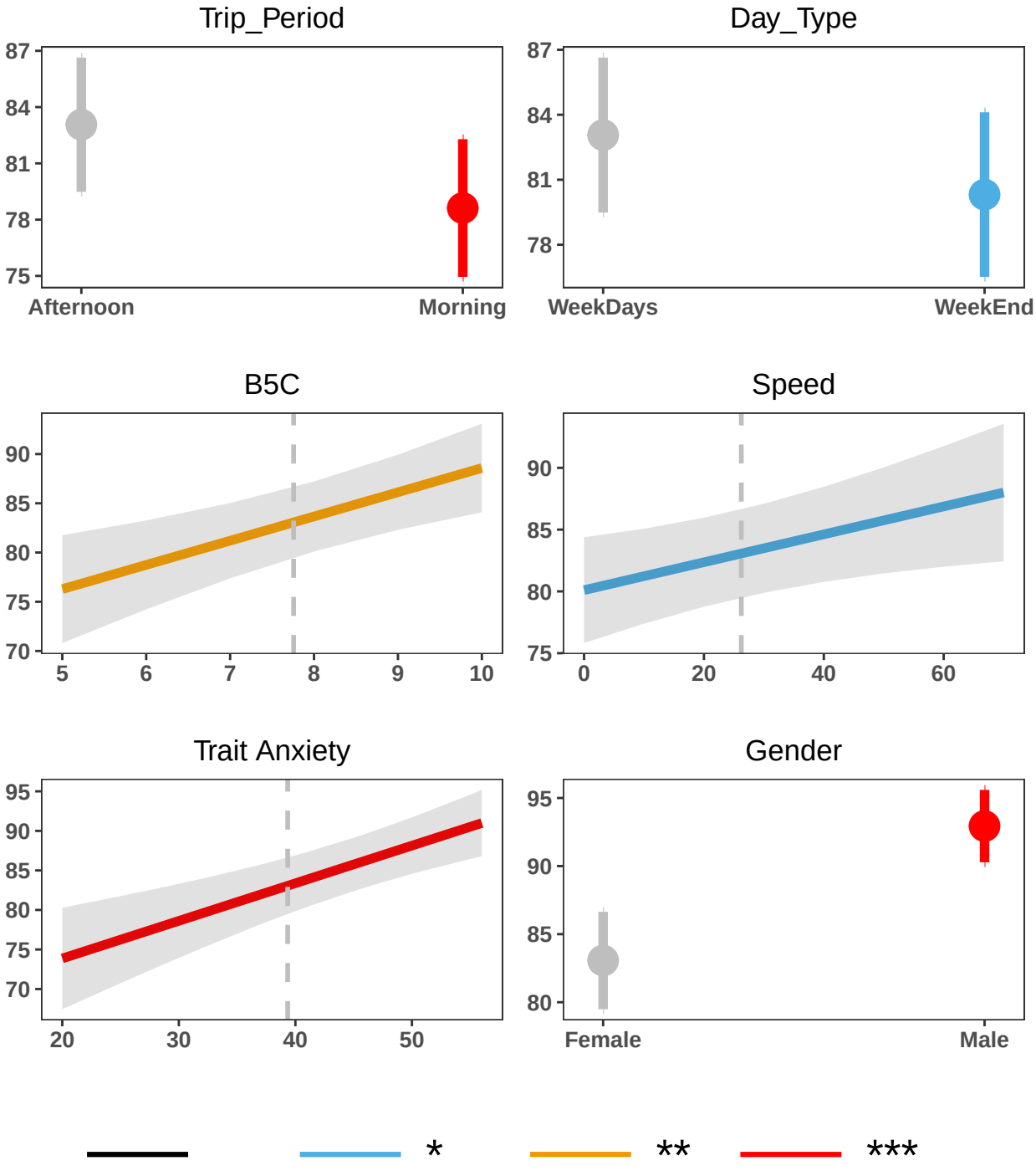
```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: HRate ~ Day_Type + Trip_Period + Gen + Spd + Trait_Anx + B5_C +
##     (1 | P_ID)
##    Data: df
##
##      AIC      BIC   logLik deviance df.resid
##   1826.8   1858.8   -904.4   1808.8      250
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.2351 -0.5903 -0.1093  0.4775  3.3613
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  P_ID     (Intercept) 14.04    3.747
##  Residual             56.63    7.526
## Number of obs: 259, groups:  P_ID, 21
##
## Fixed effects:
##                     Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         42.31026    8.57109  19.82364   4.936 8.15e-05 ***
## Day_TypeWeekEnd     -2.74980    1.20522 249.05783  -2.282 0.023358 *
## Trip_PeriodMorning  -4.44547    1.01804 246.83918  -4.367 1.86e-05 ***
## GenMale              9.87560    2.24278  17.11566   4.403 0.000383 ***
## Spd                  0.11290    0.04802 204.87005   2.351 0.019684 *
## Trait_Anx            0.47565    0.11211  16.55697   4.243 0.000579 ***
## B5_C                 2.45979    0.70205  17.13606   3.504 0.002695 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Dy_TWE Trp_PM GenMal Spd    Trt_An
## Dy_TypWkEnd -0.039
## Trp_PrdMrnn -0.079  0.121
## GenMale     -0.471  0.083 -0.008
## Spd         -0.262  0.005 -0.075 -0.090
## Trait_Anx   -0.726  0.024  0.039  0.401  0.081
## B5_C        -0.779 -0.037  0.032  0.171  0.128  0.203
```

Observations We're supposed to choose the lowest (AIC) one. However in our case all are same, we can choose any of them to plot. The model suggested by backward elimination is chosen for the optimal model.

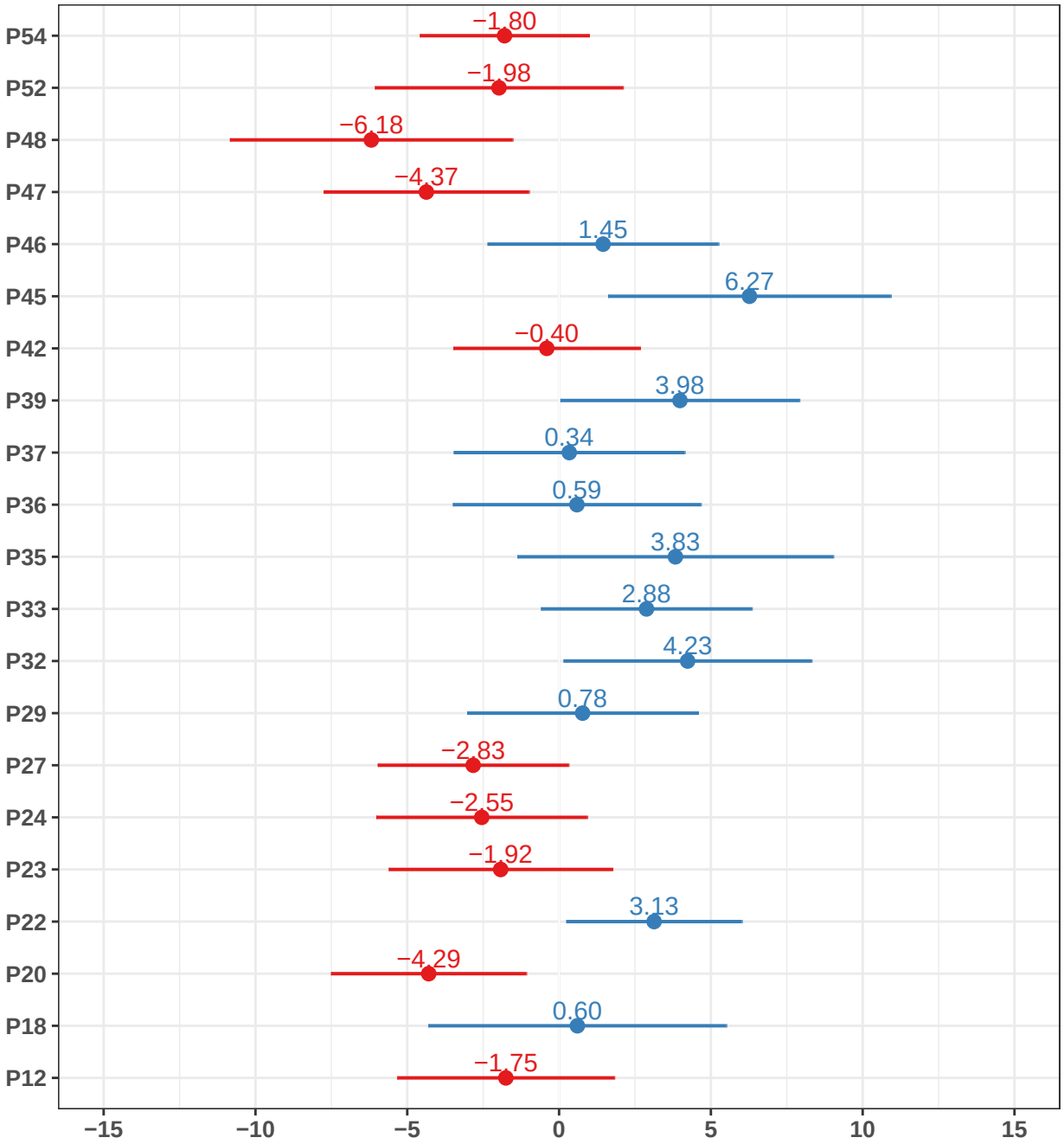
Optimal Model AIC

```
## Optimal Model AIC: 1826.779
```

Optimal Model Plots

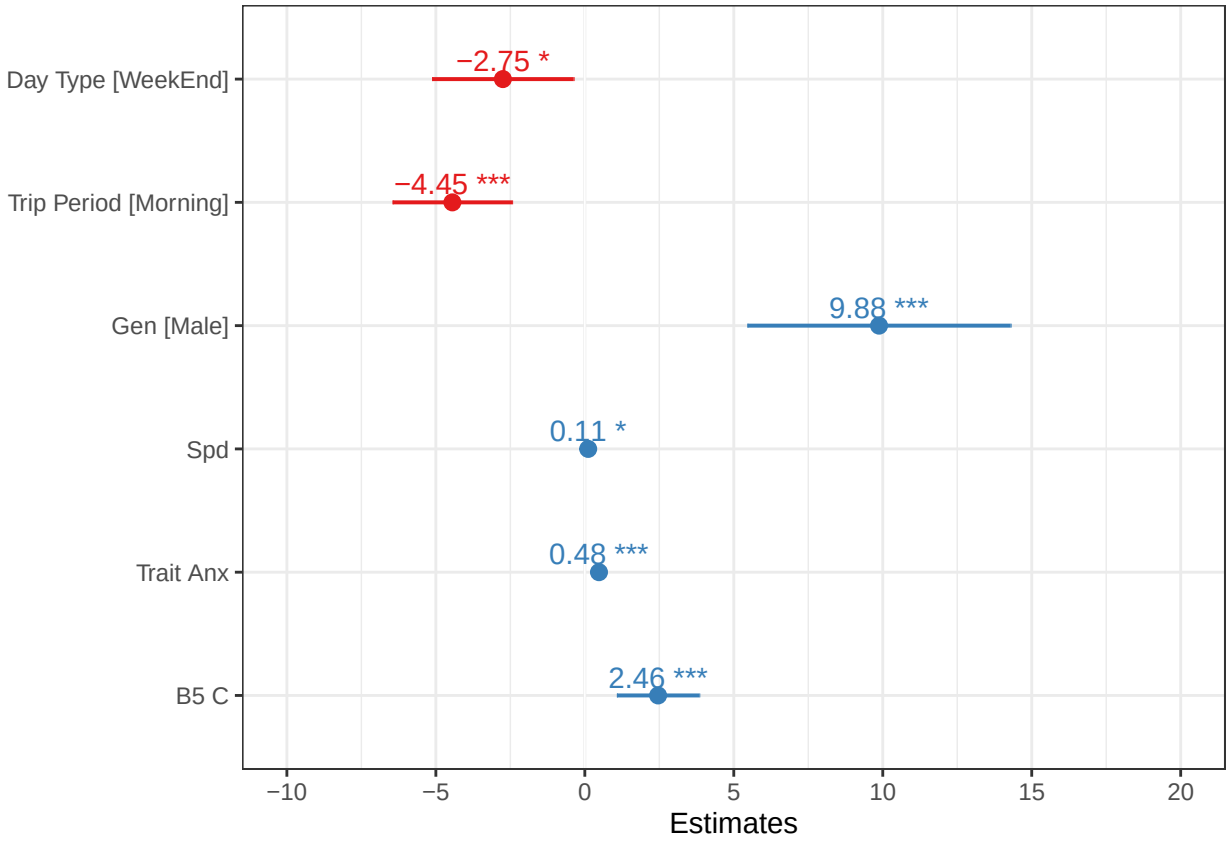


Optimal Model Random Effects Plot



Observations The random effects output shows that the variation in HRate is partially due to differences between P_IDs, with a random intercept variance of 14.04, and the residual variance is 56.63

Optimal model Predictor Plots



OBSERVATIONS AND CONCLUSIONS

The final model found is:

HRate ~ Day_Type + Trip_Period + Gen + Spd + Trait_Anx + B5_C + (1 | P_ID)

Based on the backward reduction steps, we can conclude that:

None of the fixed effects B5_E, E, M_D, P, J_F, At, State_Anx, B5_A, R_Energy, T_D, B5_O, B5_N, Weather, Acc_Energy, and F significantly explain the variation in HRate. Removing any of these fixed effects did not significantly impact the log-likelihood or AIC of the model.

The fixed effects Day_Type, Trip_Period, Gen, Spd, Trait_Anx, and B5_C significantly affect the variation in HRate. Removing any of these fixed effects resulted in a significant increase in AIC, indicating that they should be included in the final model.

Regarding the categorical predictors, compared to Day_TypeWeekday, the HRate during Day_TypeWeekend is significantly lower by 2.75 beats per minute (BPM). Similarly, compared to Trip_PeriodAfternoon, the HRate during Trip_PeriodMorning is significantly lower by 4.45 BPM.

The gender variable (Gen) has a significant positive effect on HRate, indicating that, on average, males have a higher HRate than females by 9.88 BPM.

Additionally, both Spd and Trait_Anx are positively associated with HRate, which means that as they increase, HRate also increases. Finally, the B5_C variable has a significant positive effect on HRate, suggesting that individuals with higher levels of B5_C have a higher HRate.