Predispositions define a pro-environmental attitude

Mario Schmiedebach & Vivienne Litzke

Abstract

The awareness of pressing environmental issues such as climate change, pollution and deforestation – all anthropogenic effects – has tremendously increased during the last few years. Recently initiated by Swedish climate activist Greta Thunberg, both students and the general public demand political changes to find immediate solutions to combat the destruction of our planet. It has been suggested that pro-environmental attitude strongly depends on sociodemographic factors and cultural context. In our study, we investigated the relationship between gender, age, education level, pro-environmental behavior (Fridays for Future movement participation) and environmental attitude in 222 high-school students in the region Ostwestfalen-Lippe in Germany. We found significant relationships between all assessed factors and environmental attitude. Our results suggest influential implications in the field of environmental attitude research by using predisposition data to create effective programs about environmental awareness in school.

Preface

This is an R Markdown document that will be used to recreate the analyses in our NEP paper. It is recommended to download or clone the Rmarkdown file and data from the accompanying GitHub repository to access the documentation together with all the files that are needed to repeat analyses shown in this document. Just click on the link above and then on the green box `Clone or download`. In order to function properly, the same structure of folders must be kept. If you have any questions, do not hesitate to contact vivienne.litzke@gmail.com.

The data originates from students participating in the project "Biology up close" which takes place within an external laboratory at Bielefeld University for high school classes in Ostwestfalen-Lippe, Germany.[1] The project offers multiple workshops varying from marine biology, bionics, photosynthesis and enzymatic reactions.

To measure environmental attitude, a German translation of the revised "New Ecological Paradigm Scale" (NEP) was used and calculated as the average score from the 15 NEP items.[2] Furthermore, students were asked if they participated in the FFF-movement to measure pro-ecological behavior. Finally, school type, gender and age were recorded.

[1] Wegner, C., & Strehlke, F. (2015). The Benefits of the German Science Project 'Biology Up Close'. Nordic Studies in Science Education, 11, 304–312. https://doi.org/10.5617/nordina.902

[2] Schleyer-Lindenmann, A., Ittner, H., Dauvier, B., & Piolat, M. (2018). Die NEP-Skala – hinter den (deutschen) Kulissen des Umweltbewusstseins. Diagnostica, 64, 156–167. https://doi.org/10.1026/0012-1924/a000202

Download packages and libraries

In order to repeat analyses, a number of packages that extend the functionalities of base `R` are required. These can be installed using the code shown below.

```
install.packages("readxl")
install.packages("dplyr")
install.packages("tidyr")
install.packages("ggplot2")
install.packages("ggpubr")
```

Load the packages.

```
library(readxl)
library(car)
library(dplyr)
library(tidyr)
library(ggplot2)
library(ggpubr)
```

Working with the Raw Data

First we have to open the file.

```
data <- read_excel("NEP_Arbeitsdatensatz.xlsx")
```

Here is what it looks like

```
knitr::kable(head(data[1:10, 1:8], "simple"))
```

Geschlecht	Schulform	Jahrgangsstufe	Kursart	Alter	NEP_1	NEP_2_Rec	NEP_3
2	1	5	1	16	4	5	4
1	1	5	1	15	6	3	6
1	1	5	1	16	5	2	4
2	1	5	1	15	5	4	NA
2	1	5	1	16	5	5	5
2	1	5	1	15	5	4	5
2	999	5	1	16	4	3	4
2	1	5	1	15	4	5	4
2	1	5	1	16	4	3	5
2	1	999	1	15	4	5	5

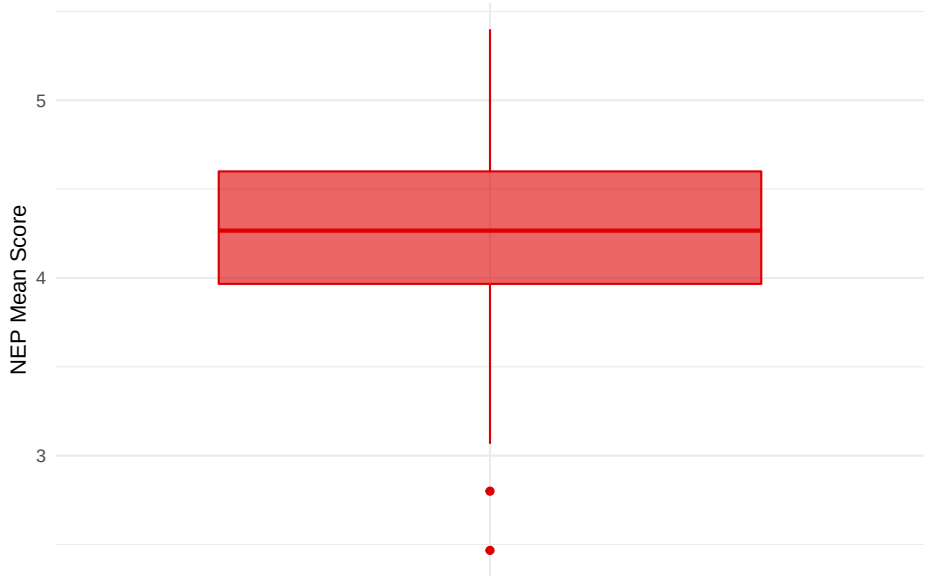
There a few things we would like to do to organize our data. For example, some of the students did not answer the questions correctly or at all.

```
# Replace missing data (coded as 999) with NA and drop rows with NA in Geschlecht and FFF
data <- na_if(data, 999)
data <- subset(data,is.na(data$Geschlecht)==FALSE)
```

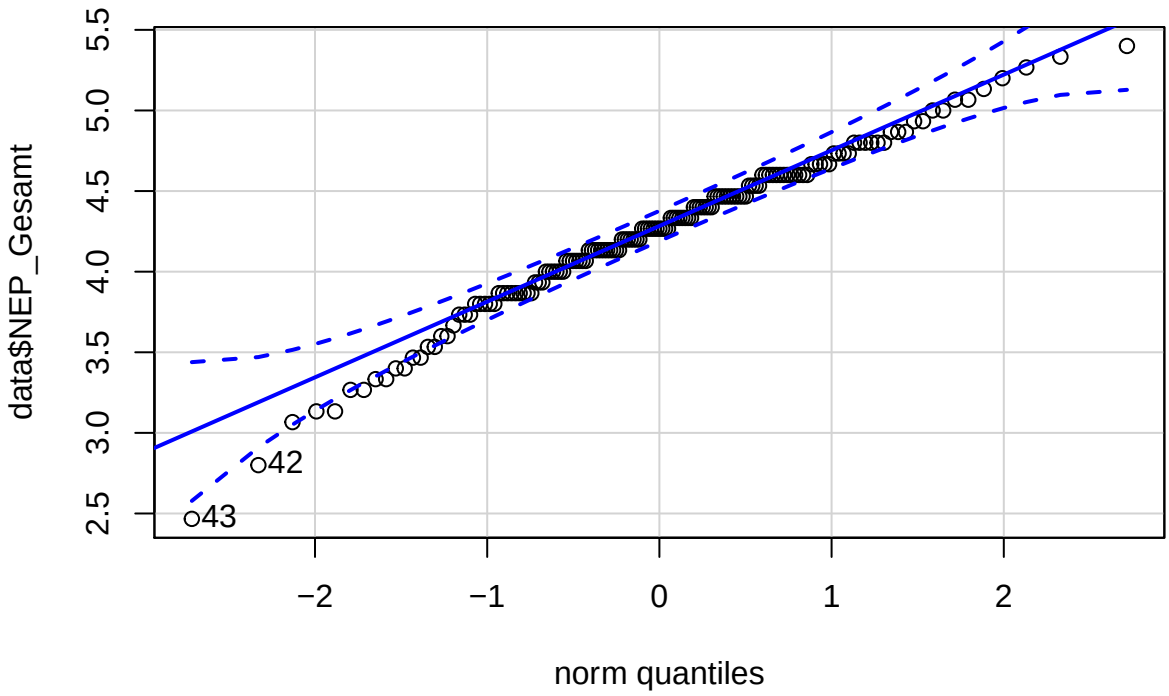
```r
data <- subset(data,is.na(data$FFF)==FALSE)
data <- subset(data,is.na(data$Alter)==FALSE)
data <- subset(data,is.na(data$Schulform)==FALSE)

# or to just clear out all NAs from the dataset
data <- data[complete.cases(data), ]

# Change sex/FFF to a factor to plot
data$Geschlecht <- as.factor(data$Geschlecht)
data$FFF <- as.factor(data$FFF)
data$Schulform <- as.factor(data$Schulform)

# Drop if Geschlecht is diverse (coded as 3)
data <- data[!(data$Geschlecht==3),]
```

Explore the data to check for outliers + strange distribution in NEP-scores

```r
test1 <- ggplot(data = data, aes(x = "", y = NEP_Gesamt)) +
  geom_boxplot(color = "#DC0000FF", fill="#DC000099") +
  theme_minimal() +
  xlab("") +
  ylab("NEP Mean Score")
```



```r
qqPlot(data$NEP_Gesamt)
```




```
## [1] 43 42
```

On the boxplot we can see two outliers, and in the QQ-Plot, you can see the tail slightly drifting outside the confidence bands on the lefthand corner. For now, we deem this as acceptable and will keep these points.

Analyses

Question 1: Run linear regression to see if age predicts NEP score

Numerous studies have observed a negative relationship between age and pro-ecological attitude, thus, we hypothesize that pro-environmental attitude decreases as age increases.

```
# Run basic linear regression
r <- lm(NEP_Gesamt~Alter, data = data)

summary(r)$coefficients[,1:4]
```

```
##                Estimate Std. Error   t value     Pr(>|t|)
## (Intercept)  5.24781625 0.49680670 10.563095 8.127008e-20
## Alter       -0.06432764 0.03172181 -2.027868 4.435583e-02
```

Predict: $\mu_i = \beta_0 + \beta_1 \cdot age_i = 5.25 + (-0.064 \cdot age_i)$

To explore our model data:

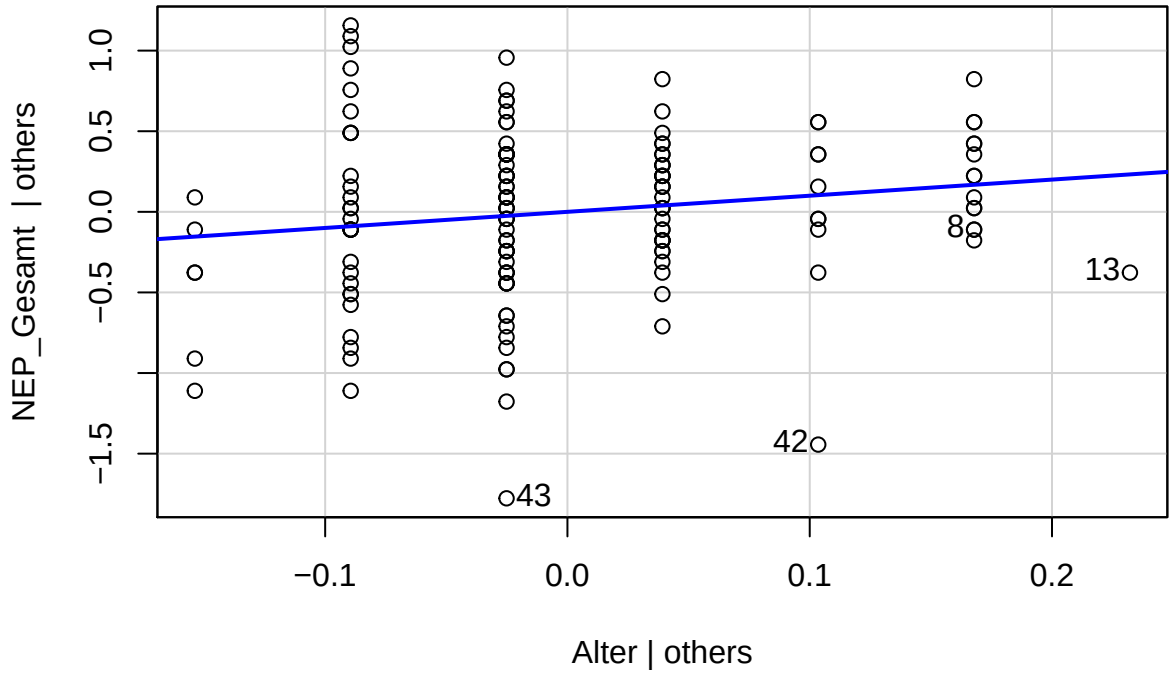
```
outlierTest(r)
```

```
##     rstudent unadjusted p-value Bonferroni p
## 43 -3.680122         0.00032585     0.049203
```

```
qqPlot(r, main="QQ Plot")
```

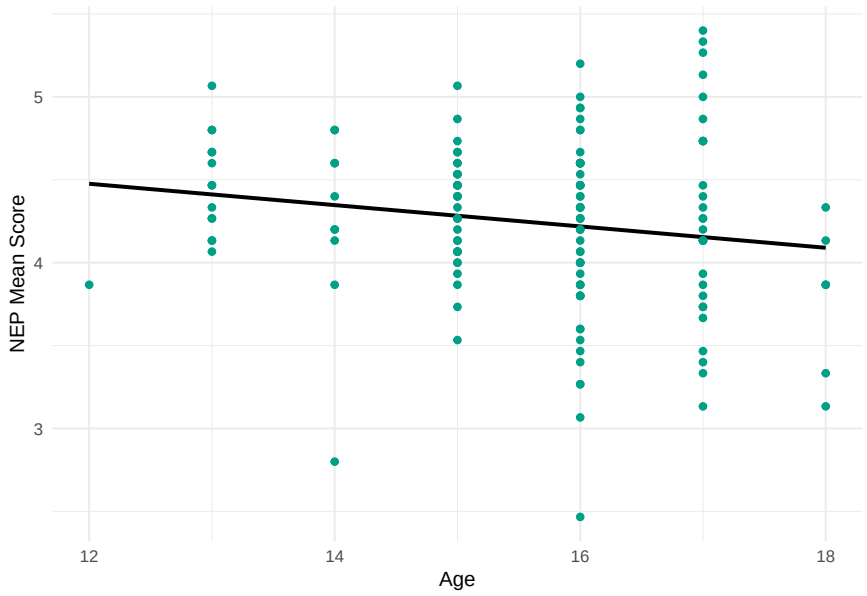
```
## [1] 42 43
```

```
leveragePlots(r)
```



Plot it:

```
# Visualize
p1 <- ggplot(data, aes(x=Alter, y=NEP_Gesamt)) +
  geom_smooth(formula = y ~ x, method = "lm", se=F, colour="black") +
  geom_point(color = "#00A087FF") +
  theme_minimal() +
  xlab("Age") +
  ylab("NEP Mean Score") +
  xlim(12, 18)
```


NEP Mean Score
5
4
3
12
14
16
18
Age

Question 2: Run unpaired t-test on mean NEP score and gender

A plethora of studies have illustrated gender as an influence; women have more positive attitudes towards sustainability, renewability and environmental concern. We hypothesize that females show a higher pro-environmental attitude than males.

```
# Independent 2-group t-test where y is a numeric and x is a binomial factor
gen_diff <- t.test(NEP_Gesamt ~ Geschlecht, data = data, var.equal = TRUE)

gen_diff$p.value
```

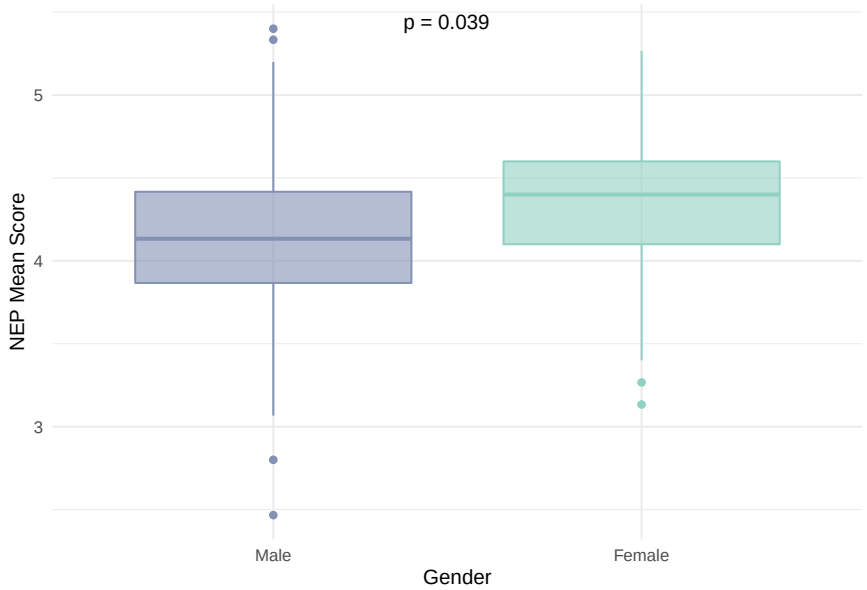
```
## [1] 0.02852028
```

```
gen_diff$estimate
```

```
## mean in group 1 mean in group 2
##        4.139583        4.320307
```

Plot it:

```
p2 <-  ggplot(data, aes(x=Geschlecht, y=NEP_Gesamt, fill=Geschlecht)) +
  geom_boxplot(color = c("#8491B4FF", "#91D1C2FF")) +
  theme_minimal() +
  scale_fill_manual(values = c("#8491B499", "#91D1C299")) +
  theme(legend.position = "none") +
  xlab("Gender") +
  ylab("NEP Mean Score") +
  scale_x_discrete(labels=c("1" = "Male", "2" = "Female")) +
  stat_compare_means(method = "t.test", label =  "p.format", label.x = 1.4)
```



Question 3: Run Welch test to look at attitude and school type

A background in science and the level of completed education plays a role in environmental attitude. As the German education system is complex and consists of distinct types of schooling, we explored environmental attitude in two different school types and hypothesized that Gymnasium students have a higher pro-environmental attitude than Gesamtschule students.

Run Welch test (R's default) as we could not assume homogeneity of variances.

```
school_diff <- t.test(NEP_Gesamt ~ Schulform, data = data)

school_diff$p.value
```

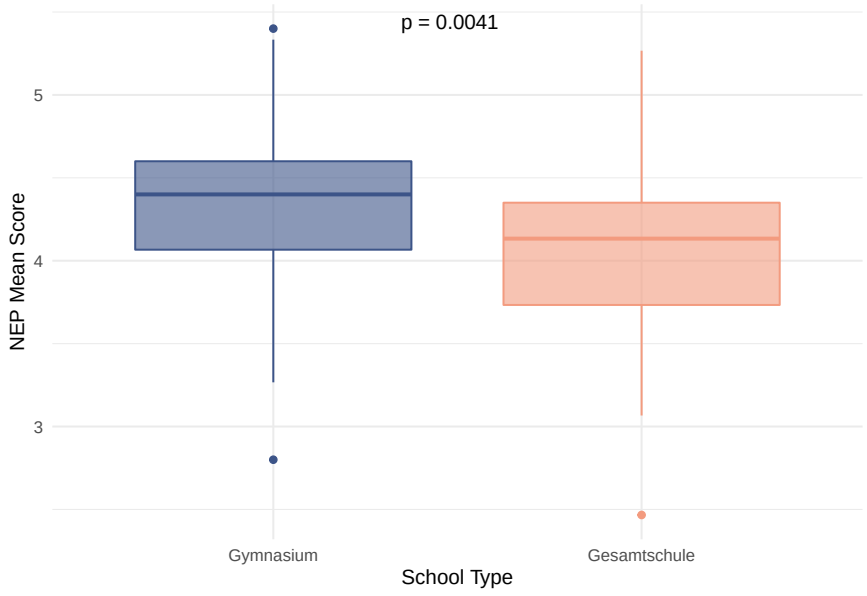
```
## [1] 0.004089659
```

```
school_diff$estimate
```

```
## mean in group 1 mean in group 2
##        4.332039        4.054167
```

Plot it:

```
p3 <-  ggplot(data, aes(x=Schulform, y=NEP_Gesamt, fill=Schulform)) +
  geom_boxplot(color = c("#3C5488FF", "#F39B7FFF")) +
  theme_minimal() +
  scale_fill_manual(values = c("#3C548899", "#F39B7F99")) +
  theme(legend.position = "none") +
  xlab("School Type") +
  ylab("NEP Mean Score") +
  scale_x_discrete(labels=c("1" = "Gymnasium", "2" = "Gesamtschule")) +
  stat_compare_means(method = "t.test", label =  "p.format", label.x = 1.4)
```



Question 4: Run unpaired t-test to look for effect of FFF participation

Actively participating in the Fridays For Future Movement can be seen as exhibiting pro-environmental behavior. As there is a strong relationship between pro-environmental behavior and pro-environmental attitude, we hypothesize that students who participated in the FFF movement show a higher pro-environmental attitude than students who did not participate.

```
FFF_diff <- t.test(NEP_Gesamt ~ FFF, data = data, var.equal = TRUE)
FFF_diff$p.value
```

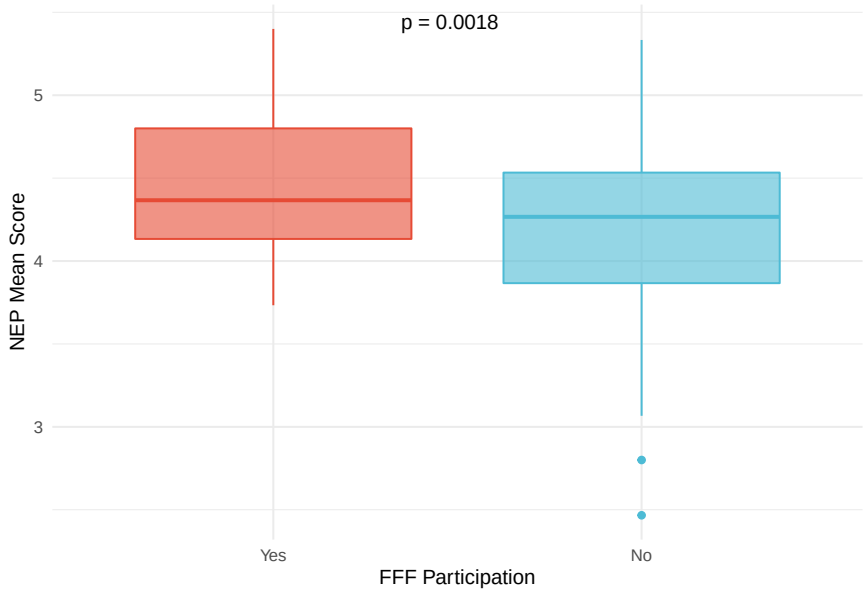
```
## [1] 0.003164334
```

```
FFF_diff$estimate
```

```
## mean in group 1 mean in group 2
##        4.457407        4.176812
```

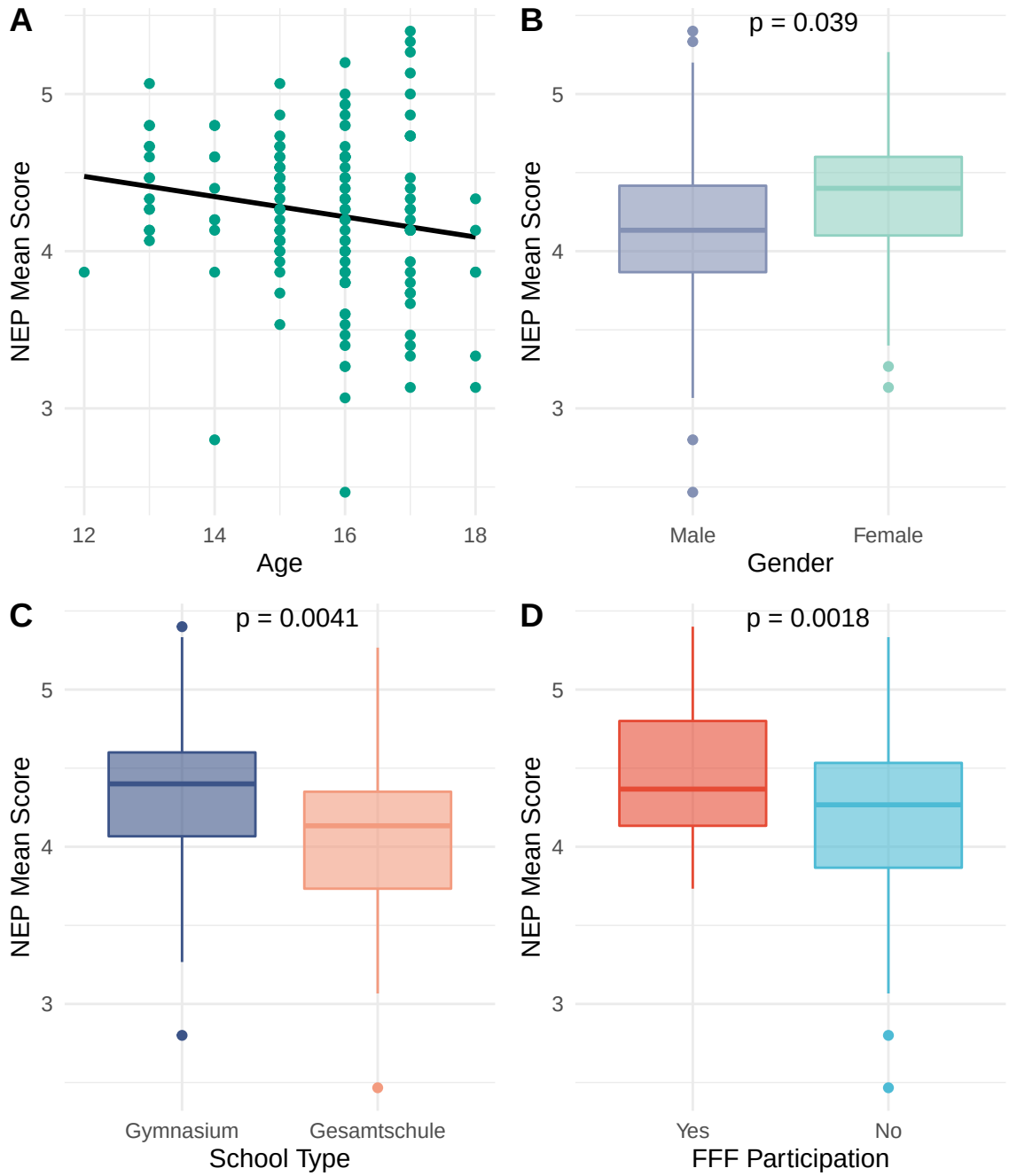
Plot it:

```
p4 <-  ggplot(data, aes(x=FFF, y=NEP_Gesamt, fill=FFF)) +
  geom_boxplot(color = c("#E64B35FF", "#4DBBD5FF")) +
  theme_minimal() +
  scale_fill_manual(values = c("#E64B3599", "#4DBBD599")) +
  theme(legend.position = "none") +
  xlab("FFF Participation") +
  ylab("NEP Mean Score") +
  scale_x_discrete(labels=c("1" = "Yes", "2" = "No")) +
  stat_compare_means(method = "t.test", label =  "p.format", label.x = 1.4)
```



Create a multiplot that combines all the figures

```
combined_figures <- ggarrange(p1, p2, p3, p4,
                              labels = c("A", "B", "C", "D"),
                              ncol = 2, nrow = 2)

ggsave("combined_figures.png", width = 8, height = 9)
```



Question 5: Plot the interaction with FFF

As all predictors were significant, we inspected the dataset for between-factor interactions in a subsequent, exploratory step.

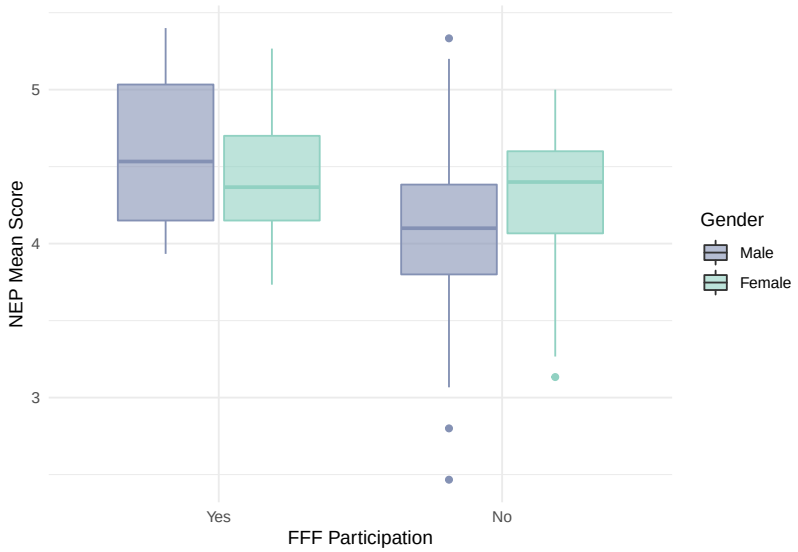
```
# Check additive model, assuming the variables are independent
aov2 <- aov(NEP_Gesamt ~ FFF + Geschlecht, data = data)
summary(aov2)
```

```
##              Df Sum Sq Mean Sq F value  Pr(>F)
## FFF           1   2.16  2.1587   9.132 0.00296 **
## Geschlecht    1   0.75  0.7506   3.175 0.07680 .
## Residuals   148  34.98  0.2364
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Run model to check for an interaction effect
aov2_int <- aov(NEP_Gesamt ~ FFF * Geschlecht, data = data)
summary(aov2_int)
```

```
##                 Df Sum Sq Mean Sq F value  Pr(>F)
## FFF              1   2.16  2.1587   9.323 0.00269 **
## Geschlecht       1   0.75  0.7506   3.242 0.07383 .
## FFF:Geschlecht   1   0.95  0.9472   4.091 0.04493 *
## Residuals      147  34.04  0.2315
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
p5 <- ggplot(data, aes(x=FFF, y=NEP_Gesamt, fill=Geschlecht)) +
  geom_boxplot(color = c("#8491B4FF", "#91D1C2FF", "#8491B4FF", "#91D1C2FF")) +
  theme_minimal() +
  xlab("FFF Participation") +
  ylab("NEP Mean Score") +
  scale_fill_manual(name = "Gender",
                    labels = c("Male", "Female"),
                    values = c("#8491B499", "#91D1C299")) +
  scale_x_discrete(labels=c("1" = "Yes", "2" = "No"))

ggsave("interaction.png", width = 4, height = 4)
```



Conclusion

To combat the demise of the planet, becoming environmentally aware is our only prevention method. There is an enormous potential to reach students using appropriate methods in schools to point out the pertinence of ecological responsibility and awareness. Our results alone indicate possible predispositions that could be used to help tailor individualized projects aimed at different genders, age ranges and educational level. As climate change is one of today's most challenging problems, it is crucial to investigate all possible influential factors and design pragmatic educational interventions to change students' attitude for good because – to put it in the words of Greta Thunberg – "our house is on fire".

```
## - Session info ---------------------------------------------------------------
##  setting  value
##  version  R version 4.0.2 (2020-06-22)
##  os       Windows 10 x64
##  system   i386, mingw32
##  ui       RTerm
##  language (EN)
##  collate  English_United Kingdom.1252
##  ctype    English_United Kingdom.1252
##  tz       Europe/London
##  date     2021-02-07
##
## - Packages -------------------------------------------------------------------
##  package     * version  date       lib source
##  abind         1.4-5    2016-07-21 [1] CRAN (R 4.0.3)
##  assertthat    0.2.1    2019-03-21 [1] CRAN (R 4.0.2)
##  backports     1.1.7    2020-05-13 [1] CRAN (R 4.0.0)
##  broom         0.7.0    2020-07-09 [1] CRAN (R 4.0.2)
##  car         * 3.0-10   2020-09-29 [1] CRAN (R 4.0.3)
##  carData     * 3.0-4    2020-05-22 [1] CRAN (R 4.0.3)
##  cellranger    1.1.0    2016-07-27 [1] CRAN (R 4.0.2)
##  cli           2.0.2    2020-02-28 [1] CRAN (R 4.0.2)
##  colorspace    1.4-1    2019-03-18 [1] CRAN (R 4.0.2)
##  cowplot       1.1.0    2020-09-08 [1] CRAN (R 4.0.3)
##  crayon        1.3.4    2017-09-16 [1] CRAN (R 4.0.2)
##  curl          4.3      2019-12-02 [1] CRAN (R 4.0.2)
##  data.table    1.12.8   2019-12-09 [1] CRAN (R 4.0.0)
##  digest        0.6.25   2020-02-23 [1] CRAN (R 4.0.2)
##  dplyr       * 1.0.0    2020-05-29 [1] CRAN (R 4.0.2)
##  ellipsis      0.3.1    2020-05-15 [1] CRAN (R 4.0.2)
##  evaluate      0.14     2019-05-28 [1] CRAN (R 4.0.2)
##  fansi         0.4.1    2020-01-08 [1] CRAN (R 4.0.2)
##  farver        2.0.3    2020-01-16 [1] CRAN (R 4.0.2)
##  forcats       0.5.0    2020-03-01 [1] CRAN (R 4.0.2)
##  foreign       0.8-80   2020-05-24 [2] CRAN (R 4.0.2)
##  generics      0.0.2    2018-11-29 [1] CRAN (R 4.0.2)
##  ggplot2     * 3.3.2    2020-06-19 [1] CRAN (R 4.0.2)
##  ggpubr      * 0.4.0    2020-06-27 [1] CRAN (R 4.0.3)
##  ggsignif      0.6.0    2019-08-08 [1] CRAN (R 4.0.3)
##  glue          1.4.1    2020-05-13 [1] CRAN (R 4.0.2)
##  gtable        0.3.0    2019-03-25 [1] CRAN (R 4.0.2)
##  haven         2.3.1    2020-06-01 [1] CRAN (R 4.0.2)
##  highr         0.8      2019-03-20 [1] CRAN (R 4.0.2)
##  hms           0.5.3    2020-01-08 [1] CRAN (R 4.0.2)
##  htmltools     0.5.0    2020-06-16 [1] CRAN (R 4.0.2)
##  knitr         1.29     2020-06-23 [1] CRAN (R 4.0.2)
##  labeling      0.3      2014-08-23 [1] CRAN (R 4.0.0)
##  lattice       0.20-41  2020-04-02 [2] CRAN (R 4.0.2)
##  lifecycle     0.2.0    2020-03-06 [1] CRAN (R 4.0.2)
##  magrittr      1.5      2014-11-22 [1] CRAN (R 4.0.2)
##  MASS          7.3-51.6 2020-04-26 [2] CRAN (R 4.0.2)
##  Matrix        1.2-18   2019-11-27 [2] CRAN (R 4.0.2)
##  mgcv          1.8-31   2019-11-09 [2] CRAN (R 4.0.2)
##  munsell       0.5.0    2018-06-12 [1] CRAN (R 4.0.2)
```

```
##  nlme          3.1-148  2020-05-24 [2] CRAN (R 4.0.2)
##  openxlsx      4.2.3    2020-10-27 [1] CRAN (R 4.0.3)
##  pillar        1.4.6    2020-07-10 [1] CRAN (R 4.0.2)
##  pkgconfig     2.0.3    2019-09-22 [1] CRAN (R 4.0.2)
##  purrr         0.3.4    2020-04-17 [1] CRAN (R 4.0.2)
##  R6            2.4.1    2019-11-12 [1] CRAN (R 4.0.2)
##  Rcpp          1.0.5    2020-07-06 [1] CRAN (R 4.0.2)
##  readxl      * 1.3.1    2019-03-13 [1] CRAN (R 4.0.2)
##  rio           0.5.16   2018-11-26 [1] CRAN (R 4.0.3)
##  rlang         0.4.6    2020-05-02 [1] CRAN (R 4.0.2)
##  rmarkdown     2.3      2020-06-18 [1] CRAN (R 4.0.2)
##  rstatix       0.6.0    2020-06-18 [1] CRAN (R 4.0.3)
##  scales        1.1.1    2020-05-11 [1] CRAN (R 4.0.2)
##  sessioninfo   1.1.1    2018-11-05 [1] CRAN (R 4.0.2)
##  stringi       1.4.6    2020-02-17 [1] CRAN (R 4.0.0)
##  stringr       1.4.0    2019-02-10 [1] CRAN (R 4.0.2)
##  tibble        3.0.2    2020-07-07 [1] CRAN (R 4.0.2)
##  tidyr       * 1.1.0    2020-05-20 [1] CRAN (R 4.0.2)
##  tidyselect    1.1.0    2020-05-11 [1] CRAN (R 4.0.2)
##  vctrs         0.3.1    2020-06-05 [1] CRAN (R 4.0.2)
##  withr         2.2.0    2020-04-20 [1] CRAN (R 4.0.2)
##  xfun          0.15     2020-06-21 [1] CRAN (R 4.0.2)
##  yaml          2.2.1    2020-02-01 [1] CRAN (R 4.0.0)
##  zip           2.1.1    2020-08-27 [1] CRAN (R 4.0.3)
##
## [1] C:/Users/vl29/Documents/R/win-library/4.0
## [2] C:/Program Files/R/R-4.0.2/library
```