Superior Temporal Cortex Functional Connectivity and Correlations with Language and Social Scores

Setup

```r
# load packages
packages <- c("here","dplyr","ggplot2","ppcor","tidyverse","nlme","multcomp","xlsx",
          "psych","boot","devtools","knitr")
lapply(packages, library, character.only = TRUE)
```

Load data

```r
data4connBehaviorCorr <- readxl::read_xlsx(here("datafile/datafile_updates.xlsx"))

data4connBehaviorCorr <- as.data.frame(data4connBehaviorCorr)

#colnames(data4connBehaviorCorr)

dim(data4connBehaviorCorr)
```

```
## [1] 86 60
```

```r
#View(data4connBehaviorCorr)

# Mullen T scores
length(which(data4connBehaviorCorr$final_mullen_ELT < 20))
```

```
## [1] 12
```

```r
length(which(data4connBehaviorCorr$final_mullen_RLT < 20))
```

```
## [1] 5
```

```r
which(data4connBehaviorCorr$final_mullen_ELT < 20)
```

```
##  [1] 13 20 38 39 41 54 59 63 64 73 76 86
```

```r
which(data4connBehaviorCorr$final_mullen_RLT < 20)
```

```
## [1] 38 39 41 59 76
```

```r
length(which(data4connBehaviorCorr$group=="ASD"))
```

```
## [1] 51
```

```r
print(paste0(round((12/51)*100,2), "% of ASD subjects had Mullen scores < 20"))
```

```
## [1] "23.53% of ASD subjects had Mullen scores < 20"
```

Demographic information

```r
# toddlers at 1-3 years old
subj_ScanAge <- length(which(data4connBehaviorCorr$Age < 48))
subj_TestAge <- length(which(data4connBehaviorCorr$final_vine_agemo < 48)) # 85


print(paste0(subj_ScanAge, " of subjects ages 1-3 years at MRI scan"))
```

```
## [1] "84 of subjects ages 1-3 years at MRI scan"
```

```r
print(paste0(round((subj_ScanAge/86)*100,2), "% of subjects ages 1-3 years at MRI scan"))
```

```
## [1] "97.67% of subjects ages 1-3 years at MRI scan"
```

```r
print(paste0(subj_TestAge, " of subjects ages 1-3 years at clinical testing"))
```

```
## [1] "85 of subjects ages 1-3 years at clinical testing"
```

```r
print(paste0(round((subj_TestAge/86)*100,2), "% of subjects ages 1-3 years at clinical testing"))
```

```
## [1] "98.84% of subjects ages 1-3 years at clinical testing"
```

```r
# mean and median age
mean_TestAge <- mean(data4connBehaviorCorr$final_vine_agemo)/12
sd_TestAge <- sd(data4connBehaviorCorr$final_vine_agemo)/12

mean_ScanAge <-mean(data4connBehaviorCorr$Age)/12
sd_ScanAge <- sd(data4connBehaviorCorr$Age)/12

Median_ScanAge <- median(data4connBehaviorCorr$Age)/12

print(paste0("mean age at clinical testing: ", round(mean_TestAge,2), " ± ",
      round(sd_TestAge,2)," years"))
```

```
## [1] "mean age at clinical testing: 2.25 ± 0.7 years"
```

```r
print(paste0("mean age at clinical testing: ", round(mean_ScanAge,2), " ± ",
      round(sd_ScanAge,2), " years"))
```

```
## [1] "mean age at clinical testing: 2.29 ± 0.75 years"
```

```r
# demographic and behavior data
group_all <- describeBy(data4connBehaviorCorr, group = data4connBehaviorCorr$group)

#colnames(data4connBehaviorCorr)

length(rownames(group_all$ASD))
```

```
## [1] 60
```

```r
max(data4connBehaviorCorr$meanFD)
```

```
## [1] 0.583
```

```r
# summary table
table <- as.data.frame(matrix(0, 22,7))

class(table)
```

```
## [1] "data.frame"
```

```r
colnames(table) <- c("ASD", "ASD_range","non-ASD","non-ASD_range","t value",
             "p value","cohen's d")

ll <- c(2,9, 13:16,23:27,30,32, 17:22) # c(2,8, 12:15,22:26,36:37,16:20)

#colnames(data4connBehaviorCorr)
colnames(data4connBehaviorCorr)[ll]
```

```
##  [1] "Age"                         "meanFD"
##  [3] "final_vine_agemo"            "final_ados_CoSoTot"
##  [5] "final_ados_RRTot"            "final_ados_CoSoTotRRTot"
##  [7] "final_mullen_VRT"            "final_mullen_FMT"
##  [9] "final_mullen_RLT"            "final_mullen_ELT"
## [11] "final_mullen_ELC_Std"        "mullen_RL_AgeEq"
## [13] "mullen_EL_AgeEq"             "final_vine_ComTotal_DomStd"
## [15] "final_vine_DlyTotal_DomStd"  "final_vine_SocTotal_DomStd"
## [17] "final_vine_MtrTotal_DomStd"  "final_vine_AdapBehav_DomStd"
## [19] "final_vine_DomStdTotal"
```

```r
# make sure all data are numeric
data4connBehaviorCorr[,ll] <- sapply(ll, function(x)
    as.numeric(data4connBehaviorCorr[,x]))

# gender
ge <- table(data4connBehaviorCorr$Gender, data4connBehaviorCorr$group)
chisq.test(ge)
```

```
##
##  Pearson's Chi-squared test with Yates' continuity correction
##
## data:  ge
## X-squared = 3.3363, df = 1, p-value = 0.06777
```

```r
ASD_mean <- paste0(round(as.data.frame(group_all$ASD)[ll,"mean"],2),
           " (",round(as.data.frame(group_all$ASD)[ll,"sd"],2),")")

ASD_range <- paste0(round(as.data.frame(group_all$ASD)[ll,"min"],3),
           "-",round(as.data.frame(group_all$ASD)[ll,"max"],3))

TD_mean <- paste0(round(as.data.frame(group_all$`non-ASD`)[ll,"mean"],2),
         " (",round(as.data.frame(group_all$`non-ASD`)[ll,"sd"],2),")")

TD_range <- paste0(round(as.data.frame(group_all$`non-ASD`)[ll,"min"],3),
            "-",round(as.data.frame(group_all$`non-ASD`)[ll,"max"],3))

ASDvsTD_t <- sapply(ll, function(x)
    t.test(data4connBehaviorCorr[data4connBehaviorCorr$group == "ASD",x],
           data4connBehaviorCorr[data4connBehaviorCorr$group == "non-ASD",x],
           na.action=na.omit)$statistic)

ASDvsTD_p <- sapply(ll, function(x)
    t.test(data4connBehaviorCorr[data4connBehaviorCorr$group == "ASD",x],
           data4connBehaviorCorr[data4connBehaviorCorr$group == "non-ASD",x],
           na.action=na.omit)$p.value)

ASDvsTD_d <- sapply(ll, function(x)
    effsize::cohen.d(data4connBehaviorCorr[data4connBehaviorCorr$group == "ASD",x],
             data4connBehaviorCorr[data4connBehaviorCorr$group == "non-ASD",x],
             na.rm = T)$estimate)

table[2:20,1:7] <- cbind(ASD_mean,ASD_range,TD_mean,TD_range,
             round(ASDvsTD_t,3),round(ASDvsTD_p,3),
             round(ASDvsTD_d,3))

table[1,c(1,3,6)] <- cbind(paste0(ge[2,1],"/",ge[1,1]), paste0(ge[2,2],"/",ge[1,2]),"0.068")

rownames(table)[1:20] <- c("Sex(M/F)",colnames(data4connBehaviorCorr)[ll])

#View(table)

# age at eye-tracking
ET_tmp <- data4connBehaviorCorr[which(!is.na(as.numeric(data4connBehaviorCorr$ET_age))),]

ET_tmp$ET_age <- as.numeric(ET_tmp$ET_age)

dim(ET_tmp)
```

```
## [1] 65 60
```

```r
ET_ASD <- length(ET_tmp$ET_date[ET_tmp$group == "ASD"])
ET_nonASD <- length(ET_tmp$ET_date[ET_tmp$group == "non-ASD"])

print(paste0(ET_ASD, " of ASD subjects had good eye-tracking data"))
```

```
## [1] "32 of ASD subjects had good eye-tracking data"
```

```r
print(paste0(ET_nonASD, " of non-ASD subjects had good eye-tracking data"))
```

```
## [1] "33 of non-ASD subjects had good eye-tracking data"
```

```r
ET_age <- describeBy(ET_tmp$ET_age, group = ET_tmp$group)

ET_age_t <- t.test(ET_tmp$ET_age[ET_tmp$group == "ASD"],
       ET_tmp$ET_age[ET_tmp$group == "non-ASD"],na.action = na.omit)

ET_age_d <- effsize::cohen.d(ET_tmp$ET_age[ET_tmp$group == "ASD"],
       ET_tmp$ET_age[ET_tmp$group == "non-ASD"])

ET_age_ASD <- paste0(round(as.data.frame(ET_age$ASD)[,"mean"],2),
           " (",round(as.data.frame(ET_age$ASD)[,"sd"],2),")")

ET_age_ASDrange <- paste0(round(as.data.frame(ET_age$ASD)[,"min"],3),
           "-",round(as.data.frame(ET_age$ASD)[,"max"],3))

ET_age_nonASD <-  paste0(round(as.data.frame(ET_age$`non-ASD`)[,"mean"],2),
           " (",round(as.data.frame(ET_age$`non-ASD`)[,"sd"],2),")")

ET_age_nonASDrange <-  paste0(round(as.data.frame(ET_age$`non-ASD`)[,"min"],3),
           "-",round(as.data.frame(ET_age$`non-ASD`)[,"max"],3))

ET_ge <- table(ET_tmp$Gender,ET_tmp$group)

kk <- chisq.test(ET_ge)

table[21,c(1,3,6)] <- cbind(paste0(ET_ge[2,1],"/",ET_ge[1,1]),
                paste0(ET_ge[2,2],"/",ET_ge[1,2]), round(kk$p.value,2))

table[22,1:7] <- cbind(ET_age_ASD,ET_age_ASDrange,ET_age_nonASD,
                      ET_age_nonASDrange,
                round(ET_age_t$statistic,3),round(ET_age_t$p.value,3),
                     round(ET_age_d$estimate,3))

row.names(table)[21:22] <- c("eye-tracking sample", "eye-tracking age")

#View(table)

# subjects with scan before/after eye-tracking
n_subj_before_ET <- length(which(ET_tmp$ScanDate_formatted > ET_tmp$ET_date))
n_subj_after_ET <- length(which(ET_tmp$ScanDate_formatted < ET_tmp$ET_date))

print(paste0(n_subj_before_ET, " out of 65 subjects had MRI scan before eye-tracking test"))
```

```
## [1] "59 out of 65 subjects had MRI scan before eye-tracking test"
```

```r
print(paste0(n_subj_after_ET, " out of 65 subjects had MRI scan after eye-tracking test"))
```

```
## [1] "6 out of 65 subjects had MRI scan after eye-tracking test"
```

```r
write.xlsx(table, here("results/clinical_table_with_range_corrected.xlsx"))
```

Socioeconomic status and environment info, added as suggested by reviewers 2022-11-27

```r
# household income
table(data4connBehaviorCorr$group)
```

```
##
##     ASD non-ASD
##      51      35
```

```r
table(data4connBehaviorCorr$Household_Income,data4connBehaviorCorr$group)
```

```
##
##                         ASD non-ASD
##   100,001-125,000         2       4
##   125,001-150,000         4       2
##   150,001-200,000         4       6
##   20,000 or less          2       0
##   20,001-40,000           8       4
##   200,000 or higher       6       2
##   40,001-60,000           6       1
##   60,001-80,000           7       9
##   80,001-100,000          1       3
##   Prefer not to answer   11       4
```

```r
data4connBehaviorCorr$Household_Income_sum <- NULL

data4connBehaviorCorr$Household_Income_sum[data4connBehaviorCorr$Household_Income == "100,001-125,000"

data4connBehaviorCorr$Household_Income_sum[data4connBehaviorCorr$Household_Income == "20,001-40,000" |

data4connBehaviorCorr$Household_Income_sum[data4connBehaviorCorr$Household_Income ==
                        "20,000 or less"] <- "<20k"

data4connBehaviorCorr$Household_Income_sum[data4connBehaviorCorr$Household_Income ==
                        "Prefer not to answer"] <- "Prefer not to answer"

household_income_sum <- table(data4connBehaviorCorr$Household_Income_sum,
                  data4connBehaviorCorr$group)

household_income_sum["<20k",]
```

```
##     ASD non-ASD
##       2       0
```

```r
print(paste0(round((household_income_sum[">100k","ASD"]/51)*100),
         "% of ASD subjects from families reporting over $100,000 in total family income") )
```

```
## [1] "31% of ASD subjects from families reporting over $100,000 in total family income"
```

```r
print(paste0(round((household_income_sum[">100k","non-ASD"]/35)*100),
         "% of non-ASD subjects from families reporting over $100,000 in total family income") )
```

```
## [1] "40% of non-ASD subjects from families reporting over $100,000 in total family income"
```

```r
print(paste0(round((household_income_sum["20k-100k","ASD"]/51)*100),
         "% of ASD subjects from families reporting $20,000-$100,000 in total family income") )
```

```
## [1] "43% of ASD subjects from families reporting $20,000-$100,000 in total family income"
```

```r
print(paste0(round((household_income_sum["20k-100k","non-ASD"]/35)*100),
         "% of non-ASD subjects from families reporting $20,000-$100,000 in total family income") )
```

```
## [1] "49% of non-ASD subjects from families reporting $20,000-$100,000 in total family income"
```

```r
# parental education
table(data4connBehaviorCorr$Parent1_Education,data4connBehaviorCorr$group)
```

```
##
##                          ASD non-ASD
##   9th-11th grade           2       0
##   Associates/2 year        4       1
##   College degree          18      12
##   Courses toward college   5       8
##   High school/GED          8       3
##   Masters degree           4       6
##   Prefer not to answer     1       0
##   Professional degree      4       2
##   Trade or Vocational      5       3
```

```r
nn_higher_degree <- table(data4connBehaviorCorr$group[data4connBehaviorCorr$Parent1_Education %in%
                            c("College degree","Masters degree",
                              "Professional degree") |
                            data4connBehaviorCorr$Parent2_Education %in%
                            c("College degree","Masters degree",
                              "Professional degree")])

nn_higher_degree
```

```
##
##     ASD non-ASD
##      32      22
```

```r
print(paste0("one or both parents of ",round((as.data.frame(nn_higher_degree)[1,2]/51)*100),
         "% of ASD subjects had a college, masters, or professional degree") )
```

```
## [1] "one or both parents of 63% of ASD subjects had a college, masters, or professional degree"
```

```r
print(paste0("one or both parents of ",round((as.data.frame(nn_higher_degree)[2,2]/35)*100),
         "% of non-ASD subjects had a college, masters, or professional degree") )
```

```
## [1] "one or both parents of 63% of non-ASD subjects had a college, masters, or professional degree"
```

```r
## language exposure
ll <- table(data4connBehaviorCorr$`Number of Languages`,data4connBehaviorCorr$group)

print(paste0("",round((sum(ll[2:4,1])/51)*100),
         "% of ASD subjects were from multilingual families") )
```

```
## [1] "61% of ASD subjects were from multilingual families"
```

```r
print(paste0("",round((sum(ll[2:4,2])/35)*100),
         "% of non-ASD subjects were from multilingual families") )
```

```
## [1] "54% of non-ASD subjects were from multilingual families"
```

```r
ee <- table(data4connBehaviorCorr$group,data4connBehaviorCorr$`English Used`)

print(paste0("",round((ee[1,1]/51)*100),
         "% of ASD subjects were from families where English was always used") )
```

```
## [1] "71% of ASD subjects were from families where English was always used"
```

```r
print(paste0("",round((ee[2,1]/35)*100),
         "% of non-ASD subjects were from families where English was always used") )
```

```
## [1] "77% of non-ASD subjects were from families where English was always used"
```

Subjects with ET data vs. those without ET data

```r
data4connBehaviorCorr$ET_age <- as.numeric(data4connBehaviorCorr$ET_age)

data4connBehaviorCorr$ET_gr[which(!is.na(data4connBehaviorCorr$ET_age))] <- "ET_Y"
data4connBehaviorCorr$ET_gr[which(is.na(data4connBehaviorCorr$ET_age))] <- "ET_N"

table(data4connBehaviorCorr$group[data4connBehaviorCorr$ET_gr == "ET_Y"])
```

```
##
##     ASD non-ASD
##      32      33
```

```r
table(data4connBehaviorCorr$group)
```

```
##
##     ASD non-ASD
##      51      35
```

```r
table(data4connBehaviorCorr$ET_gr, data4connBehaviorCorr$Gender,data4connBehaviorCorr$group)
```

```
## , ,  = ASD
##
##
##          F  M
##   ET_N  3 16
##   ET_Y  7 25
##
## , ,  = non-ASD
##
##
##          F  M
##   ET_N  2  0
##   ET_Y 12 21
```

```r
## demographic info for ASD and non-ASD with and without eye tracking
# non-ASD
gr <- "non-ASD"
table <- as.data.frame(matrix(0, 20,7))
colnames(table) <- c("ET_Y", "ET_Y_range","ET_N","ET_N_range","t value",
             "p value","cohen's d")

tmp <- data4connBehaviorCorr

# colnames(tmp)

tmp <- data4connBehaviorCorr[which(data4connBehaviorCorr$group == gr),]

group_all <- describeBy(tmp,group = tmp$ET_gr)

# gender
ge <- table(tmp$Gender, tmp$ET_gr)
chisq.test(ge)
```

```
##
##  Pearson's Chi-squared test with Yates' continuity correction
##
## data:  ge
## X-squared = 1.0827, df = 1, p-value = 0.2981
```

```r
table[1, c(1,3,5,6)] <- cbind(paste0(ge[2,2],"/",ge[1,2]),
               paste0(ge[2,1],"/",ge[1,1]),"Chi-squared = 1.08",
               "0.3")

# other info
colnames(tmp)[11]
```

```
## [1] "final_vine_MtrTotal_DomStd" "final_mullen_ELT"
## [3] "Gender"                     "subj"
## [5] "final_ados_CoSoTotRRTot"    "final_ados_CoSoTotRRTot"
## [7] "Dx"
```

```
ll <- c(2,9, 13:16,23:27,33:34, 17:22)

ET_Y_mean <- paste0(round(as.data.frame(group_all$ET_Y)[ll,"mean"],2),
           " (",round(as.data.frame(group_all$ET_Y)[ll,"sd"],2),")")

ET_Y_range <- paste0(round(as.data.frame(group_all$ET_Y)[ll,"min"],2),
           "-",round(as.data.frame(group_all$ET_Y)[ll,"max"],2))

ET_N_mean <- paste0(round(as.data.frame(group_all$ET_N)[ll,"mean"],2),
         " (",round(as.data.frame(group_all$ET_N)[ll,"sd"],2),")")

ET_N_range <- paste0(round(as.data.frame(group_all$ET_N)[ll,"min"],2),
            "-",round(as.data.frame(group_all$ET_N)[ll,"max"],2))

ET_YvsN_t <- sapply(ll, function(x)
    t.test(tmp[tmp$ET_gr == "ET_Y",x], tmp[tmp$ET_gr == "ET_N",x],
           na.action = na.omit)$statistic)

ET_YvsN_p <- sapply(ll, function(x)
    t.test(tmp[tmp$ET_gr == "ET_Y",x], tmp[tmp$ET_gr == "ET_N",x],
           na.action = na.omit)$p.value)

ET_YvsN_d <- sapply(ll, function(x)
    effsize::cohen.d(tmp[tmp$ET_gr == "ET_Y",x],tmp[tmp$ET_gr == "ET_N",x],
             na.rm = T)$estimate)

table[2:20,1:7] <- cbind(ET_Y_mean,ET_Y_range,ET_N_mean,ET_N_range,
             round(ET_YvsN_t,3),round(ET_YvsN_p,3),
             round(ET_YvsN_d,3))

rownames(table)[1:20] <- c("Sex(M/F)",colnames(data4connBehaviorCorr)[ll])

#View(table)

write.xlsx(table,here("results/ET_nonASD.xlsx"))

# ASD
gr <- "ASD"
table <- as.data.frame(matrix(0, 20,7))
colnames(table) <- c("ET_Y", "ET_Y_range","ET_N","ET_N_range","t value",
             "p value","cohen's d")

tmp <- data4connBehaviorCorr

tmp <- data4connBehaviorCorr[which(data4connBehaviorCorr$group == gr),]

group_all <- describeBy(tmp,group = tmp$ET_gr)

#group_all
```

```r
# gender
ge <- table(tmp$Gender, tmp$ET_gr)
chisq.test(ge)
```

```
##
##  Pearson's Chi-squared test with Yates' continuity correction
##
## data:  ge
## X-squared = 0.027057, df = 1, p-value = 0.8693
```

```r
table[1, c(1,3,5,6)] <- cbind(paste0(ge[2,2],"/",ge[1,2]),
               paste0(ge[2,1],"/",ge[1,1]),"Chi-squared = 0.03",
               "0.87")

# other info
colnames(tmp)[ll]
```

```
##  [1] "Age"                          "meanFD"
##  [3] "final_vine_agemo"             "final_ados_CoSoTot"
##  [5] "final_ados_RRTot"             "final_ados_CoSoTotRRTot"
##  [7] "final_mullen_VRT"             "final_mullen_FMT"
##  [9] "final_mullen_RLT"             "final_mullen_ELT"
## [11] "final_mullen_ELC_Std"         "ratio_RL"
## [13] "ratio_EL"                     "final_vine_ComTotal_DomStd"
## [15] "final_vine_DlyTotal_DomStd"  "final_vine_SocTotal_DomStd"
## [17] "final_vine_MtrTotal_DomStd"  "final_vine_AdapBehav_DomStd"
## [19] "final_vine_DomStdTotal"
```

```r
ll <- c(2,9, 13:16,23:27,33:34, 17:22)

ET_Y_mean <- paste0(round(as.data.frame(group_all$ET_Y)[ll,"mean"],2),
           " (",round(as.data.frame(group_all$ET_Y)[ll,"sd"],2),")")

ET_Y_range <- paste0(round(as.data.frame(group_all$ET_Y)[ll,"min"],2),
           "-",round(as.data.frame(group_all$ET_Y)[ll,"max"],2))

ET_N_mean <- paste0(round(as.data.frame(group_all$ET_N)[ll,"mean"],2),
         " (",round(as.data.frame(group_all$ET_N)[ll,"sd"],2),")")

ET_N_range <- paste0(round(as.data.frame(group_all$ET_N)[ll,"min"],2),
            "-",round(as.data.frame(group_all$ET_N)[ll,"max"],2))

ET_YvsN_t <- sapply(ll, function(x)
    t.test(tmp[tmp$ET_gr == "ET_Y",x], tmp[tmp$ET_gr == "ET_N",x],
          na.action = na.omit)$statistic)

ET_YvsN_p <- sapply(ll, function(x)
    t.test(tmp[tmp$ET_gr == "ET_Y",x], tmp[tmp$ET_gr == "ET_N",x],
          na.action = na.omit)$p.value)

ET_YvsN_d <- sapply(ll, function(x)
    effsize::cohen.d(tmp[tmp$ET_gr == "ET_Y",x],tmp[tmp$ET_gr == "ET_N",x],
```

```
             na.rm = T)$estimate)

table[2:20,1:7] <- cbind(ET_Y_mean,ET_Y_range,ET_N_mean,ET_N_range,
             round(ET_YvsN_t,3),round(ET_YvsN_p,3),
             round(ET_YvsN_d,3))

rownames(table)[1:20] <- c("Sex(M/F)",colnames(data4connBehaviorCorr)[ll])

#View(table)

write.xlsx(table,here("results/ET_ASD.xlsx"))
```

Connectivity-behavior corrrelation in non-ASD

```
# correlation coefficients
tmp <- data4connBehaviorCorr
#colnames(tmp)

table_for_correaltion <- as.data.frame(matrix(0, 8, 4))

# significant correlation with Vineland socialization
colnames(tmp)[46:48]
```

```
## [1] "RHtemporal_Social_ACC"        "RHtemporal_Social_LPC"
## [3] "RHtemporal_Social_cerebellum"
```

```
table_for_correaltion[1:3, 1] <- "Vineland Socialization"
table_for_correaltion[1:3, 2] <- c("ACC","LPC","cerebellum")

brain_social <- sapply(46:48, function(x) cor.test(tmp[tmp$group == "non-ASD",x],
     tmp[tmp$group == "non-ASD", "final_vine_SocTotal_DomStd"]))

table_for_correaltion[1:3, 3:4] <- rbind(cbind(paste0("r = ",
                              round(brain_social["estimate",][[1]],2)),
                      paste0("p = ",
                             round(brain_social["p.value",][[1]],4))),
                     cbind(paste0("r = ",
                             round(brain_social["estimate",][[2]],2)),
                      paste0("p = ",
                             round(brain_social["p.value",][[2]],4))),
                     cbind(paste0("r = ",
                             round(brain_social["estimate",][[3]],2)),
                      paste0("p = ",
                             round(brain_social["p.value",][[3]],4))))

# significant correlation with Vineland communication
colnames(tmp)[49:51]
```

```
## [1] "RHtemporal_Com_ACC"        "RHtemporal_Com_LPC"
## [3] "RHtemporal_Com_cerebellum"
```

```r
brain_communication <- sapply(49:51, function(x) cor.test(tmp[tmp$group == "non-ASD",x],
                           tmp[tmp$group == "non-ASD", "final_vine_ComTotal_DomStd"]))


table_for_correaltion[4:6, 1] <- "Vineland communication"
table_for_correaltion[4:6, 2] <- c("ACC","LPC","cerebellum")

table_for_correaltion[4:6, 3:4] <- rbind(cbind(paste0("r = ",
                              round(brain_communication["estimate",][[1]],2)),
                           paste0("p = ",
                                  round(brain_communication["p.value",][[1]],4))),
                     cbind(paste0("r = ",
                             round(brain_communication["estimate",][[2]],2)),
                      paste0("p = ",
                             round(brain_communication["p.value",][[2]],4))),
                     cbind(paste0("r = ",
                             round(brain_communication["estimate",][[3]],2)),
                      paste0("p = ",
                             round(brain_communication["p.value",][[3]],4))))


# significant correlation with Vineland communication and Mullen language
colnames(tmp)[44:45]
```

```
## [1] "RHtemporal_mullenEL_ACC" "RHtemporal_mullenEL_LPC"
```

```r
brain_mullenEL <- sapply(44:45, function(x) cor.test(tmp[tmp$group == "non-ASD",x],
                           tmp[tmp$group == "non-ASD", "ratio_EL"]))

table_for_correaltion[7:8, 1] <- c("Mullen EL")
table_for_correaltion[7:8, 2] <- c("ACC","LPC")


table_for_correaltion[7:8, 3:4] <- rbind(cbind(paste0("r = ",
                              round(brain_mullenEL["estimate",][[1]],2)),
                      paste0("p = ",
                             round(brain_mullenEL["p.value",][[1]],4))),
                     cbind(paste0("r = ",
                             round(brain_mullenEL["estimate",][[2]],2)),
                      paste0("p = ",
                             round(brain_mullenEL["p.value",][[2]],4))))

colnames(table_for_correaltion) <- c("behavioral measure","region","r value", "p value")

knitr::kable(table_for_correaltion)
```

behavioral measure	region	r value	p value
Vineland Socialization	ACC	r = 0.59	p = 2e-04
Vineland Socialization	LPC	r = 0.6	p = 2e-04
Vineland Socialization	cerebellum	r = -0.57	p = 4e-04
Vineland communication	ACC	r = 0.55	p = 7e-04

behavioral measure	region	r value	p value
Vineland communication	LPC	r = 0.5	p = 0.0023
Vineland communication	cerebellum	r = -0.54	p = 9e-04
Mullen EL	ACC	r = 0.61	p = 1e-04
Mullen EL	LPC	r = 0.5	p = 0.0023

Connectivity-behavior corrrelation in ASD

```
# correlation coefficients
colnames(data4connBehaviorCorr)
```

```
##  [1] "subj"                        "Age"
##  [3] "Dx"                          "Gender"
##  [5] "ScanDate"                    "ScanDate_formatted"
##  [7] "T1"                          "Resting"
##  [9] "meanFD"                      "meanDVARS"
## [11] "subjid"                      "group"
## [13] "final_vine_agemo"            "final_ados_CoSoTot"
## [15] "final_ados_RRTot"            "final_ados_CoSoTotRRTot"
## [17] "final_vine_ComTotal_DomStd"  "final_vine_DlyTotal_DomStd"
## [19] "final_vine_SocTotal_DomStd"  "final_vine_MtrTotal_DomStd"
## [21] "final_vine_AdapBehav_DomStd" "final_vine_DomStdTotal"
## [23] "final_mullen_VRT"            "final_mullen_FMT"
## [25] "final_mullen_RLT"            "final_mullen_ELT"
## [27] "final_mullen_ELC_Std"        "final_mullen_ageMo"
## [29] "mullen_RLT_2"                "mullen_RL_AgeEq"
## [31] "mullen_ELT_2"                "mullen_EL_AgeEq"
## [33] "ratio_RL"                    "ratio_EL"
## [35] "GeoPref"                     "ET_age"
## [37] "ET_gr"                       "ET_date"
## [39] "Motherese_LK"                "Motherese_QL"
## [41] "Fixation_Geo"                "LHtemporal_Cunues"
## [43] "RHtemporal_Precuneus"        "RHtemporal_mullenEL_ACC"
## [45] "RHtemporal_mullenEL_LPC"     "RHtemporal_Social_ACC"
## [47] "RHtemporal_Social_LPC"       "RHtemporal_Social_cerebellum"
## [49] "RHtemporal_Com_ACC"          "RHtemporal_Com_LPC"
## [51] "RHtemporal_Com_cerebellum"   "Race"
## [53] "Ethnicity"                   "Parent1_Education"
## [55] "Parent2_Education"           "Household_Income"
## [57] "Receiving_Services"          "Number of Languages"
## [59] "Language Comment"            "English Used"
## [61] "Household_Income_sum"
```

```
tmp <- data4connBehaviorCorr
#tmp <- datafile[tmp$final_vine_ComTotal_DomStd != max(tmp$final_vine_ComTotal_DomStd),]

cor_cunnes_communication <- cor.test(tmp[tmp$group == "ASD","LHtemporal_Cunues"],
              tmp[tmp$group == "ASD","final_vine_ComTotal_DomStd"])

cor_precunnes_EL <- cor.test(tmp[tmp$group == "ASD","RHtemporal_Precuneus"],
```

```
                 tmp[tmp$group == "ASD","ratio_EL"])

table_for_correaltion <- as.data.frame(matrix(0, 2, 4))

table_for_correaltion[1:2, 1] <- c("Vineland communication", "Mullen EL")
table_for_correaltion[1:2, 2] <- c("Cunues","Precuneus")

table_for_correaltion[1:2, 3:4] <- rbind(cbind(paste0("r = ", round(cor_cunnes_communication$estimate,2
                      paste0("p = ",round(cor_cunnes_communication$p.value,5))),
                     cbind(paste0("r = ", round(cor_precunnes_EL$estimate,2)),
                      paste0("p = ",round(cor_precunnes_EL$p.value,5))))

colnames(table_for_correaltion) <- c("behavioral measure","region","r value", "p value")
knitr::kable(table_for_correaltion)
```

behavioral measure	region	r value	p value
Vineland communication	Cunues	r = 0.55	p = 3e-05
Mullen EL	Precuneus	r = 0.58	p = 1e-05

Eye-tracking and subgroup-specific relationships in ASD

```
data4connBehaviorCorr$GeoPref_groups <- NULL

data4connBehaviorCorr$GeoPref <- as.numeric(data4connBehaviorCorr$GeoPref)
```

```
## Warning: NAs introduced by coercion
```

```
dim(data4connBehaviorCorr[data4connBehaviorCorr$group == "ASD",])
```

```
## [1] 51 61
```

```
data4connBehaviorCorr$GeoPref_groups[data4connBehaviorCorr$group == "ASD" &
                        data4connBehaviorCorr$GeoPref > 69] <- "Social"

data4connBehaviorCorr$GeoPref_groups[data4connBehaviorCorr$group == "ASD" &
                        data4connBehaviorCorr$GeoPref < 69] <- "nonSocial"

table(data4connBehaviorCorr$GeoPref_groups)
```

```
##
## nonSocial    Social
##        16        16
```

```
data4connBehaviorCorr$GeoPref_groups[data4connBehaviorCorr$group == "non-ASD" &
                        data4connBehaviorCorr$ET_gr == "ET_Y"] <- "Non-ASD"

data4connBehaviorCorr$GeoPref_groups <- factor(data4connBehaviorCorr$GeoPref_groups,
```

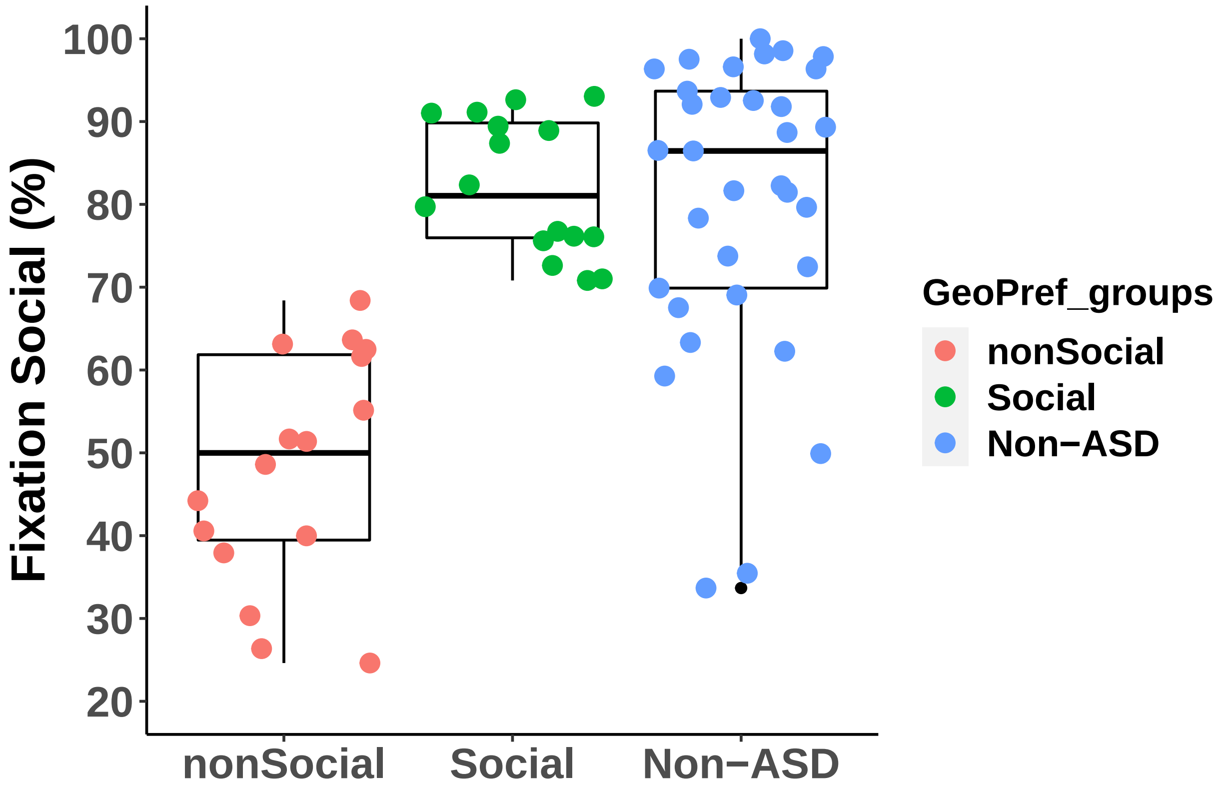
```r
                              levels = c("nonSocial", "Social","Non-ASD"))

data4connBehaviorCorr[data4connBehaviorCorr$group == "non-ASD" &
                     data4connBehaviorCorr$GeoPref < 69, c("Dx","Age","GeoPref")]
```

```
##           Dx Age  GeoPref
## 1         TD  28 35.46080
## 16        LD  23 33.67545
## 23        TD  27 49.90584
## NA      <NA>  NA       NA
## 44        LD  16 67.52617
## 45        TD  19 62.26212
## 52        LD  27 59.27042
## NA.1    <NA>  NA       NA
## 75     other  23 63.32081
```

```r
table(data4connBehaviorCorr$GeoPref_groups)
```

```
##
## nonSocial    Social   Non-ASD
##        16        16        33
```

```r
ggplot(data4connBehaviorCorr[!is.na(data4connBehaviorCorr$GeoPref),],
       aes(x = GeoPref_groups, y = GeoPref, col = GeoPref_groups)) +
    geom_boxplot(color = "black") +
    geom_point(position = "jitter", size = 3) +
    labs(x = "", y = "Fixation Social (%)") +
    theme(legend.title = element_text(colour="black", size=14, face="bold"),
          legend.text = element_text(colour="black", size=14, face="bold")) +
    theme(plot.title = element_text(hjust = 0.5))+
    theme(axis.text = element_text(size = 16, face = "bold"),
          axis.title = element_text(size = 18, face = "bold")) +
    theme(panel.background = element_blank(),
          panel.border = element_blank(),
          panel.grid = element_blank(),
          axis.line = element_line(colour = "black")) +
    coord_cartesian(ylim=c(20,100)) +
    scale_y_continuous(breaks = seq(20,100,10))
```




```
#ggsave("results/ET_subgroups.png", width = 7, height = 5,units = c("in"), dpi = 200)

# t-test
diff_12 <- t.test(data4connBehaviorCorr$GeoPref[data4connBehaviorCorr$GeoPref_groups == "nonSocial"],
           data4connBehaviorCorr$GeoPref[data4connBehaviorCorr$GeoPref_groups == "Social"])
diff_13 <- t.test(data4connBehaviorCorr$GeoPref[data4connBehaviorCorr$GeoPref_groups == "nonSocial"],
           data4connBehaviorCorr$GeoPref[data4connBehaviorCorr$GeoPref_groups == "Non-ASD"])
diff_23 <-t.test(data4connBehaviorCorr$GeoPref[data4connBehaviorCorr$GeoPref_groups == "Social"],
         data4connBehaviorCorr$GeoPref[data4connBehaviorCorr$GeoPref_groups == "Non-ASD"])

print(paste0("nonSocial vs. Social ASD: t = ", round(diff_12$statistic,2),
         " p = ", round(diff_12$p.value,4)))
```

```
## [1] "nonSocial vs. Social ASD: t = -8.41 p = 0"
```

```
print(paste0("nonSocial ASD vs. non-ASD: t = ", round(diff_13$statistic,2),
         " p = ", round(diff_13$p.value,4)))
```

```
## [1] "nonSocial ASD vs. non-ASD: t = -6.93 p = 0"
```

```
print(paste0("Social ASD vs. non-ASD: t = ", round(diff_23$statistic,2),
         " p = ", round(diff_23$p.value,4)))
```

```
## [1] "Social ASD vs. non-ASD: t = 0.46 p = 0.6485"
```

Exploratory analysis of subgroup-specific relations in ASD toddlers

```
tmp <- data4connBehaviorCorr[data4connBehaviorCorr$ET_gr == "ET_Y", ]
#colnames(tmp)

corrTest <- as.data.frame(matrix(0, 2,6))
colnames(corrTest) <- c("group","behavior","connectivity", "r","p","CI")

# temporal-cuneus iFC
x_var1 <- "final_vine_ComTotal_DomStd"
y_var1 <- "LHtemporal_Cunues"

m <- 0
    for (group in c("nonSocial","Social")) {

    m <- m+1
    tt1 <- cor.test(tmp[tmp$GeoPref_groups == group, x_var1],
            tmp[tmp$GeoPref_groups == group, y_var1])

    set.seed(1)

        data <- tmp[tmp$GeoPref_groups == group, ]
        b1 <- boot(data,
               statistic = function(data, i) {
                cor(data[i, x_var1], data[i, y_var1],
                    method='pearson')
               },
               R = 100000
        )

        bt1 <- boot.ci(b1, type = c("perc"))

        corrTest[m, 1:3] <- c(group,x_var1, y_var1)
        corrTest[m, 4:6] <- c(round(tt1$estimate[[1]],3),
                      round(tt1$p.value,3),
                      paste0("[",round(bt1$percent[1,4],3),",",
                             round(bt1$percent[1,5],3),"]"))
    }

    knitr::kable(corrTest)
```

group	behavior	connectivity	r	p	CI
nonSocial	final_vine_ComTotal_DomStd	LHtemporal_Cunues	0.551	0.027	[0.095,0.835]
Social	final_vine_ComTotal_DomStd	LHtemporal_Cunues	0.586	0.017	[-0.22,0.898]

```
    mm <- paired.r(as.numeric(corrTest$r[1]), as.numeric(corrTest$r[2]), NULL,16,16,
           twotailed = T)
    print(paste0("Differences in connectivity strength: z = ",round(mm$z,2),
          " p = ", round(mm$p,3)))
```

```
## [1] "Differences in connectivity strength: z = 0.13 p = 0.895"
```

```r
# temporal-precuneus iFC
corrTest <- as.data.frame(matrix(0, 2,6))
colnames(corrTest) <- c("group","behavior","connectivity", "r","p","CI")

    x_var2 <- "ratio_EL"
    y_var2 <- "RHtemporal_Precuneus"

    m <- 0
    for (group in c("nonSocial","Social")) {

    m <- m+1
    tt1 <- cor.test(tmp[tmp$GeoPref_groups == group, x_var2],
            tmp[tmp$GeoPref_groups == group, y_var2])

    set.seed(1)

        data <- tmp[tmp$GeoPref_groups == group, ]
        b1 <- boot(data,
               statistic = function(data, i) {
                cor(data[i, x_var2], data[i, y_var2],
                    method='pearson')
               },
               R = 100000
        )

        bt1 <- boot.ci(b1, type = c("perc"))

        corrTest[m, 1:3] <- c(group,x_var2, y_var2)
        corrTest[m, 4:6] <- c(round(tt1$estimate[[1]],3),
                      round(tt1$p.value,3),
                       paste0("[",round(bt1$percent[1,4],3),",",
                              round(bt1$percent[1,5],3),"]"))
    }

    knitr::kable(corrTest)
```

group	behavior	connectivity	r	p	CI
nonSocial	ratio_EL	RHtemporal_Precuneus	0.735	0.001	[0.395,0.912]
Social	ratio_EL	RHtemporal_Precuneus	0.624	0.01	[0.316,0.832]

```r
    mm <- paired.r(as.numeric(corrTest$r[1]), as.numeric(corrTest$r[2]), NULL,16,16,
               twotailed = T)
    print(paste0("Differences in connectivity strength: z = ",round(mm$z,2),
           " p = ", round(mm$p,3)))
```

```
## [1] "Differences in connectivity strength: z = 0.53 p = 0.596"
```