fMRI Scans and Clinical Data Analysis

Setup

```
# load packages

packages <- c("here","dplyr","data.table","psych","FSA","ggplot2")

lapply(packages, library, character.only = TRUE)
```

Read in toddler data

```
# read in data
tidy_fMRI_clinical_toddlers <- read.table(here::here("data", "tidy_fMRI_clinical_toddlers.txt"),
                 header = T, sep = "\t",stringsAsFactors = F)

# toddler sample
toddler_sample <- tidy_fMRI_clinical_toddlers[!duplicated(tidy_fMRI_clinical_toddlers$subjid), ]
dim(toddler_sample)[1]
```

```
## [1] 71
```

Toddler fMRI scans and sample size

```
# total scans
Story_scans <- tidy_fMRI_clinical_toddlers[!is.na(tidy_fMRI_clinical_toddlers$Story_Lang),]
Karen_scans <- tidy_fMRI_clinical_toddlers[!is.na(tidy_fMRI_clinical_toddlers$Karen_Lang),]
Motherese_scans <- tidy_fMRI_clinical_toddlers[!is.na(tidy_fMRI_clinical_toddlers$Motherese),]

knitr::kable(rbind(Story_Lang = table(Story_scans$group),
      Karen_Lang = table(Karen_scans$group),
      Motherese = table(Motherese_scans$group)))
```

	ASD	TD
Story_Lang	33	26
Karen_Lang	40	33
Motherese	39	29

```r
# sample size
knitr::kable(rbind(Story_Lang = table(Story_scans$group[!duplicated(Story_scans$subjid)]),
      Karen_Lang = table(Karen_scans$group[!duplicated(Karen_scans$subjid)]),
      Motherese = table(Motherese_scans$group[!duplicated(Motherese_scans$subjid)])))
```

	ASD	TD
Story_Lang	31	23
Karen_Lang	36	28
Motherese	37	25

```r
# retest scans
knitr::kable(rbind(Story_Lang = table(Story_scans$group[duplicated(Story_scans$subjid)]),
      Karen_Lang = table(Karen_scans$group[duplicated(Karen_scans$subjid)]),
      Motherese = table(Motherese_scans$group[duplicated(Motherese_scans$subjid)])))
```

	ASD	TD
Story_Lang	2	3
Karen_Lang	4	5
Motherese	2	4

Adult scans and sample size

```r
# read adult data
adult_scans <- read.table(here::here("data", "tidy_fMRI_adults.txt"),
                 header = T, sep = "\t",stringsAsFactors = F)

# adult sample
adult_sample <- adult_scans[!duplicated(adult_scans$Subj), ]
dim(adult_sample)[1]
```

```
## [1] 14
```

```r
table(adult_sample$gender)
```

```
##
## F M
## 8 6
```

```r
# adult fMRI scans and sample size
Story_scans_adult <- adult_scans[!is.na(adult_scans$Story_Lang),]
Karen_scans_adult <- adult_scans[!is.na(adult_scans$Karen_Lang),]
Motherese_scans_adult <- adult_scans[!is.na(adult_scans$Motherese),]

knitr::kable(cbind(Story_Lang = dim(Story_scans_adult)[1],
      Karen_Lang = dim(Karen_scans_adult)[1],
      Motherese = dim(Motherese_scans_adult)[1]))
```

Story_Lang	Karen_Lang	Motherese
18	12	11

```r
# sample size
knitr::kable(cbind(Story_Lang = dim(Story_scans_adult[!duplicated(Story_scans_adult$Subj),])[1],
      Karen_Lang = dim(Karen_scans_adult[!duplicated(Karen_scans_adult$Subj),])[1],
      Motherese = dim(Motherese_scans_adult[!duplicated(Motherese_scans_adult$Subj),])[1]))
```

Story_Lang	Karen_Lang	Motherese
13	12	8

```r
# retest scans
knitr::kable(cbind(Story_Lang = dim(Story_scans_adult[duplicated(Story_scans_adult$Subj),])[1],
      Karen_Lang = dim(Karen_scans_adult[duplicated(Karen_scans_adult$Subj),])[1],
      Motherese = dim(Motherese_scans_adult[duplicated(Motherese_scans_adult$Subj),])[1]))
```

Story_Lang	Karen_Lang	Motherese
5	0	3

Head motion for each language paradigm

```r
# mean and sd in toddlers
Story_mean <- describeBy(Story_scans[, c("group","Story_meanFD")], group = "group",
             mat = TRUE,  digits = 2)
Karen_mean <- describeBy(Karen_scans[, c("group","Karen_meanFD")], group = "group",
             mat = TRUE,  digits = 2)
Motherese_mean <- describeBy(Motherese_scans[, c("group","Motherese_meanFD")],
                 group = "group",mat = TRUE,  digits = 2)

# ASD vs. TD toddlers
t_Story <- t.test(Story_scans$Story_meanFD[Story_scans$group == "TD"],
          Story_scans$Story_meanFD[Story_scans$group == "ASD"])
t_Karen <-t.test(Karen_scans$Story_meanFD[Karen_scans$group == "TD"],
         Karen_scans$Story_meanFD[Karen_scans$group == "ASD"])
t_Motherese <- t.test(Motherese_scans$Story_meanFD[Motherese_scans$group == "TD"],
              Motherese_scans$Story_meanFD[Motherese_scans$group == "ASD"])

# mean and sd in adults
adult_Story <- Summarize(Story_scans_adult$Story_meanFD)[2:3]
adult_Karen <- Summarize(Karen_scans_adult$Karen_meanFD)[2:3]
adult_Motherese <-Summarize(Motherese_scans_adult$Motherese_meanFD)[2:3]

# adults vs. TD toddlers
t_Story_vsTD <- t.test(Story_scans_adult$Story_meanFD,
           Story_scans$Story_meanFD[Story_scans$group == "TD"])
t_Karen_vsTD <- t.test(Karen_scans_adult$Karen_meanFD,
```

```r
       Karen_scans$Karen_meanFD[Karen_scans$group == "TD"])
t_Motherese_vsTD <- t.test(Motherese_scans_adult$Motherese_meanFD,
       Motherese_scans$Motherese_meanFD[Motherese_scans$group == "TD"])

# adults vs. ASD toddlers
t_Story_vsASD <- t.test(Story_scans_adult$Story_meanFD,
               Story_scans$Story_meanFD[Story_scans$group == "ASD"])
t_Karen_vsASD <- t.test(Karen_scans_adult$Karen_meanFD,
                Karen_scans$Karen_meanFD[Karen_scans$group == "ASD"])
t_Motherese_vsASD <- t.test(Motherese_scans_adult$Motherese_meanFD,
                Motherese_scans$Motherese_meanFD[Motherese_scans$group == "ASD"])

# summary of head motion in each group and comparisons
FD_sum <- cbind(rbind(paste0(Story_mean$mean[3:4],"(",Story_mean$sd[3:4],")"),
      paste0(Karen_mean$mean[3:4],"(",Karen_mean$sd[3:4],")"),
      paste0(Motherese_mean$mean[3:4], "(",Motherese_mean$sd[3:4],")")),
      rbind(paste0("t=",round(t_Story$statistic,2), " p=",round(t_Story$p.value,2)),
      paste0("t=",round(t_Karen$statistic,2), " p=",round(t_Karen$p.value,2)),
      paste0("t=",round(t_Motherese$statistic,2), " p=",round(t_Motherese$p.value,2))),
      rbind(paste0(round(adult_Story[1],2),"(",round(adult_Story[2],2),")"),
            paste0(round(adult_Karen[1],2),"(",round(adult_Karen[2],2),")"),
            paste0(round(adult_Motherese[1],2),"(",round(adult_Motherese[2],2),")")),
      rbind(paste0("t=",round(t_Story_vsTD$statistic,2), " p=",round(t_Story_vsTD$p.value,2)),
      paste0("t=",round(t_Karen_vsTD$statistic,2), " p=",round(t_Karen_vsTD$p.value,2)),
      paste0("t=",round(t_Motherese_vsTD$statistic,2), " p=",round(t_Motherese_vsASD$p.value,2))),
      rbind(paste0("t=",round(t_Story_vsASD$statistic,2), " p=",round(t_Story_vsASD$p.value,2)),
      paste0("t=",round(t_Karen_vsASD$statistic,2), " p=",round(t_Karen_vsASD$p.value,2)),
      paste0("t=",round(t_Motherese_vsASD$statistic,2), " p=",round(t_Motherese_vsASD$p.value,2))))

rownames(FD_sum) <- c("Story language","Karen language", "Motherese")
colnames(FD_sum) <- c("ASD", "TD", "TD vs ASD","Adults", "Adults vs TD", "Adults vs ASD")

knitr::kable(FD_sum)
```

	ASD	TD	TD vs ASD	Adults	Adults vs TD	Adults vs ASD
Story language	0.09(0.06)	0.11(0.1)	t=0.88 p=0.38	0.08(0.02)	t=-1.46 p=0.16	t=-0.81 p=0.42
Karen language	0.09(0.06)	0.1(0.05)	t=1.28 p=0.21	0.08(0.04)	t=-1.32 p=0.2	t=-0.68 p=0.5
Motherese	0.11(0.14)	0.09(0.06)	t=-0.61 p=0.55	0.07(0.03)	t=-1.31 p=0.1	t=-1.66 p=0.1

Demographic information and clinical test scores

```r
colnames(dplyr::select(toddler_sample, contains("final")))
```

```
## [1] "final_Dx"                    "final_ados_CoSoTot"
## [3] "final_ados_RRTot"            "final_ados_CoSoTotRRTot"
```

```
##  [5] "final_vine_ComTotal_DomStd"  "final_vine_DlyTotal_DomStd"
##  [7] "final_vine_SocTotal_DomStd"  "final_vine_MtrTotal_DomStd"
##  [9] "final_vine_AdapBehav_DomStd" "final_vine_DomStdTotal"
## [11] "final_mullen_VRT"            "final_mullen_FMT"
## [13] "final_mullen_RLT"            "final_mullen_ELT"
## [15] "final_mullen_ELC_Std"
```

```
describeBy(toddler_sample[, c("group", "Gender","scan_age","test_age", colnames(dplyr::select(toddler_sa
       group = "group",mat = TRUE,  digits = 3)
```

```
##                             item group1 vars  n    mean     sd median trimmed
## group*1                        1    ASD    1 41   1.000  0.000    1.0   1.000
## group*2                        2     TD    1 30   1.000  0.000    1.0   1.000
## Gender*1                       3    ASD    2 41   1.854  0.358    2.0   1.939
## Gender*2                       4     TD    2 30   1.600  0.498    2.0   1.625
## scan_age1                      5    ASD    3 41  28.805  9.732   27.0  28.000
## scan_age2                      6     TD    3 30  23.700  5.984   22.0  23.292
## test_age1                      7    ASD    4 41  28.879  8.416   33.0  29.004
## test_age2                      8     TD    4 30  26.267  8.136   27.0  26.458
## final_Dx*1                     9    ASD    5 41   1.024  0.156    1.0   1.000
## final_Dx*2                    10     TD    5 30   4.700  2.535    4.5   4.667
## final_ados_CoSoTot1           11    ASD    6 41  12.854  4.059   13.0  13.000
## final_ados_CoSoTot2           12     TD    6 30   2.700  1.489    3.0   2.708
## final_ados_RRTot1             13    ASD    7 41   5.341  2.128    6.0   5.455
## final_ados_RRTot2             14     TD    7 30   1.233  1.165    1.0   1.125
## final_ados_CoSoTotRRTot1      15    ASD    8 41  18.195  5.372   18.0  18.394
## final_ados_CoSoTotRRTot2      16     TD    8 30   3.933  1.799    4.0   3.833
## final_vine_ComTotal_DomStd1   17    ASD    9 41  82.927 16.626   85.0  84.030
## final_vine_ComTotal_DomStd2   18     TD    9 30  97.167 11.859   96.0  96.583
## final_vine_DlyTotal_DomStd1   19    ASD   10 41  86.366 11.764   85.0  85.758
## final_vine_DlyTotal_DomStd2   20     TD   10 30  97.533 12.227   96.5  97.250
## final_vine_SocTotal_DomStd1   21    ASD   11 41  82.951 12.586   84.0  83.455
## final_vine_SocTotal_DomStd2   22     TD   11 30  98.567 10.311   99.0  98.000
## final_vine_MtrTotal_DomStd1   23    ASD   12 41  89.829 17.943   89.0  91.212
## final_vine_MtrTotal_DomStd2   24     TD   12 30  94.633 20.769   97.5  97.750
## final_vine_AdapBehav_DomStd1  25    ASD   13 41  82.366 11.510   83.0  81.667
## final_vine_AdapBehav_DomStd2  26     TD   13 30  96.800 10.889   97.5  96.333
## final_vine_DomStdTotal1       27    ASD   14 41 341.829 44.069  344.0 341.030
## final_vine_DomStdTotal2       28     TD   14 30 388.200 34.035  392.0 388.208
## final_mullen_VRT1             29    ASD   15 41  38.610 12.730   40.0  39.000
## final_mullen_VRT2             30     TD   15 30  54.300 11.621   55.0  54.000
## final_mullen_FMT1             31    ASD   16 41  39.951 11.853   42.0  40.455
## final_mullen_FMT2             32     TD   16 30  50.000  8.154   49.0  49.917
## final_mullen_RLT1             33    ASD   17 41  32.293 14.780   26.0  31.667
## final_mullen_RLT2             34     TD   17 30  48.200 11.493   47.5  48.042
## final_mullen_ELT1             35    ASD   18 41  33.098 16.143   30.0  32.879
## final_mullen_ELT2             36     TD   18 30  43.767 12.204   42.0  43.042
## final_mullen_ELC_Std1         37    ASD   19 41  74.073 21.979   72.0  74.818
## final_mullen_ELC_Std2         38     TD   19 30  98.367 16.587   97.5  98.042
##                                mad min max range   skew kurtosis    se
## group*1                      0.000   1   1     0    NaN      NaN 0.000
## group*2                      0.000   1   1     0    NaN      NaN 0.000
## Gender*1                     0.000   1   2     1 -1.928    1.764 0.056
## Gender*2                     0.000   1   2     1 -0.388   -1.910 0.091
```

```
## scan_age1                    10.378  14  55    41  0.727    0.002 1.520
## scan_age2                     6.672  14  38    24  0.511   -0.571 1.092
## test_age1                     4.448  12  51    39 -0.025   -0.205 1.314
## test_age2                    10.378  13  37    24 -0.163   -1.548 1.486
## final_Dx*1                    0.000   1   2     1  5.942   34.145 0.024
## final_Dx*2                    3.706   1   8     7 -0.005   -1.817 0.463
## final_ados_CoSoTot1           4.448   0  20    20 -0.621    0.669 0.634
## final_ados_CoSoTot2           1.483   0   6     6  0.078   -0.361 0.272
## final_ados_RRTot1             2.965   0   9     9 -0.347   -0.711 0.332
## final_ados_RRTot2             1.483   0   4     4  0.444   -0.895 0.213
## final_ados_CoSoTotRRTot1      5.930   5  27    22 -0.334   -0.372 0.839
## final_ados_CoSoTotRRTot2      1.483   1   8     7  0.474   -0.539 0.328
## final_vine_ComTotal_DomStd1  14.826  35 126    91 -0.475    0.875 2.597
## final_vine_ComTotal_DomStd2  10.378  70 122    52  0.231   -0.135 2.165
## final_vine_DlyTotal_DomStd1  14.826  68 116    48  0.469   -0.423 1.837
## final_vine_DlyTotal_DomStd2  11.119  76 122    46  0.208   -1.019 2.232
## final_vine_SocTotal_DomStd1  16.309  57 108    51 -0.205   -0.871 1.966
## final_vine_SocTotal_DomStd2   8.896  79 126    47  0.526    0.463 1.883
## final_vine_MtrTotal_DomStd1  10.378   0 117   117 -2.845   12.703 2.802
## final_vine_MtrTotal_DomStd2   9.637   0 119   119 -3.081   11.578 3.792
## final_vine_AdapBehav_DomStd1  8.896  58 111    53  0.445    0.206 1.798
## final_vine_AdapBehav_DomStd2 10.378  79 128    49  0.587    0.561 1.988
## final_vine_DomStdTotal1      51.891 250 445   195  0.099   -0.515 6.882
## final_vine_DomStdTotal2      24.463 315 483   168  0.188    0.675 6.214
## final_mullen_VRT1            11.861   1  63    62 -0.512    0.241 1.988
## final_mullen_VRT2            13.343  30  77    47  0.078   -0.746 2.122
## final_mullen_FMT1            11.861  20  57    37 -0.495   -1.074 1.851
## final_mullen_FMT2            10.378  35  64    29  0.089   -1.075 1.489
## final_mullen_RLT1            10.378   1  59    58  0.253   -1.095 2.308
## final_mullen_RLT2            12.602  23  72    49  0.093   -0.528 2.098
## final_mullen_ELT1            14.826   1  63    62  0.228   -1.011 2.521
## final_mullen_ELT2            14.085  25  70    45  0.367   -0.802 2.228
## final_mullen_ELC_Std1        22.239   7 115   108 -0.467    0.545 3.433
## final_mullen_ELC_Std2        15.567  71 127    56  0.191   -1.063 3.028
```

```
# Chi-squared test on gender by group
gender_diff <- table(toddler_sample$Gender, toddler_sample$group)
knitr::kable(gender_diff)
```

	ASD	TD
F	6	12
M	35	18

```
chisq.test(gender_diff)
```

```
##
##  Pearson's Chi-squared test with Yates' continuity correction
##
## data:  gender_diff
## X-squared = 4.6259, df = 1, p-value = 0.03149
```

```r
# group differences between ASD and TD
lapply(toddler_sample[, c("scan_age","test_age",colnames(dplyr::select(toddler_sample, contains("final"
       function(x) t.test(x ~ toddler_sample$group, var.equal = TRUE))
```

```
## $scan_age
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = 2.5404, df = 69, p-value = 0.01333
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  1.096119 9.113638
## sample estimates:
## mean in group ASD  mean in group TD
##          28.80488          23.70000
##
##
## $test_age
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = 1.3098, df = 69, p-value = 0.1946
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1.366141  6.589881
## sample estimates:
## mean in group ASD  mean in group TD
##          28.87854          26.26667
##
##
## $final_ados_CoSoTot
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = 13.052, df = 69, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##   8.601704 11.705613
## sample estimates:
## mean in group ASD  mean in group TD
##          12.85366           2.70000
##
##
## $final_ados_RRTot
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = 9.5632, df = 69, p-value = 2.845e-14
## alternative hypothesis: true difference in means is not equal to 0
```

```
## 95 percent confidence interval:
##  3.251147 4.965113
## sample estimates:
## mean in group ASD  mean in group TD
##          5.341463          1.233333
##
##
## $final_ados_CoSoTotRRTot
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = 13.956, df = 69, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  12.22313 16.30044
## sample estimates:
## mean in group ASD  mean in group TD
##         18.195122          3.933333
##
##
## $final_vine_ComTotal_DomStd
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = -4.0019, df = 69, p-value = 0.0001559
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -21.338451  -7.141224
## sample estimates:
## mean in group ASD  mean in group TD
##          82.92683          97.16667
##
##
## $final_vine_DlyTotal_DomStd
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = -3.8862, df = 69, p-value = 0.000231
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -16.900232  -5.434727
## sample estimates:
## mean in group ASD  mean in group TD
##          86.36585          97.53333
##
##
## $final_vine_SocTotal_DomStd
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
```

```
## t = -5.5628, df = 69, p-value = 4.692e-07
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -21.21549 -10.01540
## sample estimates:
## mean in group ASD  mean in group TD
##          82.95122          98.56667
##
##
## $final_vine_MtrTotal_DomStd
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = -1.0424, df = 69, p-value = 0.3008
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -13.997691   4.389561
## sample estimates:
## mean in group ASD  mean in group TD
##          89.82927          94.63333
##
##
## $final_vine_AdapBehav_DomStd
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = -5.3386, df = 69, p-value = 1.132e-06
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -19.827972  -9.040321
## sample estimates:
## mean in group ASD  mean in group TD
##          82.36585          96.80000
##
##
## $final_vine_DomStdTotal
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = -4.8061, df = 69, p-value = 8.672e-06
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -65.61853 -27.12293
## sample estimates:
## mean in group ASD  mean in group TD
##          341.8293          388.2000
##
##
## $final_mullen_VRT
##
##  Two Sample t-test
```

```
##
## data:  x by toddler_sample$group
## t = -5.3199, df = 69, p-value = 1.218e-06
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -21.574061  -9.806427
## sample estimates:
## mean in group ASD  mean in group TD
##          38.60976          54.30000
##
##
## $final_mullen_FMT
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = -3.999, df = 69, p-value = 0.0001575
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -15.061763  -5.035798
## sample estimates:
## mean in group ASD  mean in group TD
##          39.95122          50.00000
##
##
## $final_mullen_RLT
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = -4.9056, df = 69, p-value = 5.967e-06
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -22.376336  -9.438298
## sample estimates:
## mean in group ASD  mean in group TD
##          32.29268          48.20000
##
##
## $final_mullen_ELT
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = -3.038, df = 69, p-value = 0.003361
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -17.675195  -3.663016
## sample estimates:
## mean in group ASD  mean in group TD
##          33.09756          43.76667
##
##
## $final_mullen_ELC_Std
```

```
##
##  Two Sample t-test
##
## data:  x by toddler_sample$group
## t = -5.0833, df = 69, p-value = 3.037e-06
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -33.82757 -14.75943
## sample estimates:
## mean in group ASD  mean in group TD
##          74.07317          98.36667
```

Difference in age between fMRI, clinical, and eye-tracking data collection

```r
# read in data
Motherese_ET <- read.table(here::here("data","tidy_Motherese_ET.txt"),header = T,
               sep = "\t", stringsAsFactors = F)

dim(toddler_sample)
```

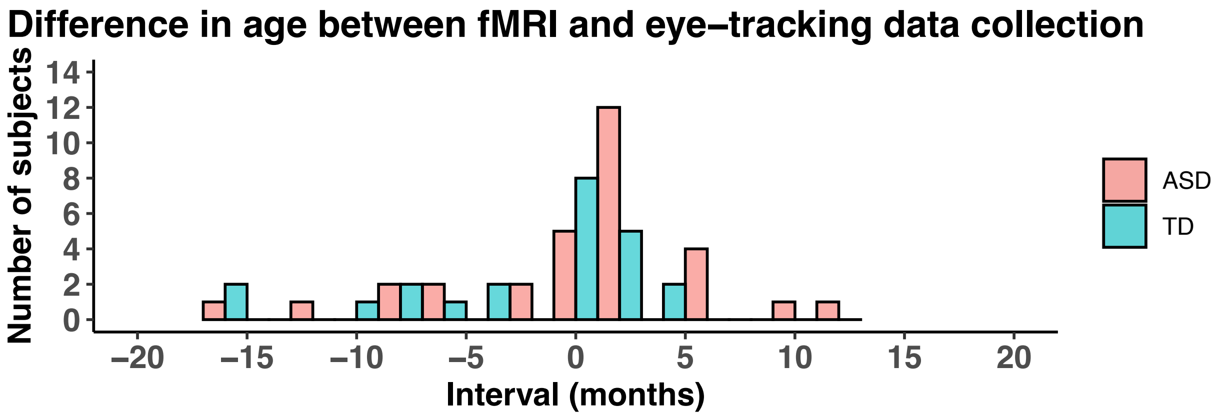
```
## [1] 71 45
```

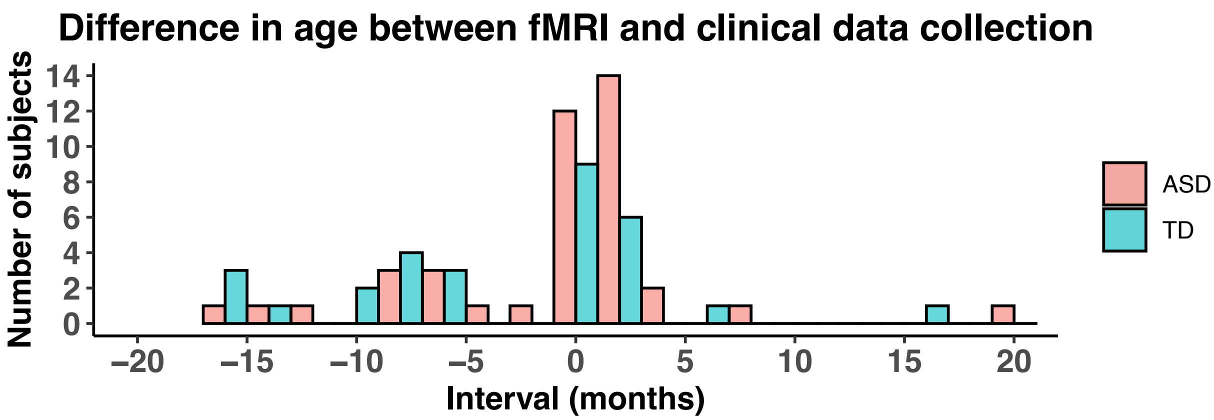
```r
Motherese_ET$age_diff <- Motherese_ET$Scan_Age - Motherese_ET$ET.Age


## age distribution between fMRI scan vs. clinical test, and between fMRI scan vs. ET
toddler_sample$age_diff <- toddler_sample$scan_age - toddler_sample$test_age

p1 <- ggplot(toddler_sample, aes(age_diff,fill = group)) +
    geom_histogram(binwidth = 2, alpha = .6,position="dodge",
               color = "black") +
    #geom_density(alpha = .2, fill = "#FF6666") +
    labs(y = "Number of subjects", x = "Interval (months)",
         title = "Difference in age between fMRI and clinical data collection") +
    #guides(fill = F) +
    theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold"),
          axis.text = element_text(size = 12, face = "bold"),
          axis.title = element_text(size = 12, face = "bold")) +
    theme(legend.title = element_blank(),
          panel.border = element_blank(),
          panel.background = element_blank(),
          panel.grid = element_blank(),
          axis.line = element_line(colour = "black")) +
    coord_cartesian(xlim=c(-20, 20), ylim = c(0,14)) +
    scale_x_continuous(breaks = seq(-20, 20, 5)) +
    scale_y_continuous(breaks = seq(0, 14, 2))

p2 <- ggplot(Motherese_ET, aes(age_diff, fill = group)) +
    geom_histogram(binwidth = 2, alpha = .6,
```

```r
              color = "black",position="dodge") +
  #geom_density(alpha = .2, fill = "#FF6666") +
  labs(y = "Number of subjects", x = "Interval (months)",
       title = "Difference in age between fMRI and eye-tracking data collection") +
  #guides(color = F, fill = F) +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold"),
        axis.text = element_text(size = 12, face = "bold"),
        axis.title = element_text(size = 12, face = "bold")) +
  theme(legend.title = element_blank(),
        panel.border = element_blank(),
        panel.background = element_blank(),
        panel.grid = element_blank(),
        axis.line = element_line(colour = "black")) +
  coord_cartesian(xlim=c(-20, 20), ylim = c(0,14)) +
  scale_x_continuous(breaks = seq(-20, 20, 5)) +
  scale_y_continuous(breaks = seq(0, 14, 2))



 library(gridExtra)
```

```
##
## Attaching package: 'gridExtra'

## The following object is masked from 'package:dplyr':
##
##     combine
```

```r
grid.arrange(p2,p1,nrow = 2)
```


Difference in age between fMRI and eye−tracking data collection
Number of subjects
0
2
4
6
8
10
12
14
−20
−15
−10
−5
0
5
10
15
20
Interval (months)
ASD
TD


Difference in age between fMRI and clinical data collection
Number of subjects
0
2
4
6
8
10
12
14
−20
−15
−10
−5
0
5
10
15
20
Interval (months)
ASD
TD

Characteristics of fMRI paradigms

Setup

```
# load packages
packages <- c("here","dplyr","openxlsx","tidyverse")
lapply(packages, library, character.only = TRUE)
```

Load data

```
Frequency <- xlsx::read.xlsx(here("data", "Characteristics_MRI_Paradigms.xlsx"), sheetIndex = 1)

Beats <- xlsx::read.xlsx(here("data", "Characteristics_MRI_Paradigms.xlsx"), sheetIndex = 2)

Frequency <- as.data.frame(Frequency)
Beats <- as.data.frame(Beats)
```

Mean, sd, and range

```
# peak frequency
frequency_sum <- cbind(rbind(paste0(round(mean(Frequency$Story.language[1:4])),
           "(",round(sd(Frequency$Story.language[1:4])),")"),
        paste0(round(mean(Frequency$Karen.language[1:18])),
               "(",round(sd(Frequency$Karen.language[1:18])),")"),
        paste0(round(mean(Frequency$Motherese[1:12])), "(",
            round(sd(Frequency$Motherese[1:12])),")")),
      rbind(paste0(round(min(Frequency$Story.language[1:4])), "-",
            round(max(Frequency$Story.language[1:4]))),
            paste0(round(min(Frequency$Karen.language[1:18])), "-",
                   round(max(Frequency$Karen.language[1:18]))),
            paste0(round(min(Frequency$Motherese[1:12])), "-",
                   round(max(Frequency$Motherese[1:12])))))

colnames(frequency_sum) <- c("mean (sd)", "range")
rownames(frequency_sum) <- c("Story language", "Karen language", "Motherese")

knitr::kable(frequency_sum)
```

	mean (sd)	range
Story language	275(35)	258-328
Karen language	236(41)	211-375
Motherese	354(67)	258-469

```r
# beats per minutes
beats_sum <- cbind(rbind(paste0(round(mean(Beats$Story.language[1:4])),
           "(",round(sd(Beats$Story.language[1:4])),")"),
        paste0(round(mean(Beats$Karen.language[1:18])),
               "(",round(sd(Beats$Karen.language[1:18])),")"),
        paste0(round(mean(Beats$Motherese[1:12])), "(",
            round(sd(Beats$Motherese[1:12])),")")),
      rbind(paste0(round(min(Beats$Story.language[1:4])), "-",
            round(max(Beats$Story.language[1:4]))),
            paste0(round(min(Beats$Karen.language[1:18])), "-",
                   round(max(Beats$Karen.language[1:18]))),
            paste0(round(min(Beats$Motherese[1:12])), "-",
                   round(max(Beats$Motherese[1:12])))))

colnames(beats_sum) <- c("mean (sd)", "range")
rownames(beats_sum) <- c("Story language", "Karen language", "Motherese")

knitr::kable(beats_sum)
```

	mean (sd)	range
Story language	60(21)	44-88
Karen language	77(27)	20-119
Motherese	59(21)	20-93

Affect level tests for three language paradigms

Setup

```
# load packages

packages <- c("here","dplyr","ggplot2","openxlsx","tidyverse","ggpubr")
lapply(packages, library, character.only = TRUE)
```

Load data from two surveys

```
Survey1 <- xlsx::read.xlsx(here("data", "AffectLevels_testing.xlsx"), sheetIndex = 1)
head(Survey1)
```

```
##   Subject  Paradigm    Score
## 1       1 Motherese 4.333333
## 2       2 Motherese 3.333333
## 3       3 Motherese 4.583333
## 4       4 Motherese 4.416667
## 5       5 Motherese 4.000000
## 6       6 Motherese 4.750000
```

```
Survey2 <- xlsx::read.xlsx(here("data", "AffectLevels_testing.xlsx"), sheetIndex = 2)
head(Survey2)
```

```
##   Subject  Paradigm    Score
## 1       1 Motherese 2.944444
## 2       2 Motherese 3.000000
## 3       3 Motherese 3.000000
## 4       4 Motherese 3.000000
## 5       5 Motherese 3.000000
## 6       6 Motherese 3.000000
```

```
Survey1 <- as.data.frame(Survey1)
Survey2 <- as.data.frame(Survey2)
```

Comparisons in affect levels between language paradigms

```r
# Survey 1
Survey1$Paradigm <- factor(Survey1$Paradigm, levels = c("Motherese", "Karen_Lang", "Story_Lang"))

Survey1 %>%
  group_by(Paradigm) %>%
  summarise_at(vars(Score), list(mean = mean, sd = sd))
```

```
## # A tibble: 3 x 3
##   Paradigm    mean    sd
##   <fct>      <dbl> <dbl>
## 1 Motherese   4.32 0.451
## 2 Karen_Lang  2.50 0.454
## 3 Story_Lang  1.45 0.598
```

```r
res.aov <- aov(Score ~ Paradigm, data = Survey1)
anova(res.aov)
```

```
## Analysis of Variance Table
##
## Response: Score
##           Df Sum Sq Mean Sq F value    Pr(>F)
## Paradigm   2 79.977  39.989   156.3 < 2.2e-16 ***
## Residuals 54 13.816   0.256
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
TukeyHSD(res.aov)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Score ~ Paradigm, data = Survey1)
##
## $Paradigm
##                            diff       lwr        upr p adj
## Karen_Lang-Motherese  -1.812521 -2.208020 -1.4170227 0e+00
## Story_Lang-Motherese  -2.868421 -3.263920 -2.4729223 0e+00
## Story_Lang-Karen_Lang -1.055900 -1.451398 -0.6604008 1e-07
```

```r
Survey1_compare_means <- compare_means(Score ~ Paradigm, data = Survey1, method = "t.test", paired = TRU
          p.adjust.method = "fdr")

data <- Survey1[Survey1$Paradigm !="Story_Lang",]
data$Paradigm <- droplevels(data$Paradigm )
comparison1 <- t.test(Score ~ Paradigm, data = data, paired = TRUE)
eff1 <- effsize::cohen.d(data$Score, data$Paradigm, paired=TRUE)

data <- Survey1[Survey1$Paradigm !="Karen_Lang",]
data$Paradigm <- droplevels(data$Paradigm )
eff2 <- effsize::cohen.d(data$Score, data$Paradigm, paired=TRUE)
comparison2 <- t.test(Score ~ Paradigm, data = data, paired = TRUE)
```

```r
data <- Survey1[Survey1$Paradigm !="Motherese",]
data$Paradigm <- droplevels(data$Paradigm )
eff3 <- effsize::cohen.d(data$Score, data$Paradigm, paired=TRUE)
comparison3 <- t.test(Score ~ Paradigm, data = data, paired = TRUE)

summary_Survey1 <- cbind.data.frame(contrast = c("MotheresevsKaren_Lang","MotheresevsStory_Lang",
                         "Karen_LangvsStory_Lang"),
                         df = rep(length(Survey1$Subject[!duplicated(Survey1$Subject)])-1,3),
                    t = c(comparison1$statistic, comparison2$statistic,
                      comparison3$statistic),
                    Survey1_compare_means$p.format, Survey1_compare_means$p.adj,
                      d = c(eff1$estimate,eff2$estimate,eff3$estimate))

colnames(summary_Survey1)[4:5] <- c("p-value","p-adjusted")
summary_Survey1
```

```
##                 contrast df        t p-value p-adjusted        d
## 1  MotheresevsKaren_Lang 18 20.52712 6.1e-14    1.2e-13 4.006231
## 2  MotheresevsStory_Lang 18 20.20427 8.1e-14    1.2e-13 5.362117
## 3 Karen_LangvsStory_Lang 18 11.74070 7.2e-10    7.2e-10 1.883057
```

```r
# Survey 2
Survey2$Paradigm <- factor(Survey2$Paradigm, levels = c("Motherese", "Karen_Lang", "Story_Lang"))

Survey2 %>%
  group_by(Paradigm) %>%
  summarise_at(vars(Score), list(mean = mean, sd = sd))
```

```
## # A tibble: 3 x 3
##   Paradigm    mean     sd
##   <fct>      <dbl>  <dbl>
## 1 Motherese   2.99 0.0330
## 2 Karen_Lang  1.92 0.0780
## 3 Story_Lang  1.09 0.0831
```

```r
res.aov <- aov(Score ~ Paradigm, data = Survey2)
anova(res.aov)
```

```
## Analysis of Variance Table
##
## Response: Score
##           Df  Sum Sq Mean Sq F value    Pr(>F)
## Paradigm   2 27.0004 13.5002  2876.5 < 2.2e-16 ***
## Residuals 42  0.1971  0.0047
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
TukeyHSD(res.aov)
```

```
##   Tukey multiple comparisons of means
```

```
##     95% family-wise confidence level
##
## Fit: aov(formula = Score ~ Paradigm, data = Survey2)
##
## $Paradigm
##                              diff        lwr        upr p adj
## Karen_Lang-Motherese  -1.0629630 -1.1237380 -1.0021879     0
## Story_Lang-Motherese  -1.8925926 -1.9533676 -1.8318176     0
## Story_Lang-Karen_Lang -0.8296296 -0.8904047 -0.7688546     0
```

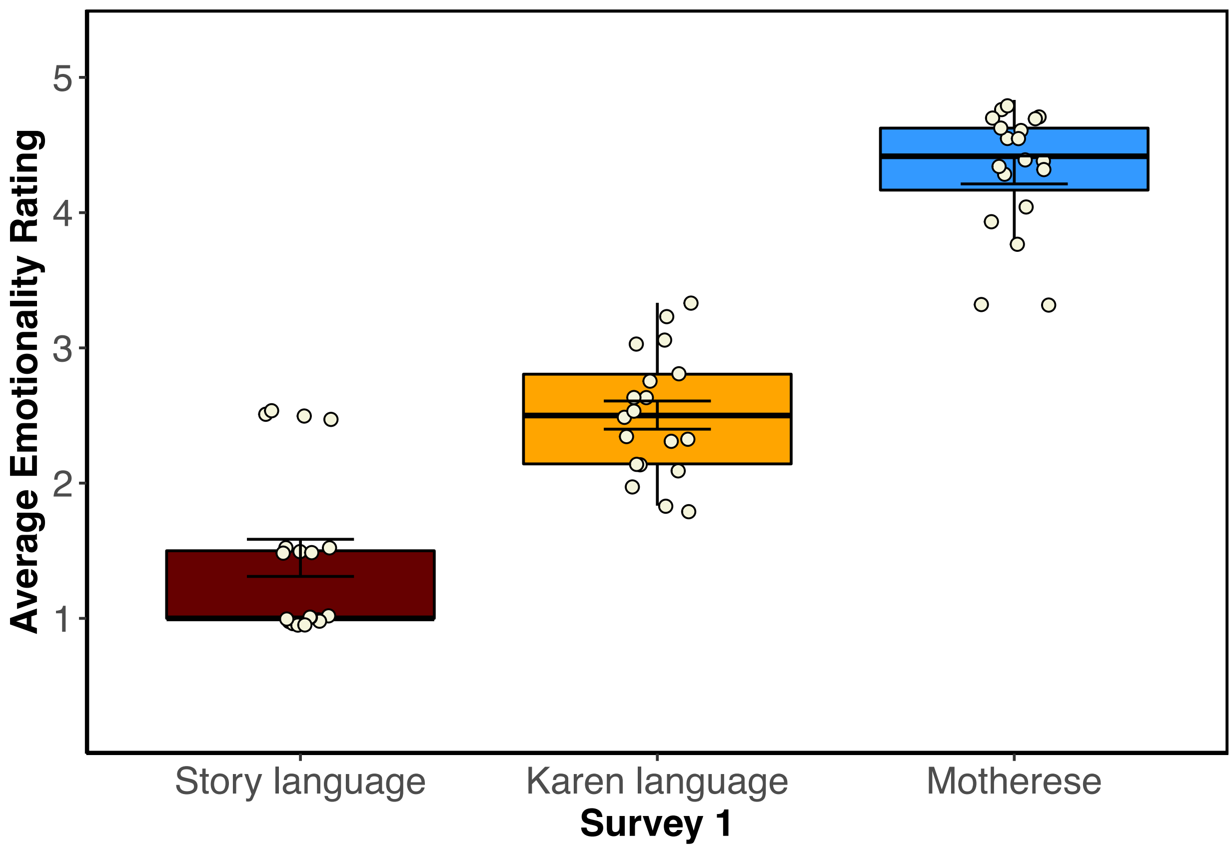
```
Survey2_compare_means <- compare_means(Score ~ Paradigm, data = Survey2, method = "t.test",
                       paired = TRUE, p.adjust.method = "fdr")

data <- Survey2[Survey2$Paradigm !="Story_Lang",]
data$Paradigm <- droplevels(data$Paradigm )
comparison1 <- t.test(Score ~ Paradigm, data = data, paired = TRUE)
eff1 <- effsize::cohen.d(data$Score, data$Paradigm, paired=TRUE)

data <- Survey2[Survey2$Paradigm !="Karen_Lang",]
data$Paradigm <- droplevels(data$Paradigm )
eff2 <- effsize::cohen.d(data$Score, data$Paradigm, paired=TRUE)
comparison2 <- t.test(Score ~ Paradigm, data = data, paired = TRUE)

data <- Survey2[Survey2$Paradigm !="Motherese",]
data$Paradigm <- droplevels(data$Paradigm )
eff3 <- effsize::cohen.d(data$Score, data$Paradigm, paired=TRUE)
comparison3 <- t.test(Score ~ Paradigm, data = data, paired = TRUE)

summary_Survey2 <- cbind.data.frame(contrast = c("MotheresevsKaren_Lang","MotheresevsStory_Lang",
                         "Karen_LangvsStory_Lang"),
                         df = rep(length(Survey2$Subject[!duplicated(Survey2$Subject)])-1,3),
                    t = c(comparison1$statistic, comparison2$statistic,
                      comparison3$statistic),
                    Survey2_compare_means$p.format, Survey2_compare_means$p.adj,
                      d = c(eff1$estimate,eff2$estimate,eff3$estimate))

colnames(summary_Survey2)[4:5] <- c("p-value","p-adjusted")
summary_Survey2
```

```
##                 contrast df        t p-value p-adjusted        d
## 1  MotheresevsKaren_Lang 14 47.73871 < 2e-16    1.0e-16 17.87426
## 2  MotheresevsStory_Lang 14 73.64698 < 2e-16    4.7e-19 31.22883
## 3 Karen_LangvsStory_Lang 14 20.36364 8.4e-12    8.4e-12 10.29827
```

Boxplots for surveys 1 and 2

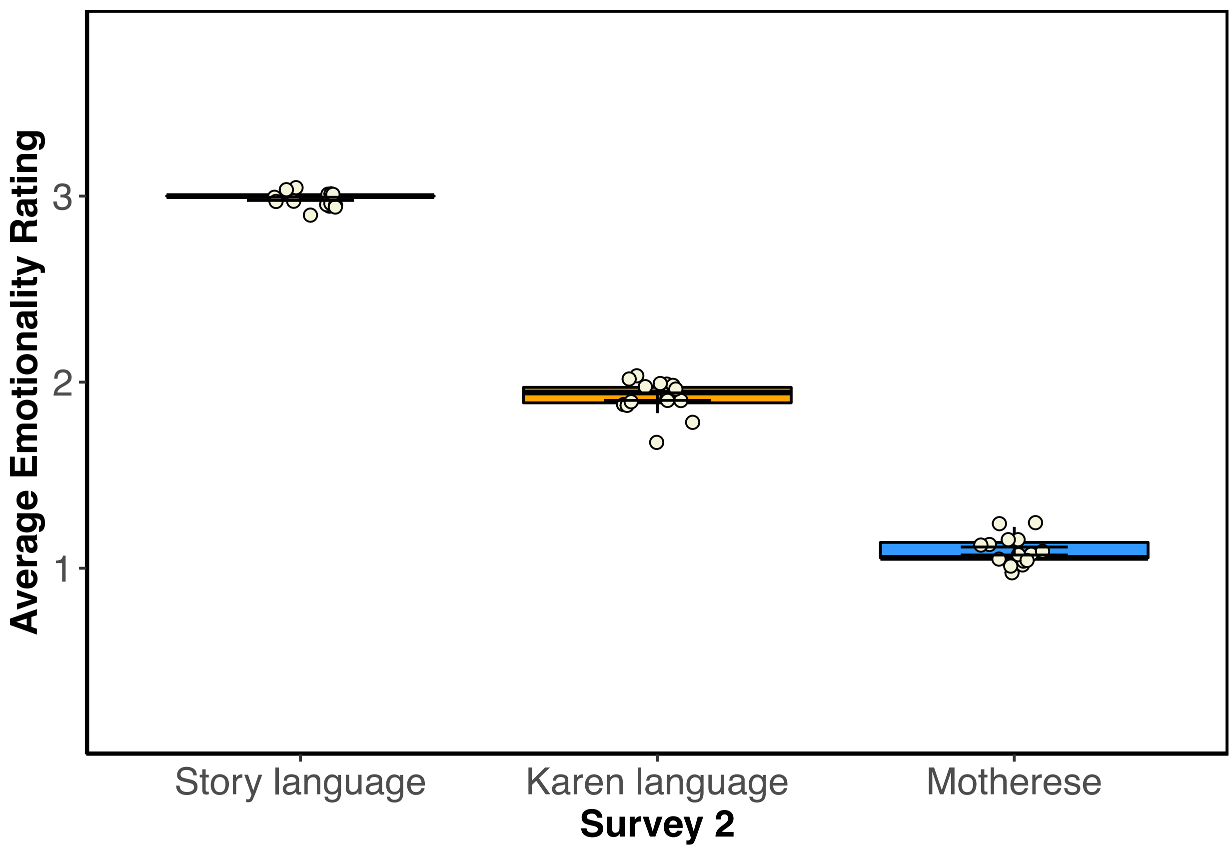
```
# Survey 1
Survey1$Paradigm <- factor(Survey1$Paradigm, levels = c("Story_Lang", "Karen_Lang","Motherese"))

ggplot(Survey1,aes(x=Paradigm, y=Score), fill=Paradigm) +
    geom_boxplot(fill=c("#660000","orange","#3399FF"), colour="black", outlier.shape = NA) +
```

```
    geom_jitter(size=2, position = position_jitter(width=0.1, height=0.05),
        shape=21, colour="black", fill="beige") +
    stat_summary(geom = "errorbar", fun.data = mean_se,
         position = position_dodge(width=0.65), width=0.3) +
    labs(x = "Survey 1", y = "Average Emotionality Rating") +
    scale_y_continuous(expand = c(0,0), limits=c(0,5.5), breaks=c(1,2,3,4,5)) +
    scale_x_discrete(labels =  c("Story language", "Karen language","Motherese")) +
    theme(axis.text=element_text(size=14),
        axis.title=element_text(size=14,face="bold"),
        axis.line = element_line(colour = "black"),
        panel.border = element_rect(colour = "black", fill=NA, size=1),
        panel.background = element_blank())
```




```
# Survey 2
Survey1$Paradigm <- factor(Survey1$Paradigm, levels = c("Story_Lang", "Karen_Lang","Motherese"))
ggplot(Survey2,aes(x=Paradigm, y=Score), fill=Paradigm) +
    geom_boxplot(fill=c("#660000","orange","#3399FF"), colour="black", outlier.shape = NA) +
    geom_jitter(size=2, position = position_jitter(width=0.1, height=0.05),
        shape=21, colour="black", fill="beige") +
  stat_summary(geom = "errorbar", fun.data = mean_se,
         position = position_dodge(width=0.65), width=0.3) +
    labs(x = "Survey 2", y = "Average Emotionality Rating") +
    scale_y_continuous(expand = c(0,0), limits=c(0,4), breaks=c(1,2,3)) +
    scale_x_discrete(labels =  c("Story language", "Karen language","Motherese")) +
    theme(axis.text=element_text(size=14),
```

```
        axis.title=element_text(size=14,face="bold"),
        axis.line = element_line(colour = "black"),
        panel.border = element_rect(colour = "black", fill=NA, size=1),
        panel.background = element_blank())
```



ROI Analysis

Setup

```r
# load packages
packages <- c("here","dplyr","WGCNA","factoextra","ggplot2","effsize","data.table",
          "lme4","lmerTest","psych","FSA","irr","lpSolve")
source(here::here("code","Mods2table.R"))
source(here::here("code","ROI_psc_plot.R"))
source(here::here("code","ROI_behavior_plot.R"))
source(here::here("code","test_retest_plot.R"))
lapply(packages, library, character.only = TRUE)
```

Read in toddler data

```r
# read in data
tidy_fMRI_clinical_toddlers <- read.table(here::here("data", "tidy_fMRI_clinical_toddlers.txt"),
                 header = T, sep = "\t",stringsAsFactors = F)

# scans for each language paradigm
Story_scans <- tidy_fMRI_clinical_toddlers[!is.na(tidy_fMRI_clinical_toddlers$Story_Lang),]
Karen_scans <- tidy_fMRI_clinical_toddlers[!is.na(tidy_fMRI_clinical_toddlers$Karen_Lang),]
Motherese_scans <- tidy_fMRI_clinical_toddlers[!is.na(tidy_fMRI_clinical_toddlers$Motherese),]
```

Read in adult data

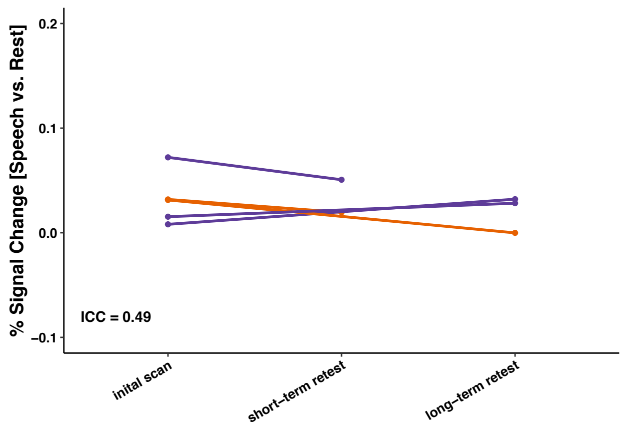
```r
# read in data
adult_scans <- read.table(here::here("data", "tidy_fMRI_adults.txt"),
                 header = T, sep = "\t",stringsAsFactors = F)

# scans for each language paradigm
Story_scans_adult <- adult_scans[!is.na(adult_scans$Story_Lang),]
Karen_scans_adult <- adult_scans[!is.na(adult_scans$Karen_Lang),]
Motherese_scans_adult <- adult_scans[!is.na(adult_scans$Motherese),]
```

Plots for test-retest percent siginal changes in each language paradigm

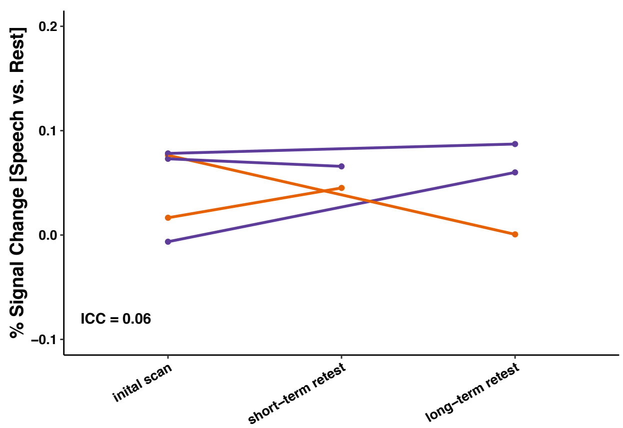
```r
# organize data file
Story_tmp <- Story_scans$subjid[duplicated(Story_scans$subjid)]
Story_retest <- Story_scans[Story_scans$subjid %in% Story_tmp,
colnames(Story_retest)[4:5] <- c("LHtemporal_psc","RHtemporal_psc")
Story_retest$task <- "Story_Lang"
Story_retest$grp <- rep(1:length(Story_tmp), each=2)

Karen_tmp <- Karen_scans$subjid[duplicated(Karen_scans$subjid)]
Karen_retest <- Karen_scans[Karen_scans$subjid %in% Karen_tmp,
        c("subjid","group","scan_age","Karen_LHtemporal_psc","Karen_RHtemporal_psc")]
colnames(Karen_retest)[4:5] <- c("LHtemporal_psc","RHtemporal_psc")
Karen_retest$task <- "Karen_Lang"
Karen_retest$grp <- rep(1:length(Karen_tmp), each=2)

Motherese_tmp <- Motherese_scans$subjid[duplicated(Motherese_scans$subjid)]
Motherese_retest <- Motherese_scans[Motherese_scans$subjid %in% Motherese_tmp,
    c("subjid","group","scan_age","Motherese_LHtemporal_psc","Motherese_RHtemporal_psc")]
colnames(Motherese_retest)[4:5] <- c("LHtemporal_psc","RHtemporal_psc")
Motherese_retest$task <- "Motherese"
Motherese_retest$grp <- rep(1:length(Motherese_tmp), each=2)

combined_retest <- rbind.data.frame(Story_retest,Karen_retest,Motherese_retest)

# add test-retest scan interval
for (i in seq(2, length(combined_retest$subjid), 2)) {
    combined_retest$interval[i-1] <- "inital scan"
    combined_retest$interval[i] <- combined_retest$scan_age[i] -
        combined_retest$scan_age[i-1]
}

Summarize(as.numeric(combined_retest$interval[seq(2, length(combined_retest$subjid), 2)]),
      digits = 2)
```

```
##      n    mean     sd    min     Q1 median     Q3    max
##  20.00    7.60   5.58   1.00   3.50   4.00  13.00  15.00
```

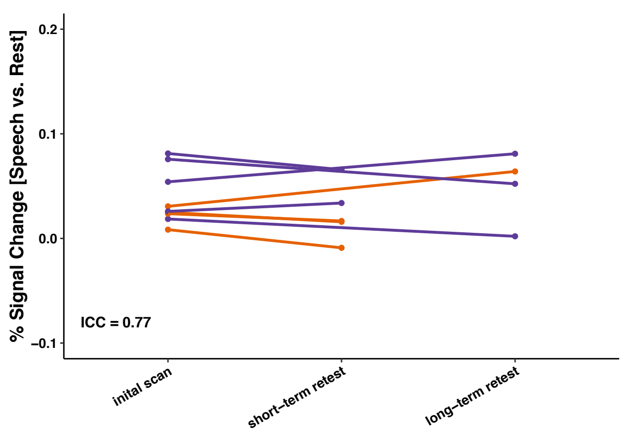
```r
# group retest scans into short-term and long-term scans
combined_retest$scan_group <- combined_retest$interval
combined_retest$scan_group[which(as.numeric(combined_retest$interval) <=4)] <- "short-term retest"
combined_retest$scan_group[which(as.numeric(combined_retest$interval) >4)] <- "long-term retest"

# plot line graphs with intraclass correlation coefficients
combined_retest$scan_group <- factor(combined_retest$scan_group,
                     levels = c("inital scan", "short-term retest",
                           "long-term retest"))

combined_retest$group <- as.factor(combined_retest$group)
test_retest_plot(combined_retest, "Story_Lang", "LHtemporal_psc")
```



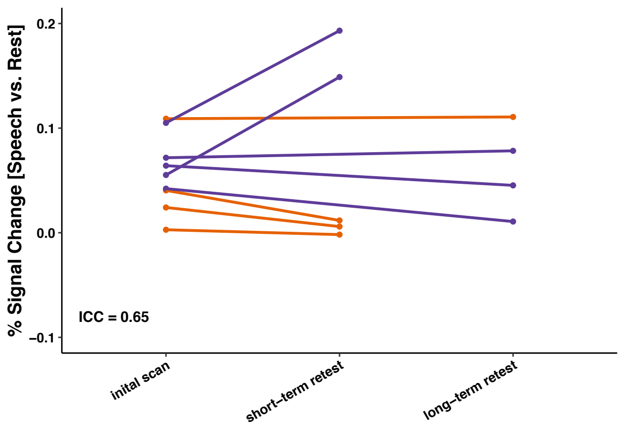

```r
test_retest_plot(combined_retest, "Story_Lang", "RHtemporal_psc")
```



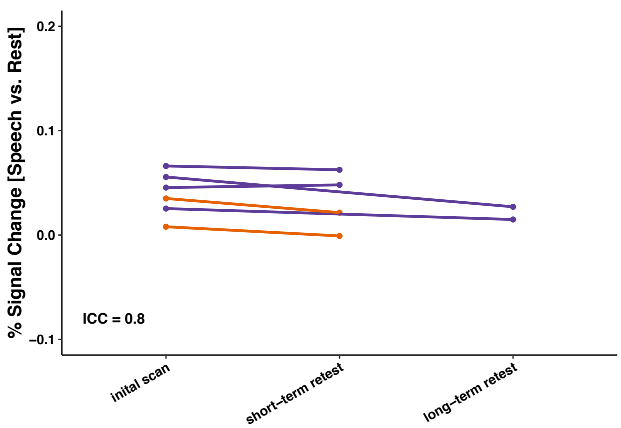

```r
test_retest_plot(combined_retest, "Karen_Lang", "LHtemporal_psc")
```



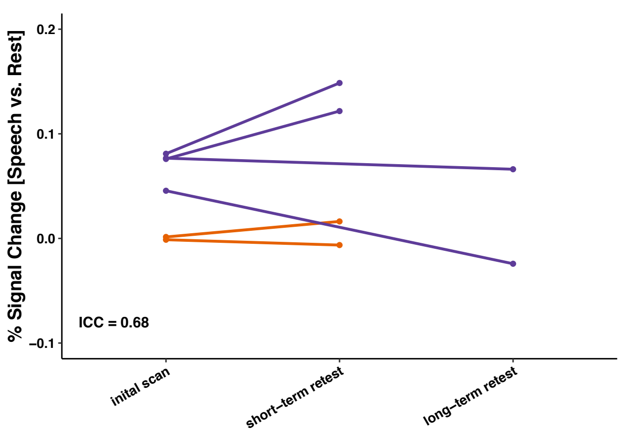

```r
test_retest_plot(combined_retest, "Karen_Lang", "RHtemporal_psc")
```




```
test_retest_plot(combined_retest, "Motherese", "LHtemporal_psc")
```




```
test_retest_plot(combined_retest, "Motherese", "RHtemporal_psc")
```



Percent signal changes in TD and ASD across three language paradigms

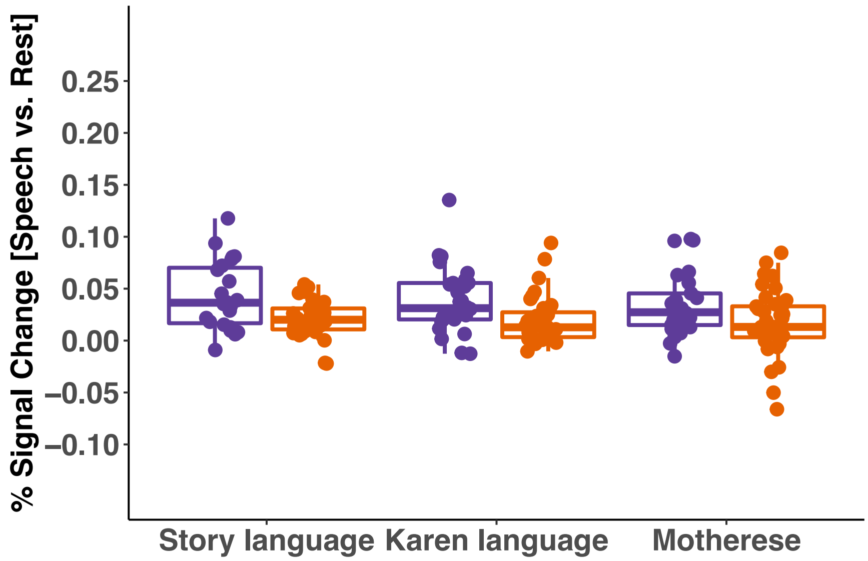
```r
# organize data file
Story_psc <- Story_scans[,c("subjid","scan_age","group","Story_LHtemporal_psc",
                "Story_RHtemporal_psc")]
colnames(Story_psc)[4:5] <- c("LHtemporal_psc","RHtemporal_psc")
Story_psc$task <- "Story language"

Story_psc <- Story_psc[!duplicated(Story_psc$subjid), ]

Karen_psc <- Karen_scans[,c("subjid","scan_age","group","Karen_LHtemporal_psc",
                "Karen_RHtemporal_psc")]
colnames(Karen_psc)[4:5] <- c("LHtemporal_psc","RHtemporal_psc")
Karen_psc$task <- "Karen language"

Karen_psc <- Karen_psc[!duplicated(Karen_psc$subjid), ]

Motherese_psc <- Motherese_scans[,c("subjid","scan_age","group","Motherese_LHtemporal_psc",
                    "Motherese_RHtemporal_psc")]
colnames(Motherese_psc)[4:5] <- c("LHtemporal_psc","RHtemporal_psc")
Motherese_psc$task <- "Motherese"

Motherese_psc <- Motherese_psc[!duplicated(Motherese_psc$subjid), ]

combined_psc <- rbind.data.frame(Story_psc, Karen_psc, Motherese_psc)

combined_psc$task <- factor(combined_psc$task, levels = unique(combined_psc$task))
combined_psc$group <- factor(combined_psc$group, levels = unique(combined_psc$group))

aggregate(LHtemporal_psc ~ group + task, FUN=mean, data=combined_psc)
```

```
##   group           task LHtemporal_psc
## 1    TD Story language     0.04286353
## 2   ASD Story language     0.02030916
## 3    TD Karen language     0.03839828
## 4   ASD Karen language     0.01992519
## 5    TD      Motherese     0.03516916
## 6   ASD      Motherese     0.01691953
```

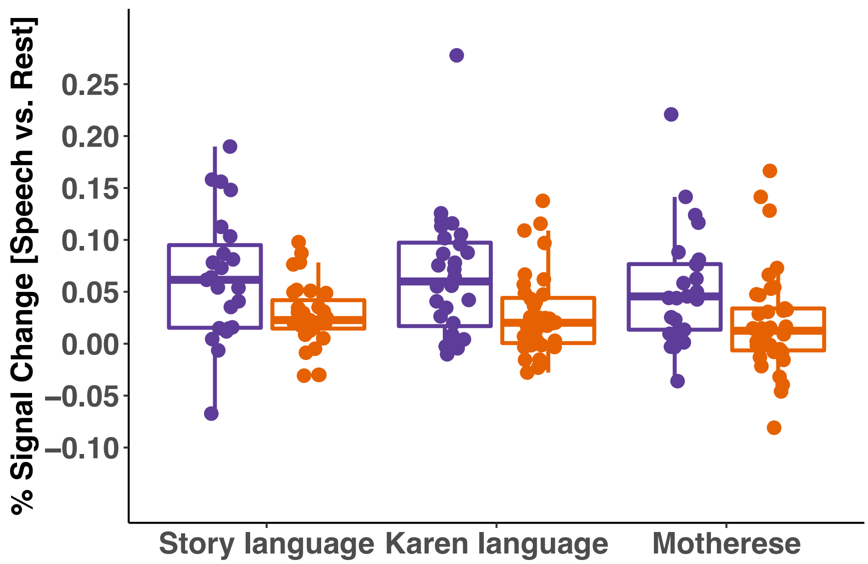
```r
dim(combined_psc)
```

```
## [1] 180   6
```

```r
# boxplots
ROI_psc_plot(combined_psc, "LHtemporal_psc", "TDvsASD")
```




```r
ROI_psc_plot(combined_psc, "RHtemporal_psc", "TDvsASD")
```




```r
# t-tests and effect sizes
tasks <- c("Story language", "Karen language", "Motherese")

es_mat <- matrix(1:12,nrow = 3, ncol = 4)
rownames(es_mat) <- c("Story language", "Karen language", "Motherese")
colnames(es_mat) <- c("left temporal", "right temporal","left temporal", "right temporal")

i <- 0
for (task in tasks) {
    i <- i + 1
    aa <- effsize::cohen.d(combined_psc[combined_psc$task == task, "LHtemporal_psc"],
```

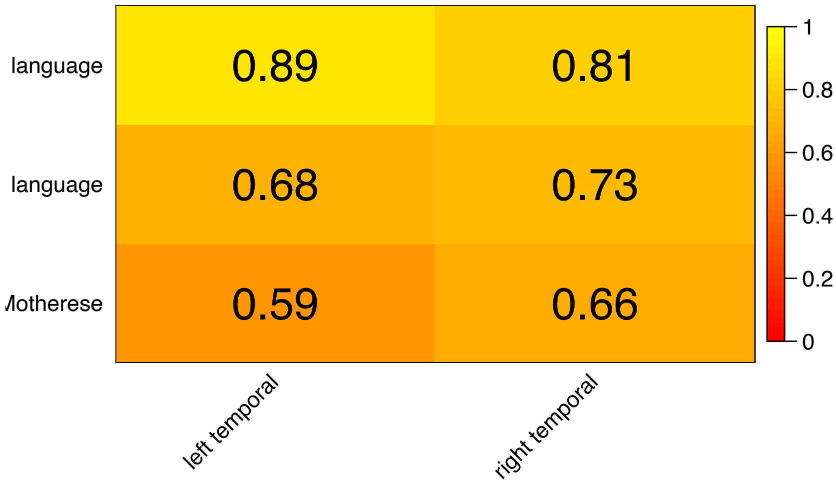
```
                       combined_psc[combined_psc$task == task, "group"],
                       pooled = T)

    bb <- effsize::cohen.d(combined_psc[combined_psc$task == task, "RHtemporal_psc"],
                       combined_psc[combined_psc$task == task, "group"],
                       pooled = T)

    tt1 <- t.test(combined_psc[combined_psc$task == task & combined_psc$group == "TD",
                     "LHtemporal_psc"],
              combined_psc[combined_psc$task == task & combined_psc$group == "ASD",
                       "LHtemporal_psc"])

    tt2 <- t.test(combined_psc[combined_psc$task == task & combined_psc$group == "TD",
                     "RHtemporal_psc"],
              combined_psc[combined_psc$task == task & combined_psc$group == "ASD",
                       "RHtemporal_psc"])

    es_mat[i, 1] <- round(abs(aa$estimate),2)
    es_mat[i, 2] <- round(abs(bb$estimate),2)
    es_mat[i, 3] <- round(abs(tt1$p.value),3)
    es_mat[i, 4] <- round(abs(tt2$p.value),3)
}

# t-values
knitr::kable(es_mat[,1:2])
```

	left temporal	right temporal
Story language	0.89	0.81
Karen language	0.68	0.73
Motherese	0.59	0.66

```
# p-values
knitr::kable(es_mat[,3:4])
```

	left temporal	right temporal
Story language	0.005	0.011
Karen language	0.012	0.009
Motherese	0.026	0.017

```
# plot the effect size matrix as a heatmap
eff <- es_mat[,1:2]
colfunc <- colorRampPalette(c("red", "yellow"))

WGCNA::labeledHeatmap(Matrix = eff, xLabels = colnames(eff),
              yLabels = rownames(eff), ySymbols = NULL, colorLabels = F,
              colors = colfunc(50), textMatrix = round(eff, digits = 2),
              setStdMargins = F, cex.text = 2, zlim = c(0, 1))
```



Group differences in percent signal changes between TD toddlers vs. adults across three language paradigms

```
# organize data file: TD toddler
combined_psc_TD <- combined_psc[combined_psc$group == "TD",
                c("subjid","LHtemporal_psc","RHtemporal_psc", "task")]
combined_psc_TD$group <- "TD Toddlers"

# organize data file: adults
Story_adult_psc <- Story_scans_adult[, c("fMRI_Subj","Subj","Story_LHtemporal_psc",
                     "Story_RHtemporal_psc")]
colnames(Story_adult_psc)[3:4] <- c("LHtemporal_psc","RHtemporal_psc")
Story_adult_psc$task <- "Story language"

Story_adult_psc <- Story_adult_psc[!duplicated(Story_adult_psc$Subj),]

Karen_adult_psc <- Karen_scans_adult[, c("fMRI_Subj","Subj","Karen_LHtemporal_psc",
                     "Karen_RHtemporal_psc")]
colnames(Karen_adult_psc)[3:4] <- c("LHtemporal_psc","RHtemporal_psc")
Karen_adult_psc$task <- "Karen language"

Karen_adult_psc <- Karen_adult_psc[!duplicated(Karen_adult_psc$Subj),]

Motherese_adult_psc <- Motherese_scans_adult[,c("fMRI_Subj","Subj","Motherese_LHtemporal_psc",
                        "Motherese_RHtemporal_psc")]
colnames(Motherese_adult_psc)[3:4] <- c("LHtemporal_psc","RHtemporal_psc")
Motherese_adult_psc$task <- "Motherese"

Motherese_adult_psc <- Motherese_adult_psc[!duplicated(Motherese_adult_psc$Subj),]
```

```r
combined_psc_adults <- rbind.data.frame(Story_adult_psc, Karen_adult_psc, Motherese_adult_psc)
colnames(combined_psc_adults)
```

```
## [1] "fMRI_Subj"      "Subj"           "LHtemporal_psc" "RHtemporal_psc"
## [5] "task"
```

```r
combined_psc_adults$group <- "TD Adults"

mean(combined_psc_adults$LHtemporal_psc[combined_psc_adults$task == "Karen language"])
```

```
## [1] 0.1290372
```

```r
mean(combined_psc_adults$RHtemporal_psc[combined_psc_adults$task == "Karen language"])
```

```
## [1] 0.2953956
```

```r
mean(combined_psc_adults$LHtemporal_psc[combined_psc_adults$task == "Story language"])
```

```
## [1] 0.103344
```

```r
mean(combined_psc_adults$RHtemporal_psc[combined_psc_adults$task == "Story language"])
```

```
## [1] 0.3077167
```

```r
mean(combined_psc_adults$LHtemporal_psc[combined_psc_adults$task == "Motherese"])
```

```
## [1] 0.1416974
```

```r
mean(combined_psc_adults$RHtemporal_psc[combined_psc_adults$task == "Motherese"])
```

```
## [1] 0.339525
```

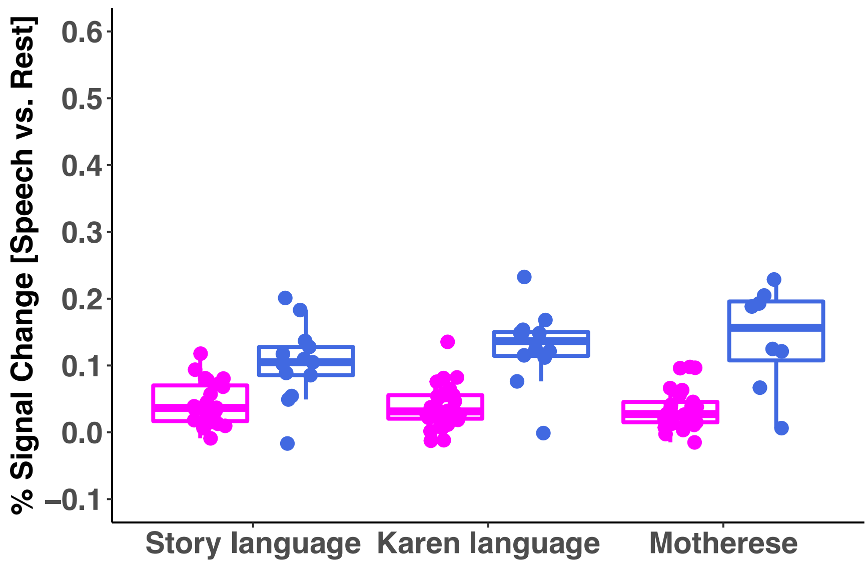
```r
# combine TD toddlers and adults
colnames(combined_psc_adults)[1] <- "subjid"
combined_psc_all <- rbind(combined_psc_TD, combined_psc_adults[,-2])
colnames(combined_psc_TD)
```

```
## [1] "subjid"         "LHtemporal_psc" "RHtemporal_psc" "task"
## [5] "group"
```

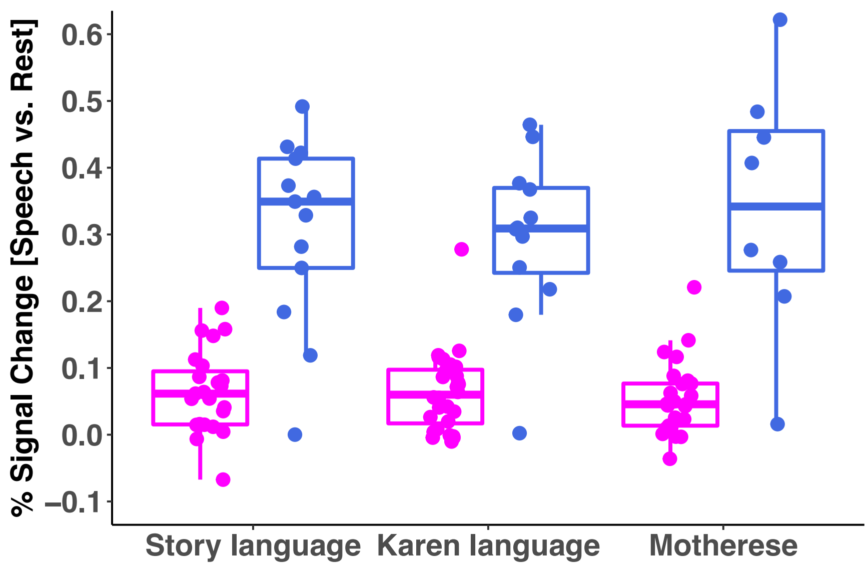
```r
colnames(combined_psc_adults[,-2])
```

```
## [1] "subjid"         "LHtemporal_psc" "RHtemporal_psc" "task"
## [5] "group"
```

```r
combined_psc_all$task <- factor(combined_psc_all$task, levels = unique(combined_psc_all$task))
combined_psc_all$group <- factor(combined_psc_all$group, levels = unique(combined_psc_all$group))

# boxplots
ROI_psc_plot(combined_psc_all, "LHtemporal_psc", "TDvsAdults")
```




```r
ROI_psc_plot(combined_psc_all, "RHtemporal_psc", "TDvsAdults")
```




```r
## t-test and effect sizes
tasks <- c("Story language", "Karen language", "Motherese")

es_mat <- matrix(1:12,nrow = 3, ncol = 4)
rownames(es_mat) <- c("Story language", "Karen language", "Motherese")
```

```r
colnames(es_mat) <- c("left temporal", "right temporal","left temporal", "right temporal")

i <- 0
for (task in tasks) {
    i <- i + 1
    aa <- effsize::cohen.d(combined_psc_all[combined_psc_all$task == task, "LHtemporal_psc"],
                     combined_psc_all[combined_psc_all$task == task, "group"],
                     pooled = T)

    bb <- effsize::cohen.d(combined_psc_all[combined_psc_all$task == task, "RHtemporal_psc"],
                     combined_psc_all[combined_psc_all$task == task, "group"],
                     pooled = T)

    tt1 <- t.test(combined_psc_all[combined_psc_all$task == task & combined_psc_all$group == "TD Toddle
                   "LHtemporal_psc"],
              combined_psc_all[combined_psc_all$task == task & combined_psc_all$group == "TD Adults",
                     "LHtemporal_psc"])

    tt2 <- t.test(combined_psc_all[combined_psc_all$task == task & combined_psc_all$group == "TD Toddle
                   "RHtemporal_psc"],
              combined_psc_all[combined_psc_all$task == task & combined_psc_all$group == "TD Adults",
                     "RHtemporal_psc"])

    es_mat[i, 1] <- round(abs(aa$estimate),2)
    es_mat[i, 2] <- round(abs(bb$estimate),2)
    es_mat[i, 3] <- round(abs(tt1$p.value),4)
    es_mat[i, 4] <- round(abs(tt2$p.value),4)
}

#  t-values
knitr::kable(es_mat[,1:2])
```

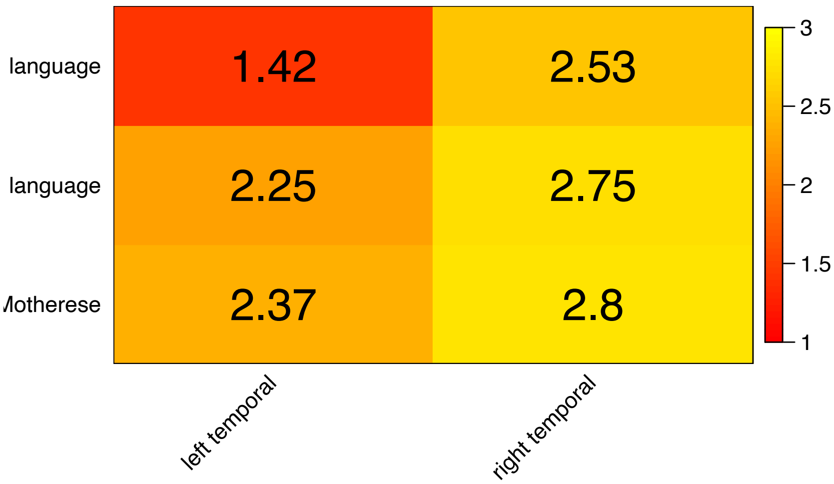
	left temporal	right temporal
Story language	1.42	2.53
Karen language	2.25	2.75
Motherese	2.37	2.80

```r
#  p-values
knitr::kable(es_mat[,3:4])
```

	left temporal	right temporal
Story language	0.0026	0.0000
Karen language	0.0001	0.0000
Motherese	0.0053	0.0035

```r
# plot the effect size matrix as a heatmap
eff <- es_mat[,1:2]
colfunc <- colorRampPalette(c("red", "yellow"))
```

```r
WGCNA::labeledHeatmap(Matrix = eff, xLabels = colnames(eff),
              yLabels = rownames(eff), ySymbols = NULL, colorLabels = F,
              colors = colfunc(50), textMatrix = round(eff, digits = 2),
              setStdMargins = F, cex.text = 2, zlim = c(1, 3))
```



Mixed effects model analysis

```r
# orgnize datafile
Story_datafile <- Story_scans[,c("subj","subjid","scan_age","gender","group","Story_meanFD",
        "Story_LHtemporal_psc","Story_RHtemporal_psc","final_vine_ComTotal_DomStd",
        "final_vine_SocTotal_DomStd")]
Story_datafile$task <- "Story_Lang"
colnames(Story_datafile)[6:8] <- c("meanFD","LHtemporal_psc","RHtemporal_psc")

Karen_datafile <- Karen_scans[,c("subj","subjid","scan_age","gender","group","Karen_meanFD",
            "Karen_LHtemporal_psc","Karen_RHtemporal_psc","final_vine_ComTotal_DomStd",
            "final_vine_SocTotal_DomStd")]
Karen_datafile$task <- "Karen_Lang"
colnames(Karen_datafile)[6:8] <- c("meanFD","LHtemporal_psc","RHtemporal_psc")

Motherese_datafile <- Motherese_scans[,c("subj","subjid","scan_age","gender","group",
                     "Motherese_meanFD","Motherese_LHtemporal_psc",
                     "Motherese_RHtemporal_psc","final_vine_ComTotal_DomStd",
                     "final_vine_SocTotal_DomStd")]
Motherese_datafile$task <- "Motherese"
colnames(Motherese_datafile)[6:8] <- c("meanFD","LHtemporal_psc","RHtemporal_psc")

combined_datafile <- rbind.data.frame(Story_datafile, Karen_datafile, Motherese_datafile)

# run mixed effects models
ROIs <- c("LHtemporal_psc","RHtemporal_psc")
```

```r
clins <- c("final_vine_ComTotal_DomStd", "final_vine_SocTotal_DomStd")
cnames <- c("Estimate", "Std. Error", "df","t value", "p value", "R2")

mixed_effects <- Mods2table(combined_datafile, ROIs, clins, cnames) %>%
    as.data.frame()

knitr::kable(mixed_effects)
```

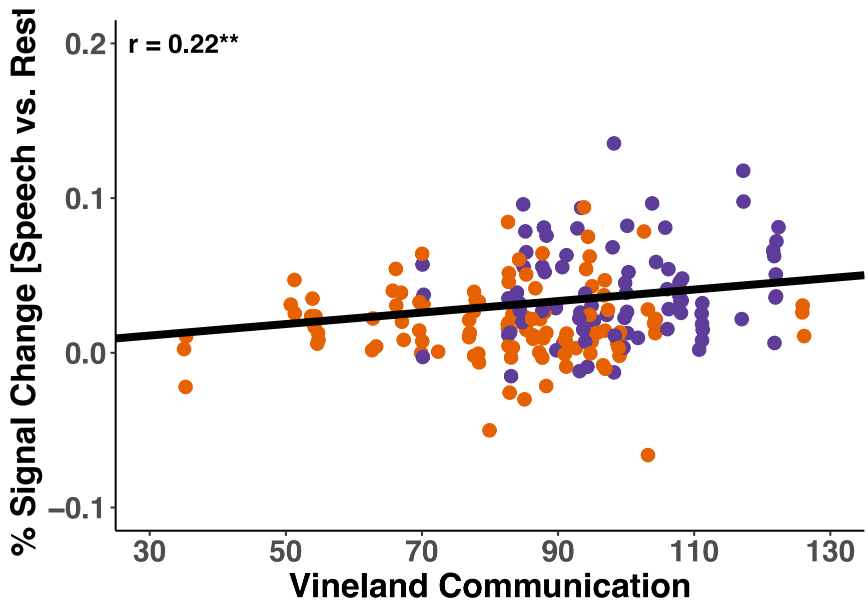
Variables	Estimate	Std. Error	df	t value	p value	R2
Communication scores	0.00037	0.00016	48.236	2.397	0.02	0.068
scan_age	-7e-05	0.00029	78.495	-0.26	0.795	0.068
gender	0.00707	0.00602	55.391	1.173	0.246	0.068
meanFD	-0.02732	0.02545	159.588	-1.073	0.285	0.068
Social scores	5e-04	0.00018	49.539	2.727	0.009	0.08
scan_age	-3e-05	0.00029	77.449	-0.106	0.916	0.08
gender	0.00513	0.00592	54.593	0.866	0.39	0.08
meanFD	-0.02635	0.02525	157.384	-1.044	0.298	0.08
Communication scores	0.00081	0.00032	49.888	2.577	0.013	0.094
scan_age	-7e-04	0.00056	90.451	-1.267	0.209	0.094
gender	0.00515	0.0121	55.451	0.426	0.672	0.094
meanFD	-0.02706	0.04586	178.257	-0.59	0.556	0.094
Social scores	0.00118	0.00037	50.654	3.227	0.002	0.125
scan_age	-0.00058	0.00055	87.498	-1.056	0.294	0.125
gender	0.00065	0.01174	54	0.056	0.956	0.125
meanFD	-0.02335	0.04528	174.624	-0.516	0.607	0.125

```r
write.csv(mixed_effects, "SNF_results/mixed_effects.csv")

# fdr correction
p.adjust(as.numeric(Mods2table(combined_datafile, ROIs, clins, cnames)[,"p value"][c(1,5,9,13)]),
     method = "fdr")
```

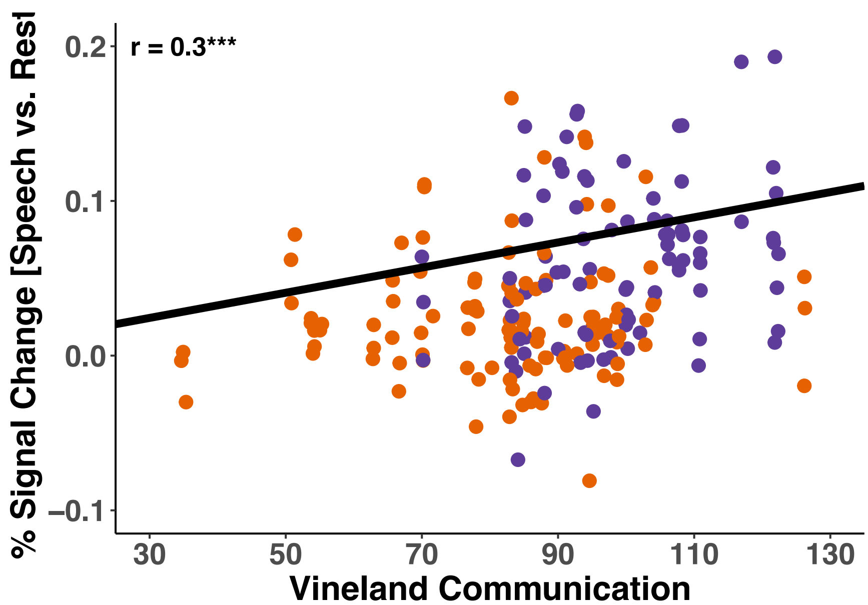
```
## [1] 0.02000000 0.01733333 0.01733333 0.00800000
```

Scatterplots: ROI activation and Vineland communication and social scores

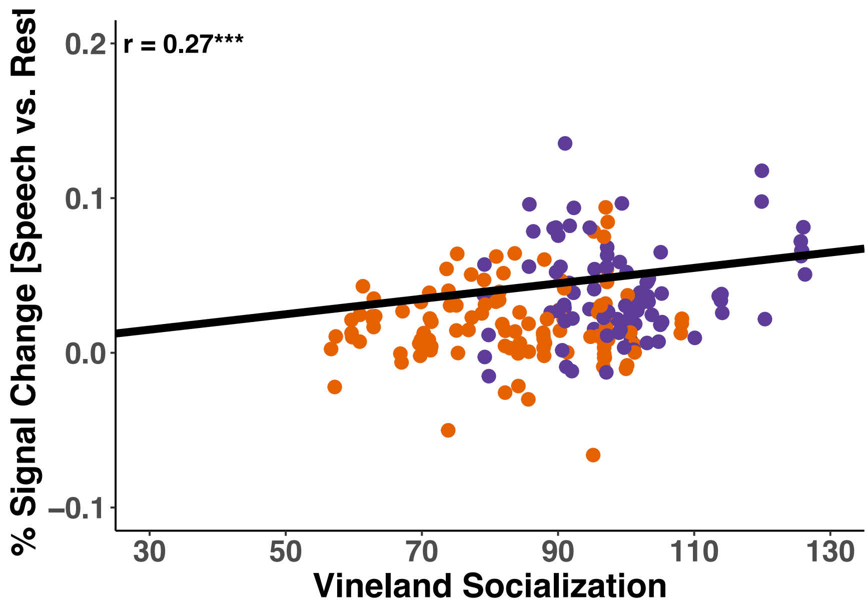
```r
dat <- combined_datafile

ROI_behavior_plot(dat, "final_vine_ComTotal_DomStd", "LHtemporal_psc",
          "Vineland Communication")
```



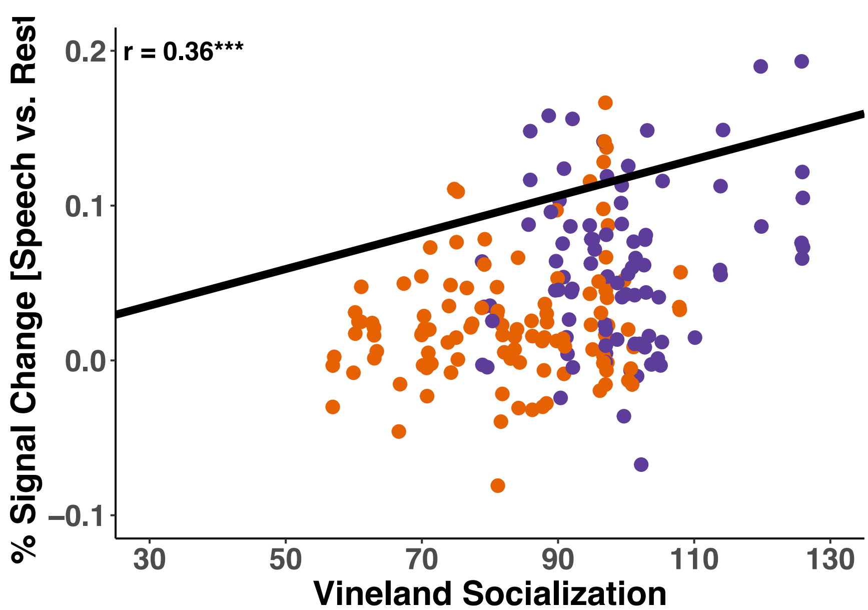

```
ROI_behavior_plot(dat, "final_vine_ComTotal_DomStd", "RHtemporal_psc",
          "Vineland Communication")
```




```
ROI_behavior_plot(dat, "final_vine_SocTotal_DomStd", "LHtemporal_psc",
          "Vineland Socialization")
```




```
ROI_behavior_plot(dat, "final_vine_SocTotal_DomStd", "RHtemporal_psc",
          "Vineland Socialization")
```



SNF/Clustering and Motherese Eye-Tracking Analysis

Setup

```
# load packages
packages <- c("here","tidyr","WGCNA","dplyr","SNFtool","ggplot2","effsize","data.table",
          "psych","FSA")
lapply(packages, library, character.only = TRUE)

source(here::here("code","SNF_Louvain.R"))
source(here::here("code","clusters_plot.R"))
source(here::here("code","ET_clusters.R"))
```

Read in toddler data

```
tidy_fMRI_clinical_toddlers <- read.table(here::here("data", "tidy_fMRI_clinical_toddlers.txt"),
                 header = T, sep = "\t",stringsAsFactors = F)

# subjects with all three language paradigms
fMRI_clinical_all <- tidy_fMRI_clinical_toddlers[!is.na(tidy_fMRI_clinical_toddlers$Story_Lang) &
                        !is.na(tidy_fMRI_clinical_toddlers$Karen_Lang) &
                         !is.na(tidy_fMRI_clinical_toddlers$Motherese), ]

# repeated fMRI scans
knitr::kable(fMRI_clinical_all[duplicated(fMRI_clinical_all$subjid), c(1:4,8)])
```

	subj	subjid	scan_age	group	Gender
11	B6C2P_02	B6C2P	46	TD	M
51	K6E5T_01b	K6E5T	23	TD	F

```
# exclude repeated fMRI scans
dat <- fMRI_clinical_all[!duplicated(fMRI_clinical_all$subjid), ]
```

Run Similarity Network Fusion analysis

```
ROI_var <- colnames(dplyr::select(fMRI_clinical_all, contains("psc")))
clinic_var <- colnames(dplyr::select(fMRI_clinical_all, contains("final")))[-1]
```

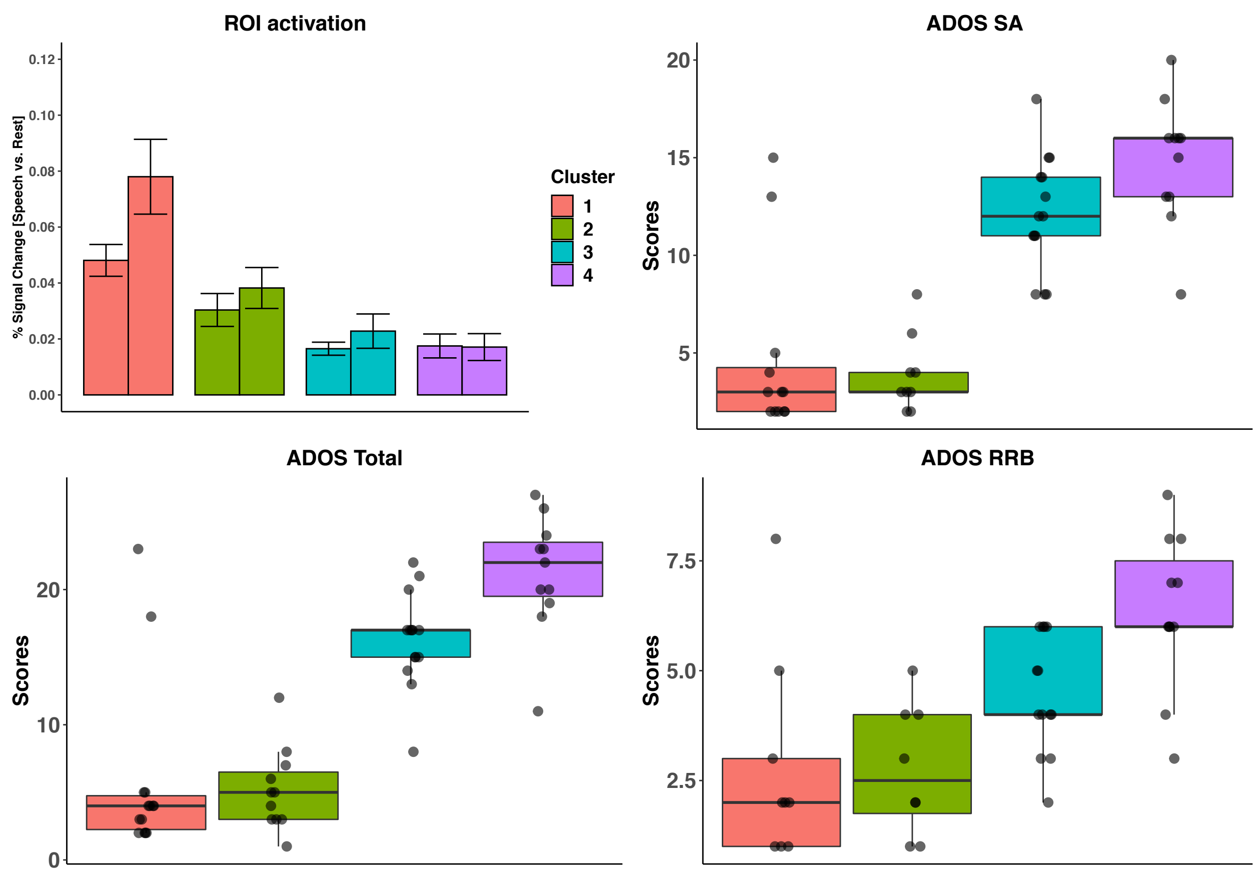
```r
cluster_results <- SNF_Louvain(dat, ROI_var, clinic_var)
```

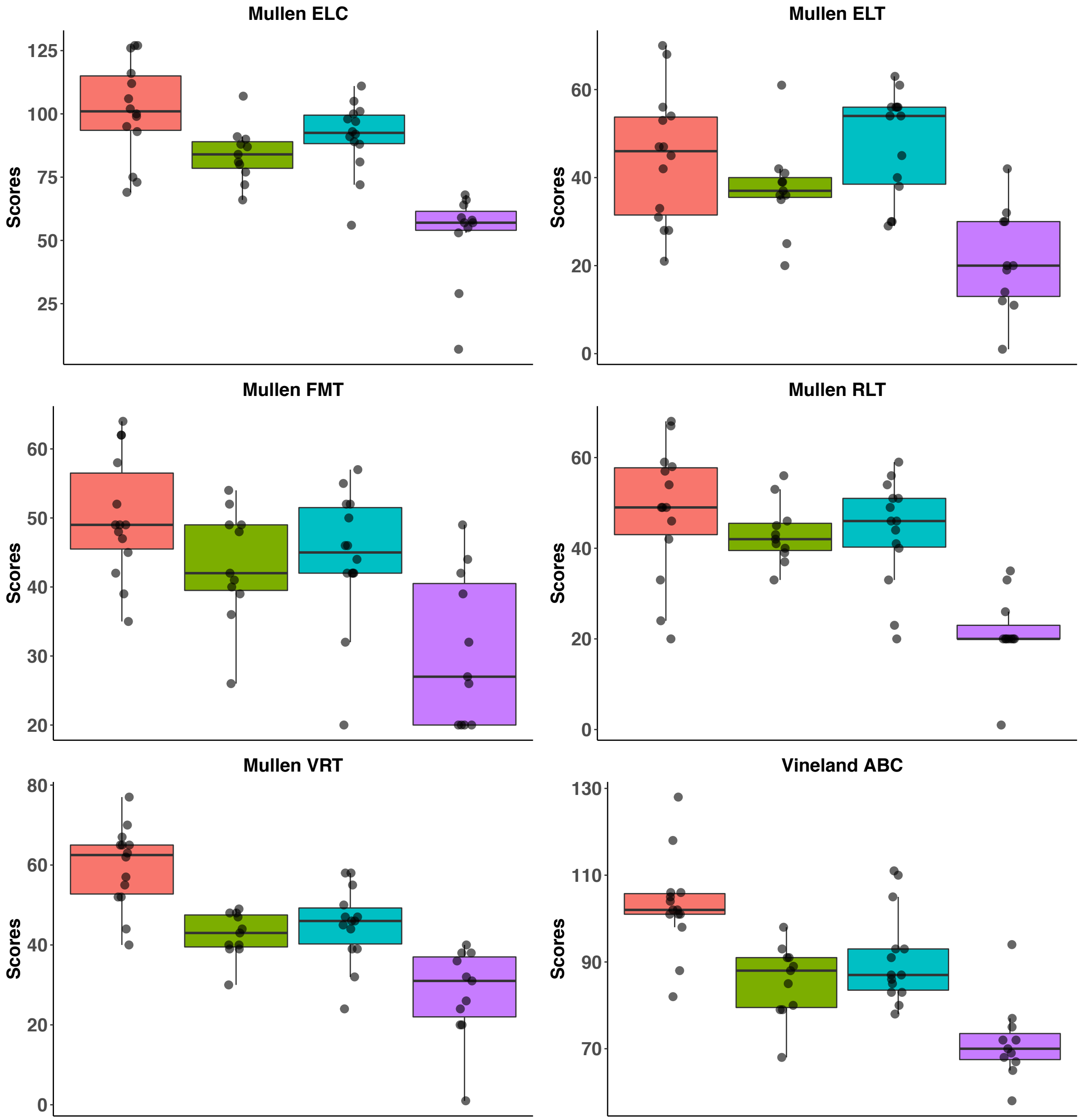
```
## [1] "There are 4 clusters"
```

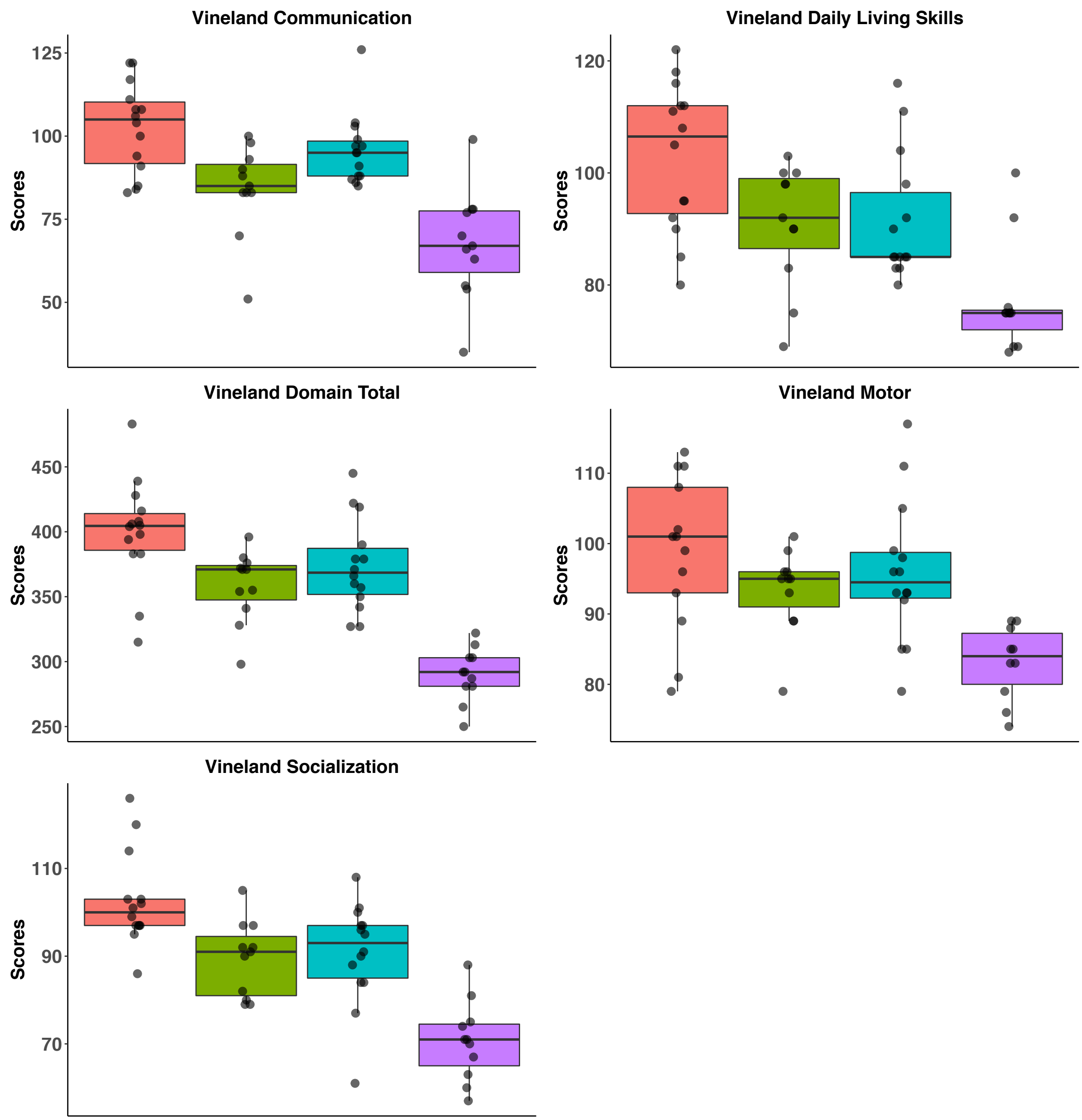
```r
SNF_clusters <- cluster_results[[2]]

# save matrix and clustering results for visualization

cluster_results[[1]][3:6]$Weight <- as.numeric(cluster_results[[1]][3:6]$Weight)

write.table(SNF_clusters, "SNF_results/SNF_clusters.txt",col.names = T, row.names = F,quote = F, sep =
write.csv(cluster_results[[1]], "SNF_results/SNF_matrix.csv",row.names = F,quote=F)
```

Plot fMRI/ROI data and clinical scores across clusters

```r
# plot fMRI and clinical data across clusters
ROI_clinic_clusters = clusters_plot(fMRI_clinical_all, SNF_clusters, ROI_var, clinic_var)
```

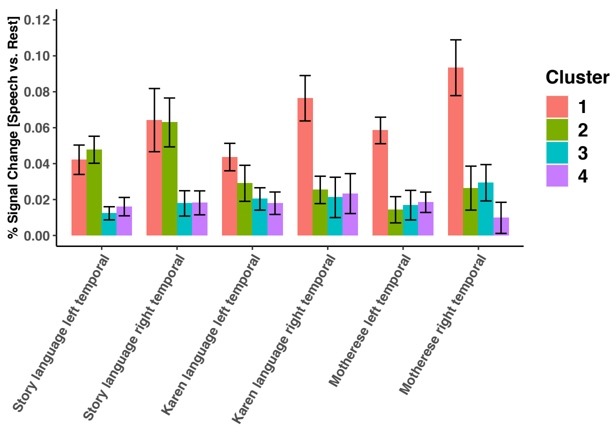



Mullen ELC
Scores
125
100
75
50
25
Mullen ELT
Scores
60
40
20
0
Mullen FMT
Scores
60
50
40
30
20
Mullen RLT
Scores
60
40
20
0
Mullen VRT
Scores
80
60
40
20
0
Vineland ABC
Scores
130
110
90
70




```
# barplot of %signal change for each language paradigm
tmp <- ROI_clinic_clusters[[3]]
tmp$test <- factor(tmp$test, levels = levels(tmp$test)[c(1,4,2,5,3,6)])
tmp$gr[grep("Story*", tmp$test)] <- "Story"
tmp$gr[grep("Karen*", tmp$test)] <- "Karen"
tmp$gr[grep("Motherese*", tmp$test)] <- "Motherese"
tmp$gr <- as.factor(tmp$gr)
ggplot(tmp, aes(x = test, y = values, fill = index)) +
        geom_bar(width = 0.8, stat = "summary",fun = "mean",position = position_dodge(width = 0.8))+
    geom_errorbar(width = 0.6, stat = "summary", fun.data = "mean_se", position = position_dodge(width
        labs(y = "% Signal Change [Speech vs. Rest]", x = "") +
        theme(legend.title = element_text(colour="black", size=14, face="bold"),
```

```r
        legend.text = element_text(colour="black", size=14, face="bold")) +
  theme(plot.title = element_text(hjust = 0.5, size = 16, face = "bold"))+
  theme(axis.text.y = element_text(size = 10, face = "bold"),
        axis.text.x = element_text(size = 10, face = "bold", angle = 60,
                     hjust = 1),
        axis.title.y = element_text(size = 10, face = "bold"),
        axis.title.x = element_blank()) +
  theme(panel.background = element_blank(),
        panel.grid = element_blank(),
        panel.border = element_blank(),
        axis.line = element_line(colour = "black")) + # remove background
  scale_fill_hue(name = "Cluster") +
  scale_x_discrete(labels=c("Story_LHtemporal_psc" = "Story language left temporal",
              "Story_RHtemporal_psc" = "Story language right temporal",
              "Karen_LHtemporal_psc" = "Karen language left temporal",
              "Karen_RHtemporal_psc" = "Karen language right temporal",
              "Motherese_LHtemporal_psc" = "Motherese left temporal",
              "Motherese_RHtemporal_psc" = "Motherese right temporal")) +
  coord_cartesian(ylim=c(0,0.12)) +
  scale_y_continuous(breaks = seq(0,0.12, 0.02))
```




```r
# % signal change in Motherese and Karen language across clusters
knitr::kable(aggregate(values ~ index, FUN = mean, tmp[tmp$test == "Motherese_LHtemporal_psc",]))
```

index	values
1	0.0584732
2	0.0143072
3	0.0168655
4	0.0184826

```r
knitr::kable(aggregate(values ~ index, FUN = mean, tmp[tmp$test == "Motherese_RHtemporal_psc",]))
```

index	values
1	0.0933836
2	0.0263609

index	values
3	0.0293463
4	0.0098087

```r
knitr::kable(aggregate(values ~ index, FUN = mean, tmp[tmp$test == "Karen_RHtemporal_psc",]))
```

index	values
1	0.0763932
2	0.0253648
3	0.0211965
4	0.0233187

```r
# % signal change in Cluster 1 across three language paradigms
knitr::kable(aggregate(values ~ test, FUN = mean, tmp[tmp$index == 1,]))
```

test	values
Story_LHtemporal_psc	0.0421555
Story_RHtemporal_psc	0.0642198
Karen_LHtemporal_psc	0.0436429
Karen_RHtemporal_psc	0.0763932
Motherese_LHtemporal_psc	0.0584732
Motherese_RHtemporal_psc	0.0933836

```r
# distribution of clusters
ab <- table(ROI_clinic_clusters[[2]]$index,ROI_clinic_clusters[[2]]$group.x)
knitr::kable(ab)
```

ASD	TD
2	12
3	8
14	0
11	0

```r
# percent of TD subjects in TD cluters
(colSums(ab[1:2,])[2]/colSums(ab)[2])*100
```

```
##  TD
## 100
```

```r
# percent of ASD subjects in ASD cluters
(colSums(ab[3:4,])[1]/colSums(ab)[1])*100
```

```
##      ASD
## 83.33333
```

```r
# ASD in TD clusters
tmp0 <- ROI_clinic_clusters[[2]]

# ASD subjects in TD clusters
tmp0[which(tmp0$index == 1 & tmp0$group.x == "ASD"), 1:22]
```

```
##        subj group.x Story_LHtemporal_psc Story_RHtemporal_psc
## 26 G4M3R_01     ASD             0.045812             0.087231
## 39 M2E2P_01     ASD             0.054112             0.097860
##    Karen_LHtemporal_psc Karen_RHtemporal_psc Motherese_LHtemporal_psc
## 26             0.003444             0.066628                 0.084549
## 39             0.094039             0.137590                 0.075005
##    Motherese_RHtemporal_psc final_ados_CoSoTot final_ados_RRTot
## 26                  0.16645                 15                8
## 39                  0.14142                 13                5
##    final_ados_CoSoTotRRTot final_vine_ComTotal_DomStd
## 26                      23                         83
## 39                      18                         94
##    final_vine_DlyTotal_DomStd final_vine_SocTotal_DomStd
## 26                         95                         97
## 39                        105                         97
##    final_vine_MtrTotal_DomStd final_vine_AdapBehav_DomStd
## 26                        108                          88
## 39                        102                          98
##    final_vine_DomStdTotal final_mullen_VRT final_mullen_FMT final_mullen_RLT
## 26                    383               44               45               20
## 39                    398               40               49               24
##    final_mullen_ELT final_mullen_ELC_Std
## 26               33                   73
## 39               21                   69
```

```r
tmp0[which(tmp0$index == 2 & tmp0$group.x == "ASD"), 1:22]
```

```
##        subj group.x Story_LHtemporal_psc Story_RHtemporal_psc
## 4  A4Q8J_01     ASD             0.031846            0.0165600
## 31 H7R5P_01     ASD             0.018560            0.0052373
## 41 N3C4G_01     ASD             0.047103            0.0782720
##    Karen_LHtemporal_psc Karen_RHtemporal_psc Motherese_LHtemporal_psc
## 4              0.024894             0.040457               -0.0030474
## 31             0.014264             0.016447               -0.0257340
## 41             0.031161             0.061965                0.0254680
##    Motherese_RHtemporal_psc final_ados_CoSoTot final_ados_RRTot
## 4                 -0.015587                  6                2
## 31                -0.021631                  0                5
## 41                 0.033967                  8                4
##    final_ados_CoSoTotRRTot final_vine_ComTotal_DomStd
## 4                        8                         83
## 31                       5                         83
## 41                      12                         51
##    final_vine_DlyTotal_DomStd final_vine_SocTotal_DomStd
## 4                          69                         97
## 31                        100                         82
```

```
## 41                          75                          79
##    final_vine_MtrTotal_DomStd final_vine_AdapBehav_DomStd
## 4                          79                           80
## 31                         89                           85
## 41                         93                           68
##    final_vine_DomStdTotal final_mullen_VRT final_mullen_FMT final_mullen_RLT
## 4                     328               39               36               40
## 31                    354               49               40               56
## 41                    298               48               26               33
##    final_mullen_ELT final_mullen_ELC_Std
## 4                37                   77
## 31               36                   91
## 41               20                   66
```

Motherese eye-tracking data

```
# read in data
Motherese_ET <- read.table(here::here("data","tidy_Motherese_ET.txt"),header = T,
               sep = "\t", stringsAsFactors = F)

# age at Motherese eye-tracking test
table(Motherese_ET$group)
```

```
##
## ASD  TD
##  31  23
```

```
min(Motherese_ET$ET.Age)
```

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

```
max(Motherese_ET$ET.Age)
```

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

```
mean(Motherese_ET$ET.Age[Motherese_ET$group == "ASD"])
```

```
## [1] 25.32258
```

```
sd(Motherese_ET$ET.Age[Motherese_ET$group == "ASD"])
```

```
## [1] 8.553312
```

```
mean(Motherese_ET$ET.Age[Motherese_ET$group == "TD"])
```

```
## [1] 26.39435
```

```r
sd(Motherese_ET$ET.Age[Motherese_ET$group == "TD"])
```

```
## [1] 8.056302
```

```r
t.test(Motherese_ET$ET.Age[Motherese_ET$group == "TD"],
       Motherese_ET$ET.Age[Motherese_ET$group == "ASD"])
```

```
##
##  Welch Two Sample t-test
##
## data:  Motherese_ET$ET.Age[Motherese_ET$group == "TD"] and Motherese_ET$ET.Age[Motherese_ET$group ==
## t = 0.47082, df = 49.035, p-value = 0.6399
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -3.502699  5.646234
## sample estimates:
## mean of x mean of y
##  26.39435  25.32258
```

```r
# Motherese eye-tracking test: how many completed before the scan and how many after the scan
dim(Motherese_ET[as.Date(Motherese_ET$ScanDate) > as.Date(Motherese_ET$LK_Date),])[1]
```

```
## [1] 37
```

```r
dim(Motherese_ET[as.Date(Motherese_ET$ScanDate) < as.Date(Motherese_ET$LK_Date),])[1]
```

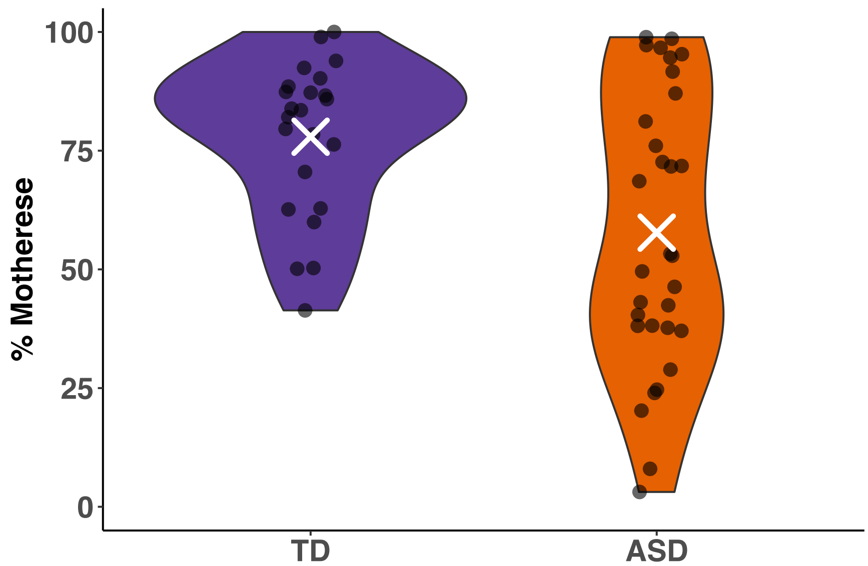
```
## [1] 17
```

```r
# group differences in Motherese eye-tracking between ASD and TD
eff <- effsize::cohen.d(Motherese_ET$LK_.fixation.Motherese, Motherese_ET$group, pooled = T)
tvalue <- t.test(Motherese_ET$LK_.fixation.Motherese ~ Motherese_ET$group)

knitr::kable(cbind(effect_size = eff$estimate, p_value = tvalue$p.value))
```

effect_size	p_value
-0.8258775	0.0021

```r
# plot Motherese eye-tracking data in ASD and TD
Motherese_ET$group <- factor(Motherese_ET$group, levels = unique(Motherese_ET$group))

ggplot(Motherese_ET, aes(x = group, y = `LK_.fixation.Motherese`)) +
    geom_violin(aes(fill = group), position = "dodge",trim = T) +
    geom_point(aes(fill = group),size = 3, alpha = 0.6, position =
            position_jitterdodge(jitter.width = 0.3)) +
    stat_summary(fun = "mean", geom = "point", shape = 4, size = 7,
             color = "white",stroke = 2) +
    scale_fill_manual(values = c("#5e3c99", "#e66101")) +
    labs(y = "% Motherese", x = "") +
```

```r
    guides(color = F, fill = F) +
    theme(plot.title = element_text(hjust = 0.5, size = 16, face = "bold"),
          axis.text = element_text(size = 16, face = "bold"),
          axis.title.y = element_text(size = 16, face = "bold"))+
    theme(panel.border = element_blank(),
          panel.background = element_blank(),
          panel.grid = element_blank(),
          axis.line = element_line(colour = "black")) +
    coord_cartesian(ylim=c(00, 100)) +
    scale_y_continuous(breaks = seq(0, 100, 25))
```



Association of clusters and gaze preference for motherese

```r
# organize datafile
clusters <- ROI_clinic_clusters[[2]][,c("subj","Clustering","index")]
dim(clusters)
```

```
## [1] 50  3
```

```r
colnames(Motherese_ET)[2] <- "subj"
Motherese_ET_clusters <- merge(Motherese_ET, clusters, by = "subj")

dim(Motherese_ET_clusters)[1]
```

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

```r
Motherese_ET_clusters$index <- as.factor(Motherese_ET_clusters$index)

# number of subjects in each cluster
table(Motherese_ET_clusters$group)
```

```
##
##  TD ASD
##  19  24
```

```
table(Motherese_ET_clusters$index)
```

```
##
##  1  2  3  4
## 13 10 12  8
```

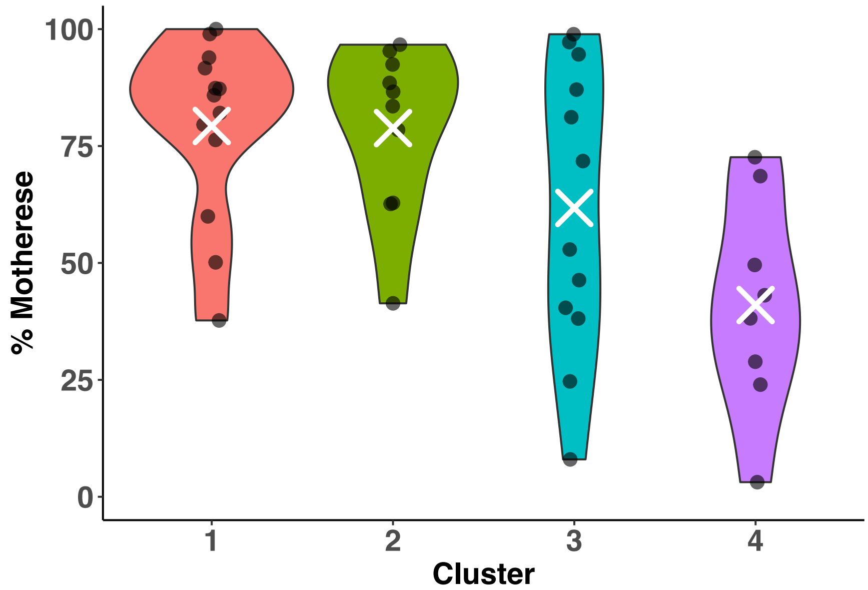
```
# difference between Clusters 3 and 4
k <- aggregate(LK_.fixation.Motherese ~ index, FUN = mean, Motherese_ET_clusters)
knitr::kable(k[3:4,])
```

	index	LK_.fixation.Motherese
3	3	61.75918
4	4	40.99659

```
tt <- t.test(Motherese_ET_clusters$LK_.fixation.Motherese[Motherese_ET_clusters$index == 3],
       Motherese_ET_clusters$LK_.fixation.Motherese[Motherese_ET_clusters$index == 4])
cohens <- effsize::cohen.d(Motherese_ET_clusters$LK_.fixation.Motherese[Motherese_ET_clusters$index == 3
       Motherese_ET_clusters$LK_.fixation.Motherese[Motherese_ET_clusters$index == 4])
knitr::kable(cbind(t_value = tt$statistic, pvalue = tt$p.value, d = cohens$estimate))
```

	t_value	pvalue	d
t	1.721914	0.1025522	0.7405704

```
# violin plots
ET_clusters(Motherese_ET_clusters)
```




```
# t-tests and effect sizes
    cohen <- matrix(1:16, 4, 4)
    ttest <- matrix(1:16, 4, 4)
    rownames(cohen) <- c("Cluster 1", "Cluster 2", "Cluster 3","Cluster 4")
    colnames(cohen) <- c("Cluster 1", "Cluster 2", "Cluster 3","Cluster 4")
    rownames(ttest) <- c("Cluster 1", "Cluster 2", "Cluster 3","Cluster 4")
    colnames(ttest) <- c("Cluster 1", "Cluster 2", "Cluster 3","Cluster 4")

    for (i in 1:4) {
        for (j in 1:4) {
            if (i == j) {
                cohen[i, j] <- NA
                ttest[i, j] <- NA
            } else {
                aa <- effsize::cohen.d(Motherese_ET_clusters$LK_.fixation.Motherese[Motherese_ET_cluste

                bb <- t.test(Motherese_ET_clusters$LK_.fixation.Motherese[Motherese_ET_clusters$index =

                cohen[i, j] <- abs(round(aa$estimate,2))
                ttest[i, j] <- abs(round(bb$p.value,3))
            }

        }
    }

# effect size: Cohen's d
knitr::kable(cohen)
```

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Cluster 1	NA	0.02	0.69	1.86
Cluster 2	0.02	NA	0.66	1.86
Cluster 3	0.69	0.66	NA	0.74
Cluster 4	1.86	1.86	0.74	NA

```r
# p-values from t-tests
knitr::kable(ttest)
```

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Cluster 1	NA	0.954	0.107	0.002
Cluster 2	0.954	NA	0.122	0.002
Cluster 3	0.107	0.122	NA	0.103
Cluster 4	0.002	0.002	0.103	NA

```r
# plot the effect size matrix as a heatmap: 4 clusters
colfunc <- colorRampPalette(c("red", "yellow"))

WGCNA::labeledHeatmap(Matrix = cohen[1:4,1:4], xLabels = colnames(cohen)[1:4],
              yLabels = rownames(cohen)[1:4], ySymbols = NULL, colorLabels = F,
              colors = colfunc(50), textMatrix = round(cohen[1:4,1:4], digits = 2),
              setStdMargins = F, cex.text = 2, zlim = c(0, 2))
```