Statistics Examen_NeuroBIM

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Loading the data file into R

First of all, the data was loaded into R from the textfile. A summary of the data was obtained as an indication whether the data was correctly loaded into R.

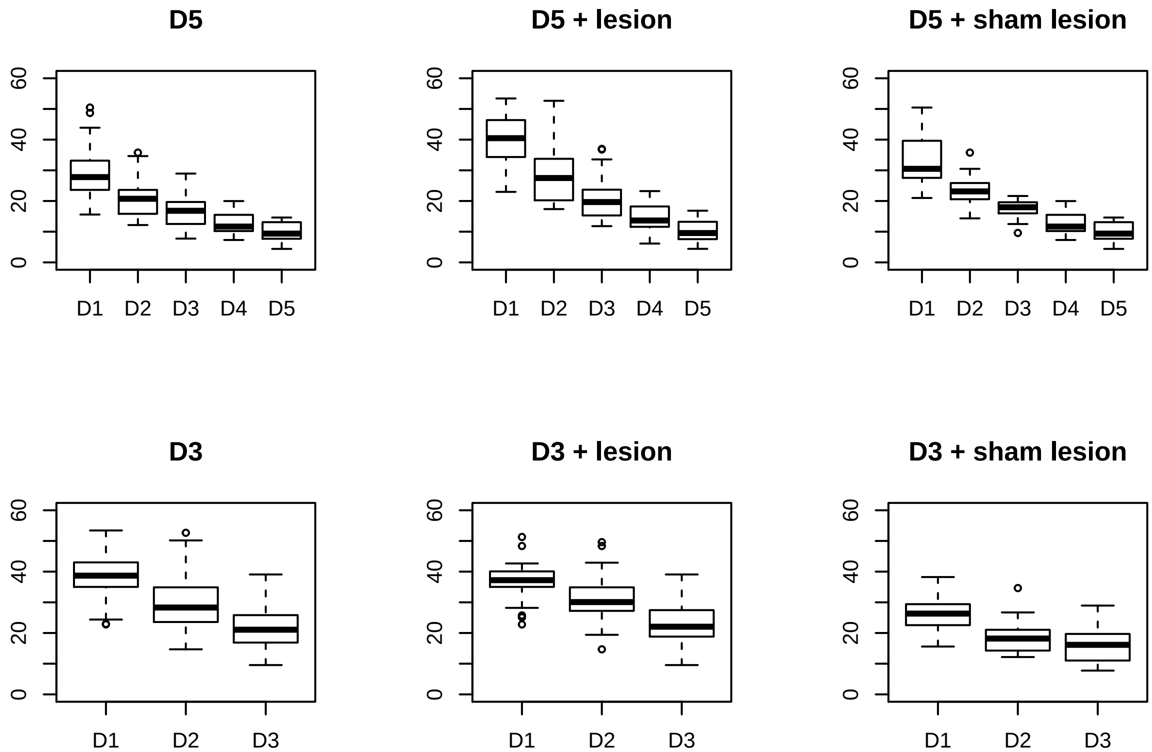
Let's add a collumn for the difference between time needed

Creating seperate files for the 4 conditions

The mice were either trained in 3 sessions (D3) or in 5 sessions (D5). Within each of these two groups, the animals were either lesioned in the dorsal hippocampus (H) or they were given a sham lesion (SH). These groups were originally stored in the datafile, but will now be sorted in order to easily be able to display them seperately.

Learning time

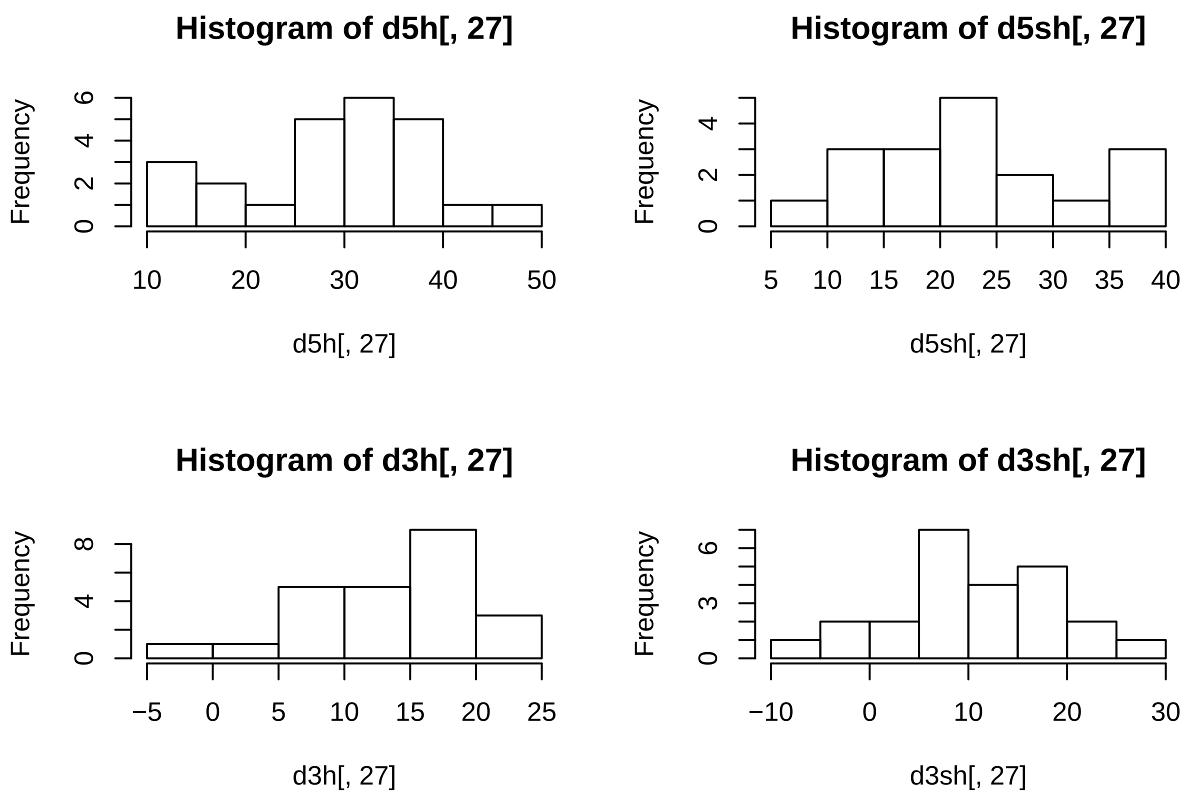
The mice were given a task, and the time they spent in the dark is a measure of how well they learnt it.




```
## [1] 29.5587

## [1] 22.88382

## [1] 13.70844

## [1] 10.73177
```

Is the data normally distributed?

First, Let's look at histograms of each group.



NORMAL DISTIBUTION?

We will carry out the shapiro-Wilk test. If p>a (bigger than 0.05 generally), the data is normal.

```
##
##  Shapiro-Wilk normality test
##
## data:  d5h[, 27]
## W = 0.96506, p-value = 0.5482
```

```
##
##  Shapiro-Wilk normality test
##
## data:  d5sh[, 27]
## W = 0.94456, p-value = 0.3461
```

```
##
##  Shapiro-Wilk normality test
##
## data:  d3h[, 27]
## W = 0.95398, p-value = 0.3297
```

```
##
```

```
##  Shapiro-Wilk normality test
##
## data:  d3sh[, 27]
## W = 0.98565, p-value = 0.9735
```

All the values are higher than p=0.05, so the data is normally distributed.

Making a new dataframe for ANOVA

We will make a list of the factors (d5h, d5sh, d3h, d3sh), and a list with the "learned" decrease in time needed to explore the matrix.

Homogeneity of Variance

```
##
##  Bartlett test of homogeneity of variances
##
## data:  d1$values by d1$exp
## Bartlett's K-squared = 3.6572, df = 3, p-value = 0.3009
```

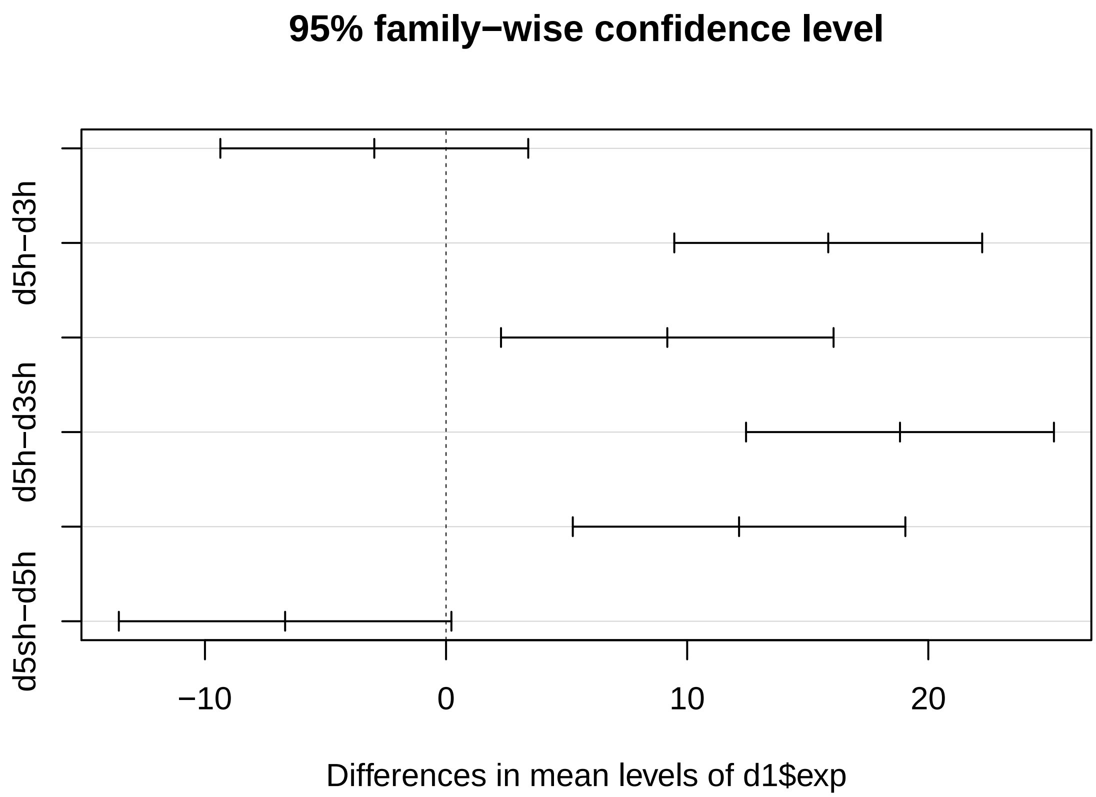
ANOVA

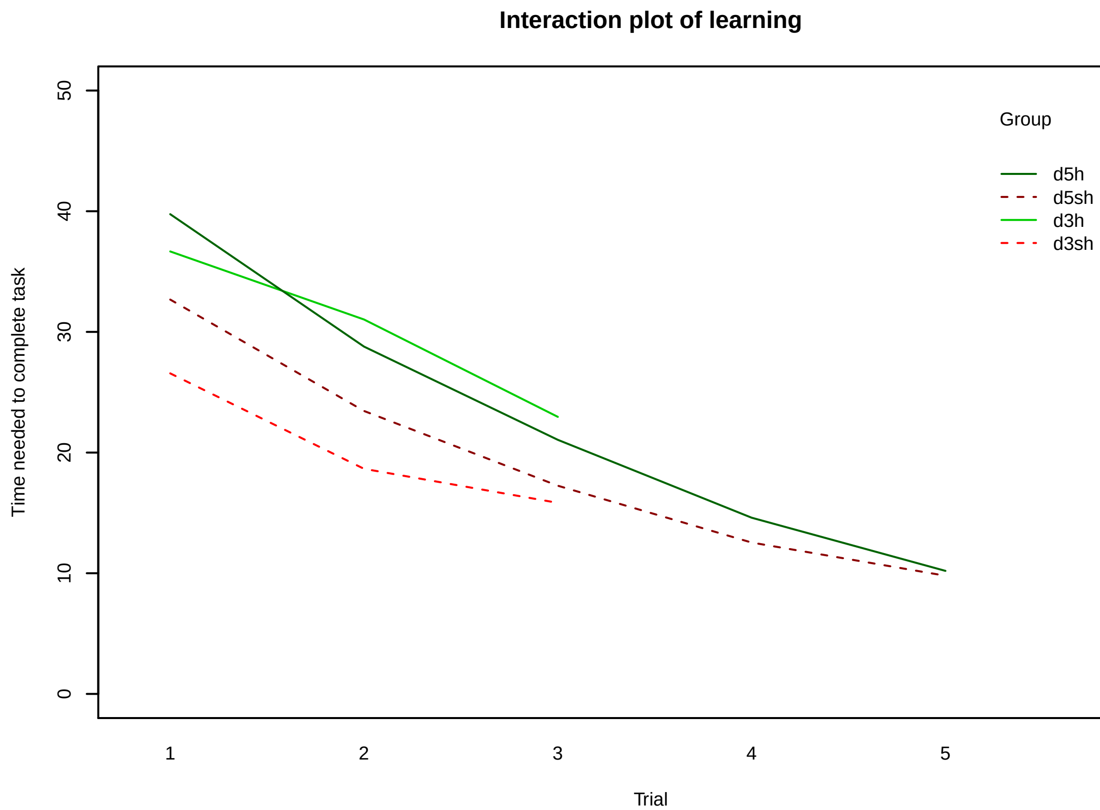
Maybe we should instead to a repeated measures anova where we follow the animal over the different learning trials.

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## d1$exp       3   5260  1753.3    24.6 1.38e-11 ***
## Residuals   86   6129    71.3
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The anova is highly significant at $p<0.05$. Let's do a post-hoc Tukey test to find where the differences are #Tukey posthoc

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = f1)
##
## $`d1$exp`
##                 diff        lwr        upr     p adj
## d3sh-d3h  -2.976667  -9.361469  3.4081355 0.6150204
## d5h-d3h   15.850260   9.465458 22.2350626 0.0000000
## d5sh-d3h   9.175382   2.279007 16.0717565 0.0042380
## d5h-d3sh  18.826927  12.442125 25.2117293 0.0000000
## d5sh-d3sh 12.152049   5.255674 19.0484232 0.0000790
## d5sh-d5h  -6.674878 -13.571253  0.2214961 0.0614873
```


95% family−wise confidence level
d5h−d3h
d5h−d3sh
d5sh−d5h
−10
0
10
20
Differences in mean levels of d1$exp



#Repeated measures ANOVA

```
##
## Error: id
##           Df Sum Sq Mean Sq F value   Pr(>F)
## group      3   5594  1864.7   27.11 1.95e-12 ***
## Residuals 86   5914    68.8
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: Within
##             Df Sum Sq Mean Sq F value  Pr(>F)
## time         4  22320    5580 169.998 < 2e-16 ***
## group:time   8    751      94   2.861 0.00462 **
## Residuals  252   8272      33
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Loading required package: lme4
## Loading required package: Matrix
## Loading required package: reshape2
## Loading required package: lsmeans
## Loading required package: estimability
##
## Attaching package: 'lsmeans'
##
## The following object is masked from 'package:base':
```

```
##
##     rbind
##
## ************
## Welcome to afex. Important changes in the current version:
## - Functions for ANOVAs have been renamed to: aov_car(), aov_ez(), and aov_4().
## - ANOVA functions return an object of class 'afex_aov' as default, see: ?aov_car
## - 'afex_aov' objects can be passed to lsmeans for contrasts and follow-up tests.
## - Reset previous (faster) behavior via: afex_options(return_aov='nice')
## - Many more arguments can now be set globally via options, see: afex_options()
## ************
## Loading required package: mvtnorm
## Loading required package: survival
## Loading required package: TH.data
```

model.cs <- gls(tasktime ~ group * time , data = d2, corr = corCompSymm(, form = ~ 1 | id))

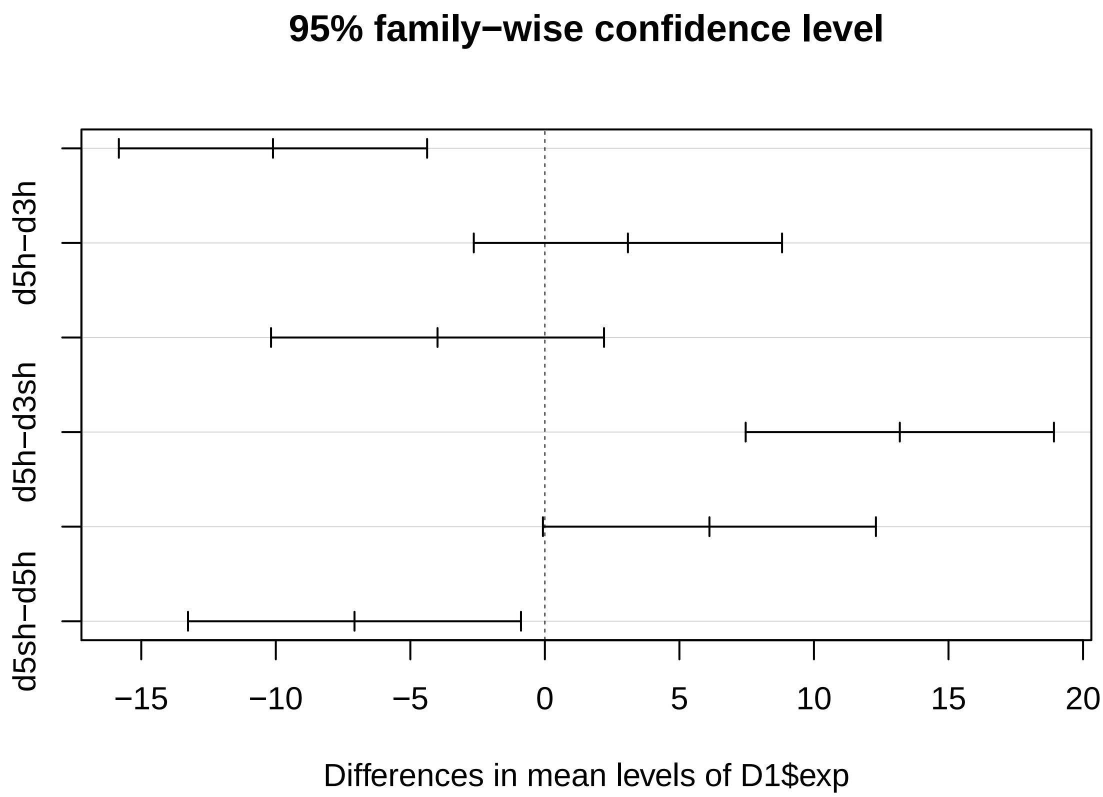
summary(model.cs)

The between group tests indicates that the variable group is significant. consequently, int he graph we see that the liens for the two groups are rather far apart. The within subject test indicates that there is a significant time effect, inother words, the groups do change other time, both groups are taking less time to complete the task over time. Morover, the interaction of time and group is significant which means that the groups are changing over time but are changing in different ways, which means that in the graph, the liens will not be parallel.

DAY 1

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## D1$exp       3   2324   774.7    13.5 2.68e-07 ***
## Residuals   86   4934    57.4
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

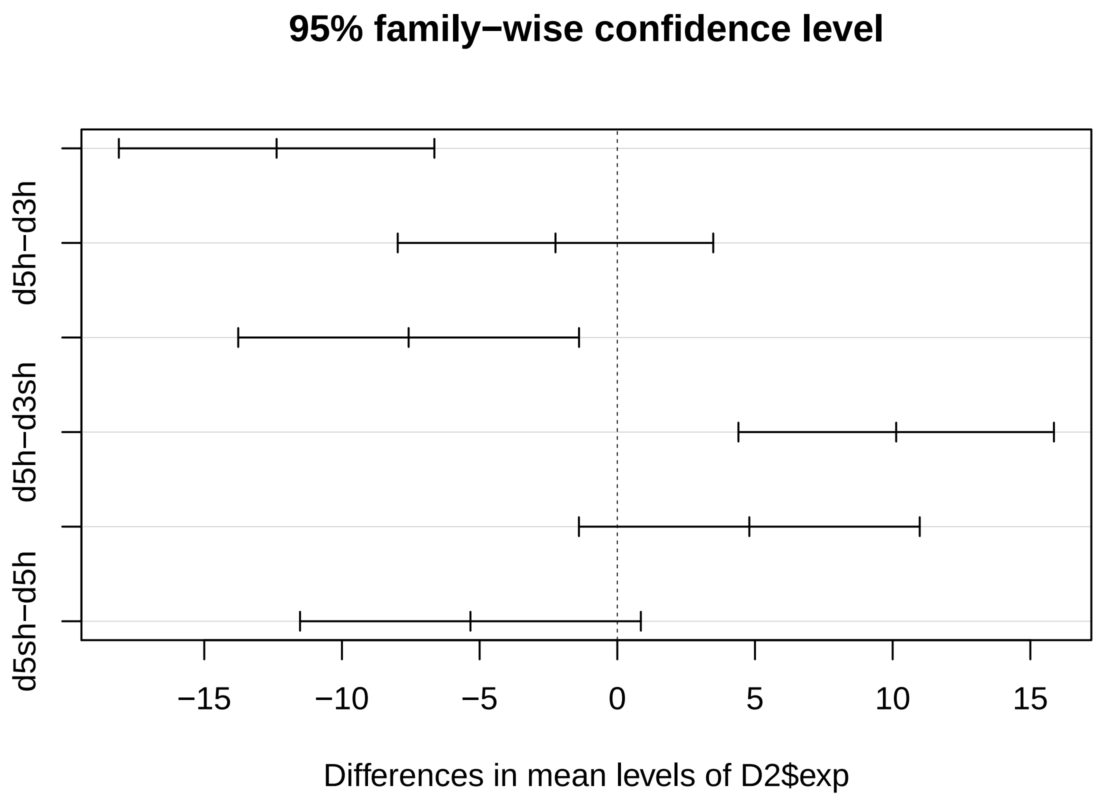
```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = fD1)
##
## $`D1$exp`
##                 diff          lwr        upr     p adj
## d3sh-d3h  -10.104688 -15.83327806 -4.3760969 0.0000775
## d5h-d3h     3.086062  -2.64252806  8.8146531 0.4957580
## d5sh-d3h   -3.989444 -10.17702945  2.1981406 0.3356221
## d5h-d3sh   13.190750   7.46215944 18.9193406 0.0000002
## d5sh-d3sh   6.115243  -0.07234195 12.3028281 0.0539491
## d5sh-d5h   -7.075507 -13.26309195 -0.8879219 0.0184144
```



DAY 2

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## D2$exp       3   2191   730.4   12.73 5.84e-07 ***
## Residuals   86   4935    57.4
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

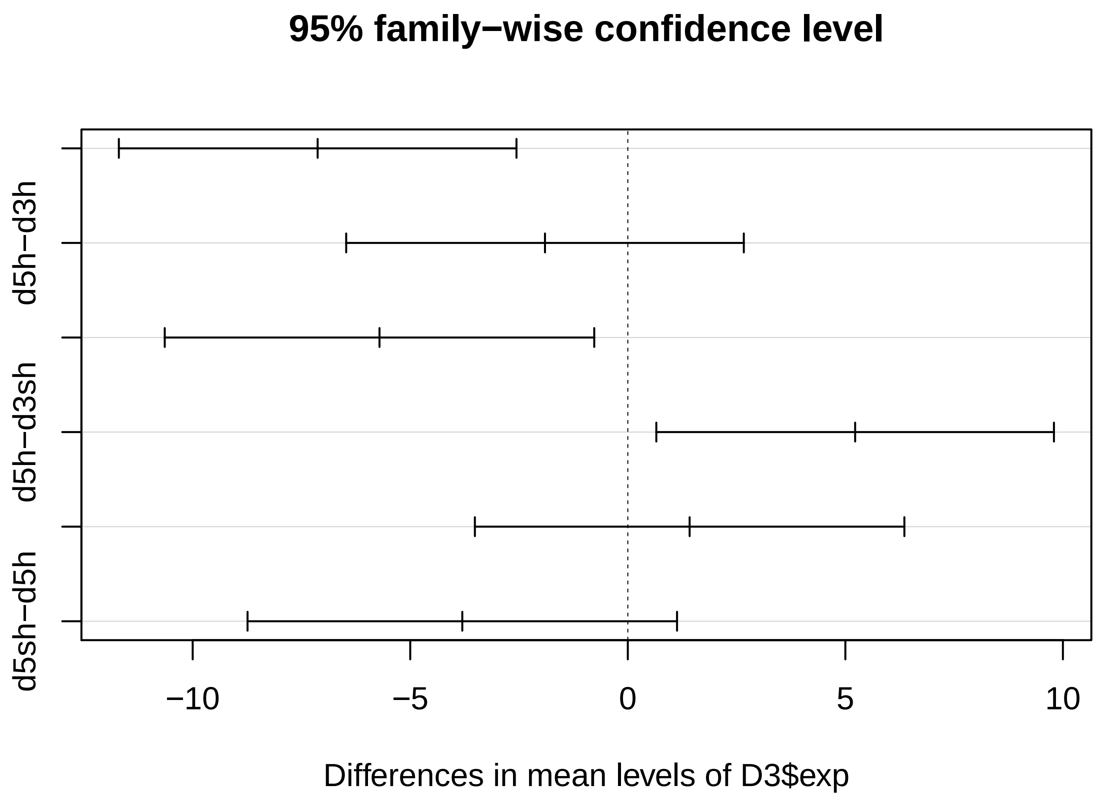
```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = fD2)
##
## $`D2$exp`
##                  diff        lwr        upr     p adj
## d3sh-d3h  -12.373333 -18.102674 -6.6439923 0.0000012
## d5h-d3h    -2.244844  -7.974185  3.4844973 0.7343947
## d5sh-d3h   -7.578073 -13.766469 -1.3896773 0.0099558
## d5h-d3sh   10.128490   4.399149 15.8578307 0.0000745
## d5sh-d3sh   4.795260  -1.393135 10.9836561 0.1850429
## d5sh-d5h   -5.333229 -11.521625  0.8551665 0.1161882
```



#DAY 3

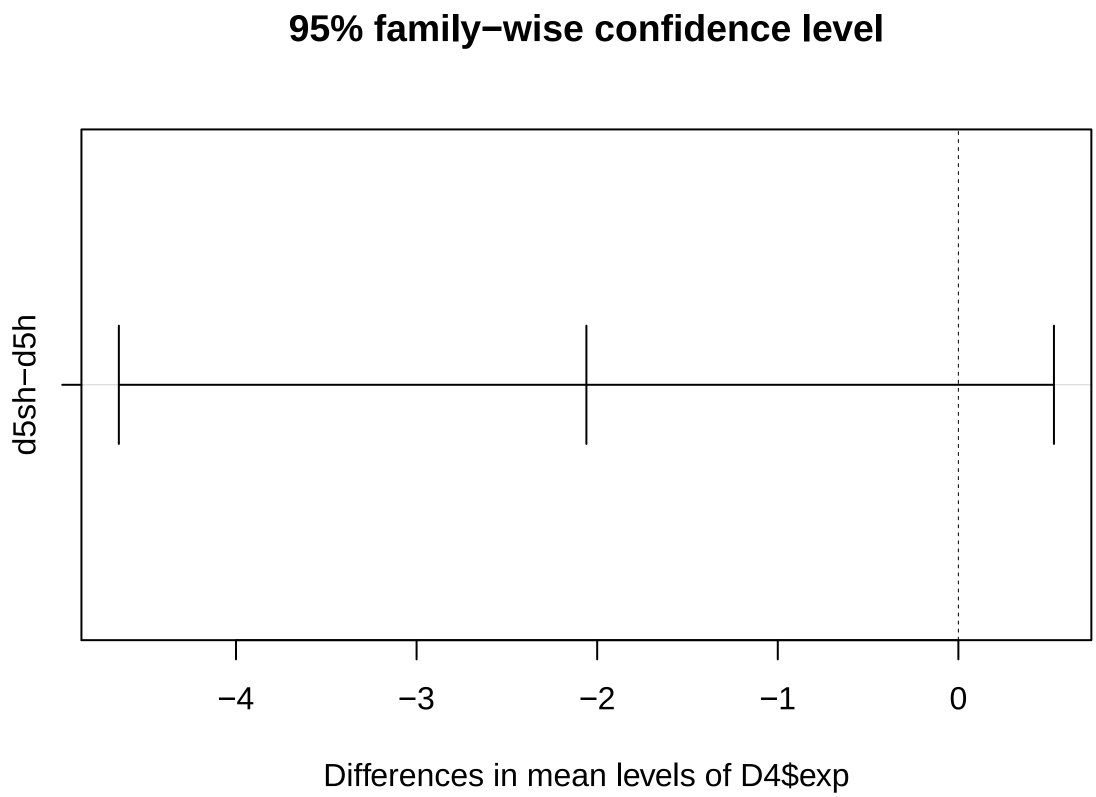
```
##             Df Sum Sq Mean Sq F value   Pr(>F)    
## D3$exp       3  758.6   252.8   6.927 0.000313 ***
## Residuals   86 3139.3    36.5                     
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
## 
## Fit: aov(formula = fD3)
## 
## $`D3$exp`
##                  diff        lwr        upr     p adj
## d3sh-d3h  -7.128021 -11.697564 -2.5584780 0.0005588
## d5h-d3h   -1.903073  -6.472616  2.6664700 0.6958769
## d5sh-d3h  -5.706979 -10.642650 -0.7713088 0.0167529
## d5h-d3sh   5.224948   0.655405  9.7944908 0.0184241
## d5sh-d3sh  1.421042  -3.514629  6.3567121 0.8745762
## d5sh-d5h  -3.803906  -8.739577  1.1317642 0.1889809
```



#DAY 4

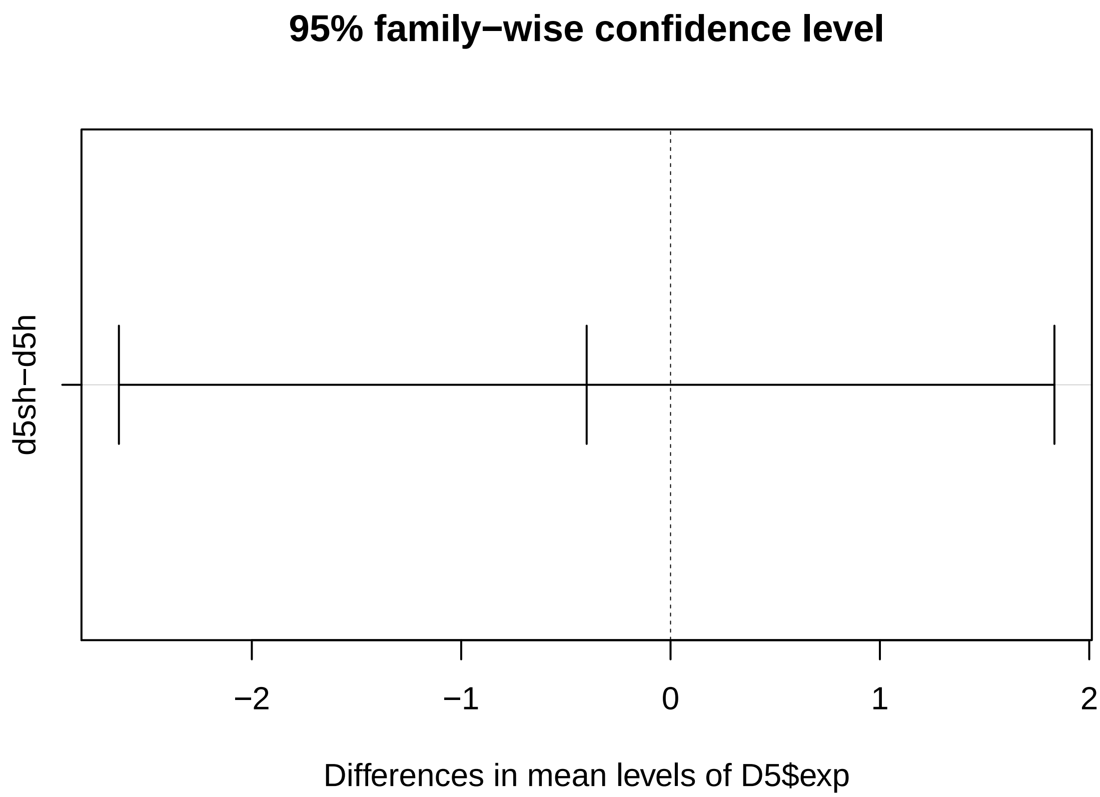
```
##             Df Sum Sq Mean Sq F value Pr(>F)
## D4$exp       1   43.6   43.64   2.586  0.116
## Residuals   40  675.1   16.88

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = fD4)
##
## $`D4$exp`
##                diff       lwr       upr     p adj
## d5sh-d5h -2.059722 -4.648644 0.5291991 0.1157122
```



#DAY 5

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## D5$exp       1    1.7   1.651   0.131  0.719
## Residuals   40  502.8  12.571
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = fD5)
##
## $`D5$exp`
##                diff       lwr      upr     p adj
## d5sh-d5h -0.4006285 -2.634966 1.833709 0.7189687
```



Are there structures that are differentially activated depending on the duration of the training?

I think the best option here is MANOVA. I used this video first https://www.youtube.com/watch?v=48cZ2cMBpio

```
##                   Df  Pillai approx F num Df den Df    Pr(>F)
## as.factor(TRAIN)  1 0.87467   8.0807     19     22 4.842e-06 ***
## Residuals        40
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

I don't think these results are helpful at all. So there are areas that differ.. ok..

What are the structure activities that are correlated with performance (in the last training session) ?

Ok. So we need a correlation. then we need a matrix.

```
## Loading required package: grid
## Loading required package: Formula
## Loading required package: ggplot2
##
```

```
## Attaching package: 'Hmisc'
##
## The following objects are masked from 'package:base':
##
##     format.pval, round.POSIXt, trunc.POSIXt, units

##            row column         cor          p
## 172       STLD  final -0.25688878 0.01451892
## 173       STMD  final -0.11459476 0.28215434
## 174   AMBASLAT  final  0.12201443 0.25194559
## 175      AMLAT  final  0.03474115 0.74512462
## 176     ENTORH  final -0.08409247 0.43068690
## 177     PERIRH  final -0.06621543 0.53520851
## 178        CA1  final -0.29772902 0.05549844
## 179        CA3  final -0.30402470 0.05029389
## 180         DG  final -0.15854518 0.31593655
## 181   CINGULAR  final -0.23694505 0.02454052
## 182    PRELIMB  final  0.06786582 0.52505980
## 183    SOMSENS  final  0.09701581 0.36300415
## 184  SUBICULUM  final  0.24090412 0.02218022
## 185    ACCCORE  final -0.08076198 0.44922795
## 186   ACCSHELL  final -0.06811436 0.52353991
## 187     VISUAL  final  0.05980199 0.57554592
## 188   PIRIFORM  final -0.05737391 0.59117707
## 189   PARIETAL  final  0.06761815 0.52657656
## 190 RETROSPLEN  final  0.23501243 0.02576832

##            row      column          cor          p
## 121       STLD data1[, 26]  0.420943916 0.04052046
## 122       STMD data1[, 26]  0.508609712 0.01115149
## 123   AMBASLAT data1[, 26]  0.314945042 0.13387549
## 124      AMLAT data1[, 26]  0.153313786 0.47446618
## 125     ENTORH data1[, 26]  0.022545485 0.91671974
## 126     PERIRH data1[, 26] -0.029052418 0.89280380
## 127   CINGULAR data1[, 26]  0.275005847 0.19340416
## 128    PRELIMB data1[, 26] -0.273405820 0.19611358
## 129    SOMSENS data1[, 26] -0.005872661 0.97827284
## 130  SUBICULUM data1[, 26] -0.185807616 0.38469403
## 131    ACCCORE data1[, 26]  0.351101816 0.09251817
## 132   ACCSHELL data1[, 26]  0.088317879 0.68153189
## 133     VISUAL data1[, 26]  0.062166829 0.77290674
## 134   PIRIFORM data1[, 26]  0.175138682 0.41304156
## 135   PARIETAL data1[, 26]  0.292301059 0.16573976
## 136 RETROSPLEN data1[, 26]  0.003533508 0.98692608

## Warning in sqrt(npair - 2): NaNs produced

##            row      column          cor           p
## 172       STLD data1[, 24] -0.076227695 0.723325284
## 173       STMD data1[, 24] -0.002770538 0.989748891
## 174   AMBASLAT data1[, 24]  0.225778431 0.288775563
## 175      AMLAT data1[, 24]  0.246296376 0.245979988
## 176     ENTORH data1[, 24] -0.179720566 0.400729262
```

```
## 177     PERIRH data1[, 24] -0.532149076 0.007435526
## 178        CA1 data1[, 24]           NA          NA
## 179        CA3 data1[, 24]           NA          NA
## 180         DG data1[, 24]           NA          NA
## 181   CINGULAR data1[, 24] -0.004120424 0.984754725
## 182    PRELIMB data1[, 24] -0.236160472 0.266572650
## 183    SOMSENS data1[, 24]  0.205784410 0.334698112
## 184  SUBICULUM data1[, 24] -0.109996065 0.608889819
## 185    ACCCORE data1[, 24]  0.075546660 0.725703792
## 186   ACCSHELL data1[, 24]  0.177521572 0.406612533
## 187     VISUAL data1[, 24] -0.021707390 0.919805660
## 188   PIRIFORM data1[, 24]  0.150478333 0.482773527
## 189   PARIETAL data1[, 24]  0.236988276 0.264850721
## 190 RETROSPLEN data1[, 24] -0.021632330 0.920082088
```

```
##            row      column         cor          p
## 172       STLD data1[, 24] -0.32145479 0.12559258
## 173       STMD data1[, 24] -0.28133541 0.18293688
## 174   AMBASLAT data1[, 24] -0.25245550 0.23398786
## 175      AMLAT data1[, 24] -0.21934773 0.30309215
## 176     ENTORH data1[, 24] -0.44434154 0.02960353
## 177     PERIRH data1[, 24] -0.30310613 0.14993311
## 178        CA1 data1[, 24] -0.14480291 0.49961947
## 179        CA3 data1[, 24] -0.10614695 0.62155328
## 180         DG data1[, 24]  0.06378335 0.76715843
## 181   CINGULAR data1[, 24] -0.45524520 0.02539334
## 182    PRELIMB data1[, 24]  0.06031009 0.77952358
## 183    SOMSENS data1[, 24] -0.22309427 0.29469885
## 184  SUBICULUM data1[, 24] -0.36111617 0.08296873
## 185    ACCCORE data1[, 24] -0.35409132 0.08958555
## 186   ACCSHELL data1[, 24] -0.06335748 0.76867166
## 187     VISUAL data1[, 24]  0.41607288 0.04314844
## 188   PIRIFORM data1[, 24] -0.36375323 0.08058232
## 189   PARIETAL data1[, 24] -0.29271892 0.16510766
## 190 RETROSPLEN data1[, 24] -0.17931114 0.40182103
```

```
##            row      column         cor          p
## 172       STLD data1[, 26]  0.35961094 0.14272193
## 173       STMD data1[, 26]  0.11980815 0.63584001
## 174   AMBASLAT data1[, 26]  0.08361112 0.74151822
## 175      AMLAT data1[, 26]  0.20436074 0.41597587
## 176     ENTORH data1[, 26] -0.01583276 0.95028112
## 177     PERIRH data1[, 26]  0.12335004 0.62581283
## 178        CA1 data1[, 26] -0.06897060 0.78567310
## 179        CA3 data1[, 26]  0.20157377 0.42249904
## 180         DG data1[, 26]  0.12214736 0.62921076
## 181   CINGULAR data1[, 26]  0.26162213 0.29432116
## 182    PRELIMB data1[, 26]  0.52393258 0.02562968
## 183    SOMSENS data1[, 26]  0.39525074 0.10449866
## 184  SUBICULUM data1[, 26]  0.35399941 0.14951909
## 185    ACCCORE data1[, 26]  0.18270271 0.46806182
## 186   ACCSHELL data1[, 26]  0.13056333 0.60558531
## 187     VISUAL data1[, 26]  0.27053288 0.27757543
## 188   PIRIFORM data1[, 26]  0.25667286 0.30388027
```

```
## 189   PARIETAL data1[, 26]  0.38416871 0.11549134
## 190 RETROSPLEN data1[, 26]  0.35882717 0.14365820
```

First took all the data to see whether they are normally distributed or not: per brain area per group 4 groups, lesion vs. non lesion depending on normality: t test or wilcox

NORMAL DISTIBUTION?

We will carry out the shapiro-Wilk test. If p>a (bigger than 0.05 generally), the data is normal.

d5h[,c(3,17,20,21)] are not normally distributed d5sh[,c(3)] is not normally distributed d3h[,c(15,21)] are not normally distributed d3sh[,c(3,8,2,14,16,18)] is not normally distributed. You have a small sample size but the population is actually normally distributed, so we will use a parametric test anyway

ok fuck this shit let's do a t test for all these fuckers

t.test(collumn 1, collumn 2) skip collumns 9:11 for d3h vs d5h

```
for(i in c(3:8,12:21)){
  print(t.test(d3h[,i],d5h[,i]))
}
```

```
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -1.3064, df = 45.032, p-value = 0.1981
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -675.4311  143.9513
## sample estimates:
## mean of x mean of y
##  1612.441  1878.181
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = 1.0996, df = 45.955, p-value = 0.2772
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -115.6838  394.2305
## sample estimates:
## mean of x mean of y
##  1339.385  1200.111
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -0.32978, df = 38.962, p-value = 0.7433
```

```
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -139.8576  100.6467
## sample estimates:
## mean of x mean of y
##  494.7242  514.3297
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -0.81178, df = 45.571, p-value = 0.4211
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -323.4522  137.5726
## sample estimates:
## mean of x mean of y
##  1027.418  1120.357
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -0.94103, df = 44.666, p-value = 0.3518
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -138.88516   50.44491
## sample estimates:
## mean of x mean of y
##  324.3175  368.5376
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -0.50866, df = 44.331, p-value = 0.6135
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -182.7754  109.0943
## sample estimates:
## mean of x mean of y
##  473.4962  510.3367
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -2.9969, df = 45.89, p-value = 0.004389
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -544.3015 -106.8962
## sample estimates:
## mean of x mean of y
##  1216.220  1541.819
```

```
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -0.70902, df = 45.997, p-value = 0.4819
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -283.2634  135.6917
## sample estimates:
## mean of x mean of y
##  781.9456  855.7315
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = 1.6793, df = 45.154, p-value = 0.1
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -31.6646 349.4785
## sample estimates:
## mean of x mean of y
##  973.9191  815.0121
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -0.13494, df = 44.752, p-value = 0.8933
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -136.0261  118.9459
## sample estimates:
## mean of x mean of y
##  267.2530  275.7931
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = 0.029937, df = 45.939, p-value = 0.9762
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -202.1064  208.2086
## sample estimates:
## mean of x mean of y
##  620.3324  617.2813
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = 0.85777, df = 45.962, p-value = 0.3955
```

```
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -98.57526 244.96806
## sample estimates:
## mean of x mean of y
##  436.4552  363.2588
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -0.10222, df = 45.497, p-value = 0.919
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -377.8926  341.3776
## sample estimates:
## mean of x mean of y
##  1620.243  1638.500
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -0.77948, df = 42.538, p-value = 0.44
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -325.3603  144.0024
## sample estimates:
## mean of x mean of y
##  912.9051 1003.5840
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = 2.282, df = 45.091, p-value = 0.02726
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##   34.44698 552.19530
## sample estimates:
## mean of x mean of y
##  1086.926   793.605
##
##
##  Welch Two Sample t-test
##
## data:  d3h[, i] and d5h[, i]
## t = -0.54259, df = 45.789, p-value = 0.59
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -246.8148  142.0159
## sample estimates:
## mean of x mean of y
##  402.9082  455.3077
```

```r
for(i in c(3:21)){
  print(t.test(d3sh[,i],d5sh[,i]))
}
```

```
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -2.8767, df = 27.78, p-value = 0.007635
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -997.2579 -167.5475
## sample estimates:
## mean of x mean of y
##  798.6822 1381.0849
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -2.1563, df = 31.541, p-value = 0.0388
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -647.7289  -18.2504
## sample estimates:
## mean of x mean of y
##  1031.708  1364.697
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = 0.22244, df = 31.349, p-value = 0.8254
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -119.5437  148.8271
## sample estimates:
## mean of x mean of y
##  575.9308  561.2891
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -2.7633, df = 29.22, p-value = 0.0098
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -602.5997  -90.0839
## sample estimates:
## mean of x mean of y
##  1081.114  1427.455
##
##
```

```
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -2.8569, df = 21.807, p-value = 0.009218
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -366.34520  -58.08466
## sample estimates:
## mean of x mean of y
##  312.2207  524.4357
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -3.7813, df = 25.461, p-value = 0.0008469
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -644.1981 -190.1669
## sample estimates:
## mean of x mean of y
##  464.6539  881.8364
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -4.662, df = 39.474, p-value = 3.537e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -899.4325 -355.2715
## sample estimates:
## mean of x mean of y
##  1065.894  1693.246
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -5.5277, df = 24.487, p-value = 1.027e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -608.6800 -277.9728
## sample estimates:
## mean of x mean of y
##  304.2655  747.5919
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -1.1798, df = 38.161, p-value = 0.2454
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
```

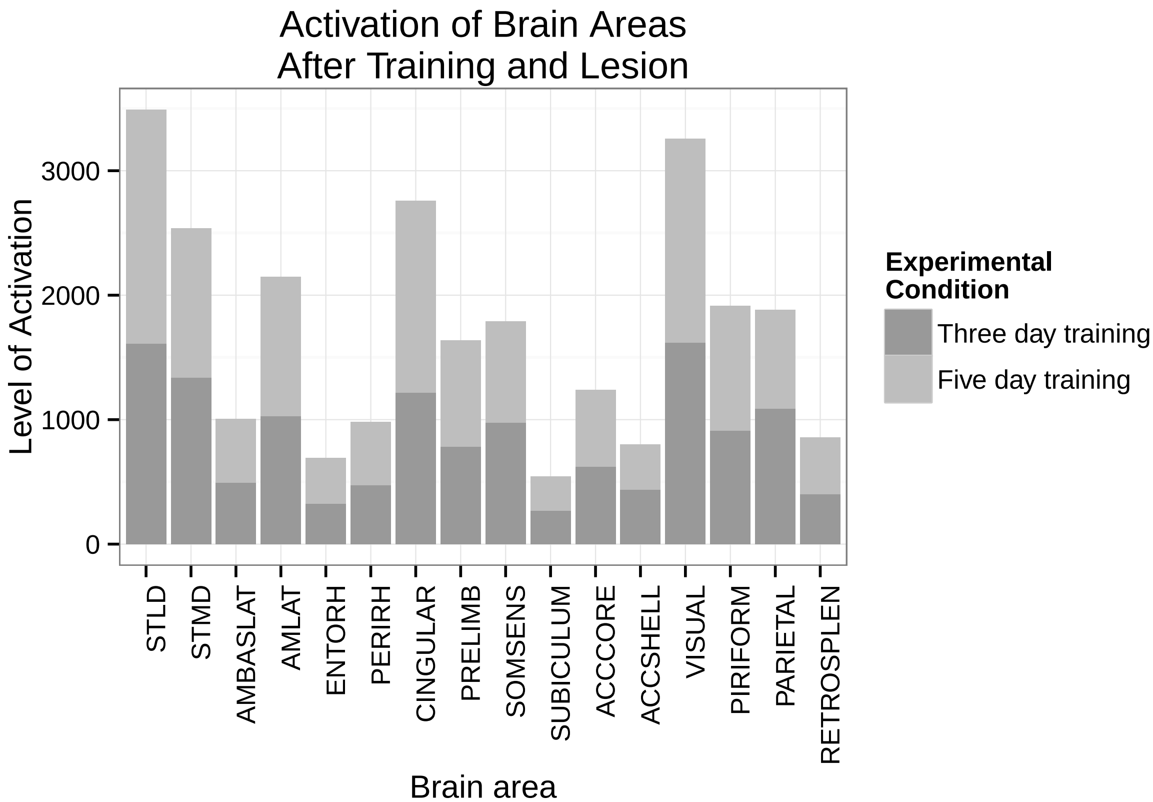
```
##  -140.84168   37.11607
## sample estimates:
## mean of x mean of y
##  256.5610  308.4238
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -0.59702, df = 23.292, p-value = 0.5563
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -402.6953  222.2184
## sample estimates:
## mean of x mean of y
##  1031.653  1121.892
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -0.44025, df = 31.991, p-value = 0.6627
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -349.0704  224.9968
## sample estimates:
## mean of x mean of y
##  929.2108  991.2476
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -0.10443, df = 26.241, p-value = 0.9176
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -309.8448  279.8704
## sample estimates:
## mean of x mean of y
##  1018.052  1033.039
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -1.7484, df = 32.93, p-value = 0.08971
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -365.88103   27.68379
## sample estimates:
## mean of x mean of y
##  505.7771  674.8757
##
##
```

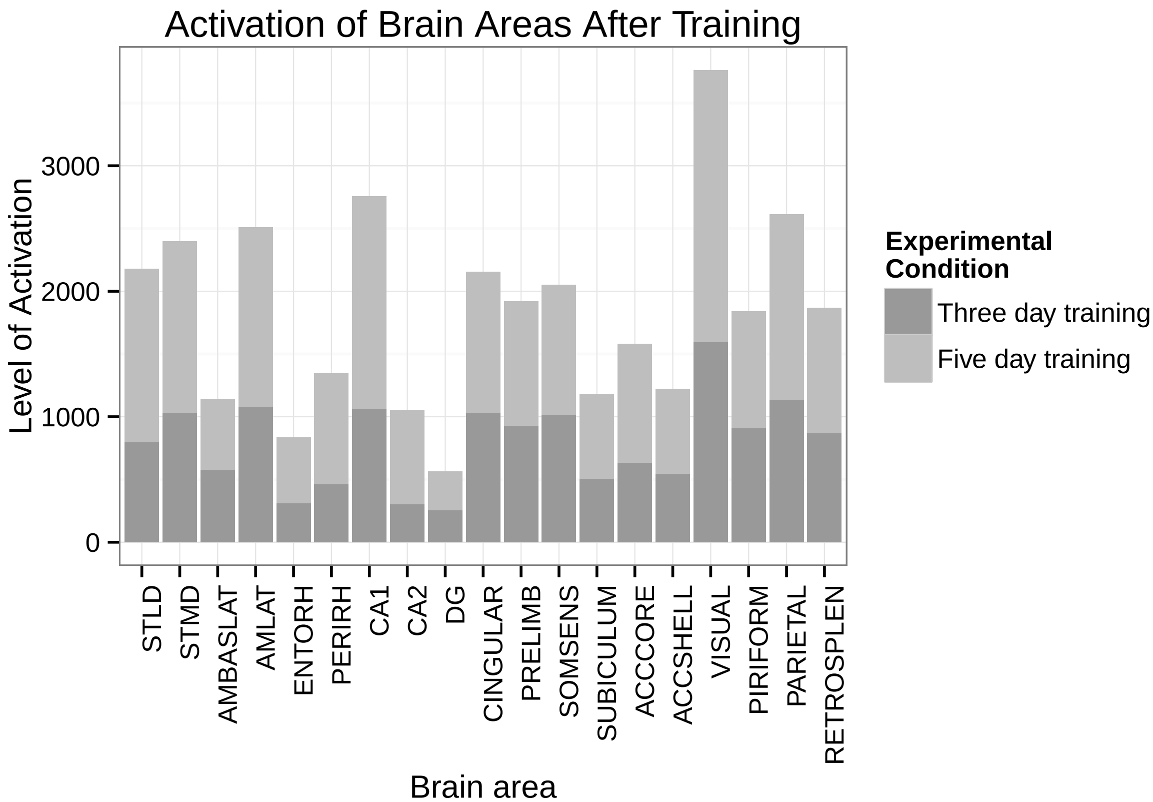
```
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -1.9937, df = 29.799, p-value = 0.05541
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -634.816975    7.733769
## sample estimates:
## mean of x mean of y
##  633.9459  947.4875
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -0.91218, df = 28.386, p-value = 0.3694
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -421.5918  161.6901
## sample estimates:
## mean of x mean of y
##  547.3349  677.2858
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -2.482, df = 22.529, p-value = 0.02098
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1051.34862   -94.89004
## sample estimates:
## mean of x mean of y
##  1594.843  2167.963
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -0.1828, df = 29.808, p-value = 0.8562
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -301.8090  252.2322
## sample estimates:
## mean of x mean of y
##  906.9945  931.7829
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -1.7383, df = 23.722, p-value = 0.09512
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
```

```
##  -744.10838   63.94894
## sample estimates:
## mean of x mean of y
##  1136.431  1476.511
##
##
##  Welch Two Sample t-test
##
## data:  d3sh[, i] and d5sh[, i]
## t = -1.0525, df = 21.17, p-value = 0.3044
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -383.0276  125.5168
## sample estimates:
## mean of x mean of y
##  869.4037  998.1591
```

FIGURETIME.

```
##
## Attaching package: 'reshape'
##
## The following objects are masked from 'package:reshape2':
##
##     colsplit, melt, recast
##
## The following object is masked from 'package:Matrix':
##
##     expand
```


Activation of Brain Areas
After Training and Lesion
Level of Activation
0
1000
2000
3000
STLD
STMD
AMBASLAT
AMLAT
ENTORH
PERIRH
CINGULAR
PRELIMB
SOMSENS
SUBICULUM
ACCCORE
ACCSHELL
VISUAL
PIRIFORM
PARIETAL
RETROSPLEN
Brain area
Experimental Condition
Three day training
Five day training


Activation of Brain Areas After Training
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0
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STLD
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DG
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SUBICULUM
ACCCORE
ACCSHELL
VISUAL
PIRIFORM
PARIETAL
RETROSPLEN
Brain area
Experimental Condition
Three day training
Five day training