Hypothesis Testing for NSF Office Stress Project - Reduced Sensor Set

Below are the test results for each of the Conditions that had $n \ge 7$ subjects. Statistical testing can have three different possible outcomes: the data is already normal (t-test), the logarithm of the data is normal (t-test with log data), or the data is NOT normal (Wilcoxon test).

For notation, let:

```
WB-RB = Writing Baseline - Resting Baseline
SC-RB = Stress Condition - Resting Baseline
SC-WB = Stress Condition - Writing Baseline
DT-RB = Dual Task - Resting Baseline
DT-WB = Dual Task - Writing Baseline
DT-SC = Dual Task - Stress Condition
P-RB = Presentation - Resting Baseline
P-WB = Presentation - Writing Baseline
P-SC = Presentation - Stress Condition
P-DT = Presentation - Dual Task
```

For each of the graphs, let:

```
* = 0.01 

<math>** = 0.001 

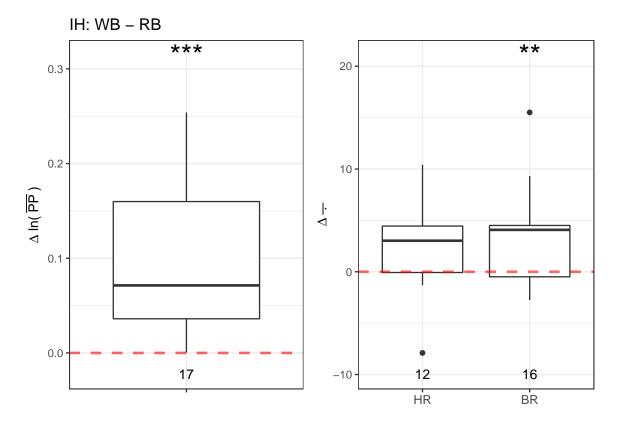
<math>*** = p <= 0.001

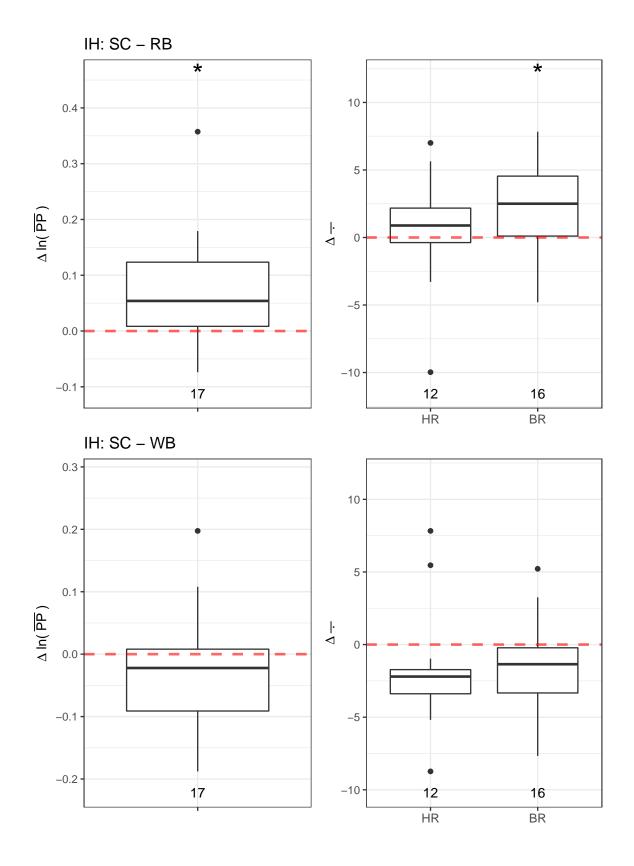
? = Did not run statistical test (n < 7)
```

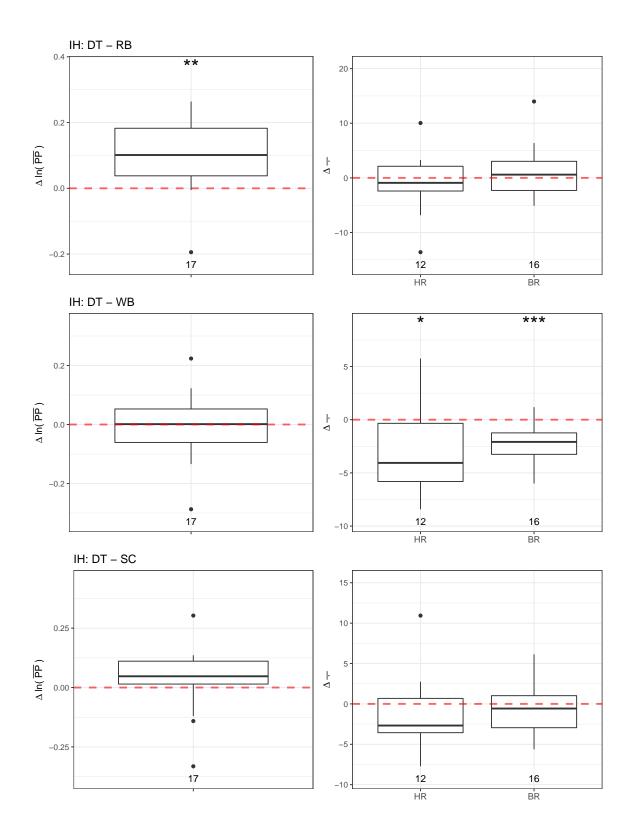
Differences in **Reduced Sensor Set**:

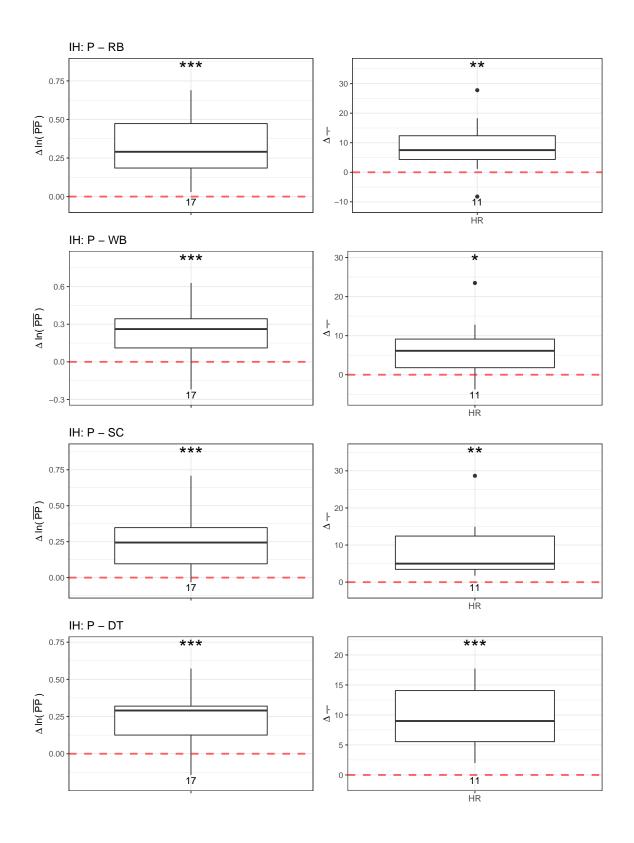
- Signals for D.EDA, N.EDA, D.HR, and N.HR and removed completely.
- Breathing Rate (BR) measurements for the Presentation session are removed completely.
- Easier on the eyes.

Intermittent-High (IH)



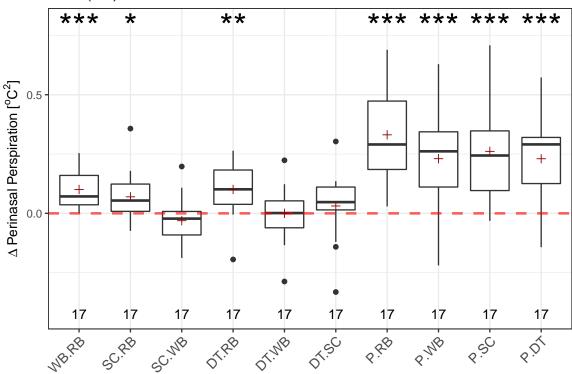






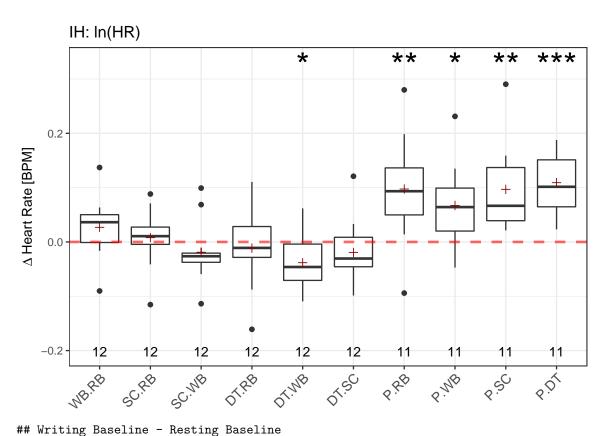
Sensor Channel across Session

IH: In(PP)



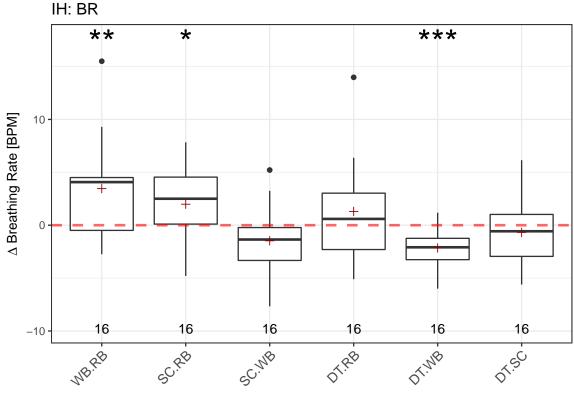
```
## In the following tests, we applied ln(PP).
## Writing Baseline - Resting Baseline
## t-test p = 1e-04 < 0.001 ***
## Stress Condition - Resting Baseline
## t-test p = 0.0145 < 0.05 *
##
## StressCondition - Writing Baseline
## t-test p = 0.2084 > 0.05
##
## Dual Task - Resting Baseline
## t-test p = 0.0016 < 0.01 **
## Dual Task - Writing Baseline
## t-test p = 0.9946 > 0.05
## Dual Task - Stress Condition
## t-test p = 0.3697 > 0.05
##
## Presentation - Resting Baseline
## t-test p = 0 < 0.001 ***
##
```

```
## Presentation - Writing Baseline
## t-test p = 2e-04 < 0.001 ***
##
## Presentation - Stress Condition
## t-test p = 1e-04 < 0.001 ***
##
## Presentation - Dual Task
## t-test p = 2e-04 < 0.001 ***</pre>
```



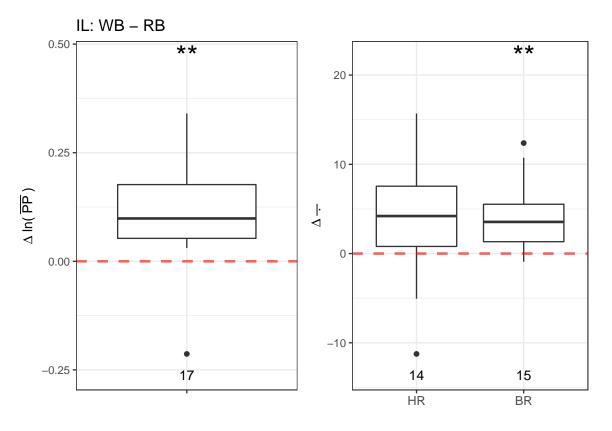
```
## Transformed t-test p = 0.1185 > 0.05
##
## Stress Condition - Resting Baseline
## Transformed t-test p = 0.6095 > 0.05
## StressCondition - Writing Baseline
## Transformed t-test p = 0.2597 > 0.05
## Dual Task - Resting Baseline
## Transformed t-test p = 0.5735 > 0.05
##
## Dual Task - Writing Baseline
## Transformed t-test p = 0.0172 < 0.05 *
## Dual Task - Stress Condition
## Transformed t-test p = 0.2853 > 0.05
## Presentation - Resting Baseline
## Transformed t-test p = 0.0079 < 0.01 **
## Presentation - Writing Baseline
## Transformed t-test p = 0.0153 < 0.05 *
##
## Presentation - Stress Condition
## Transformed t-test p = 0.0026 < 0.01 **
```

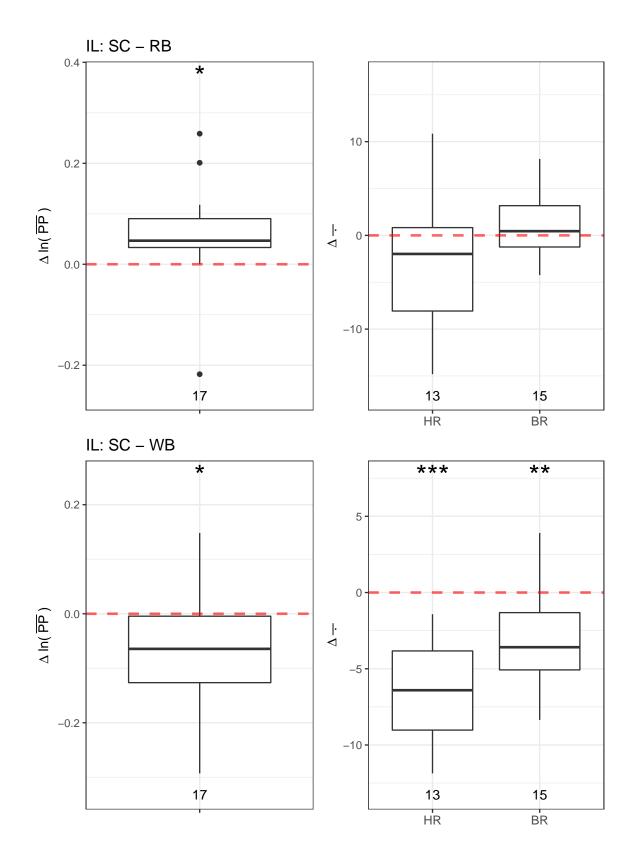
```
##
## Presentation - Dual Task
## Transformed t-test p = 0 < 0.001 ***</pre>
```

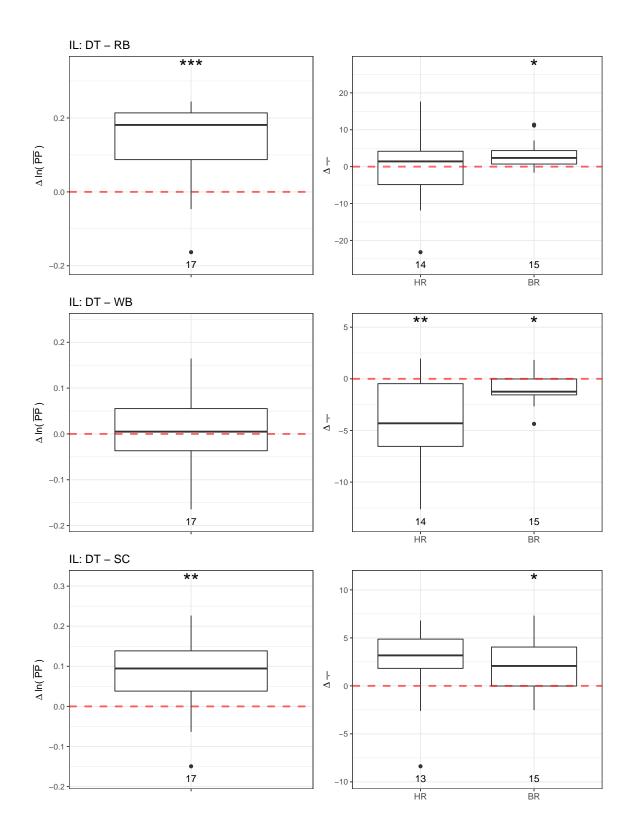


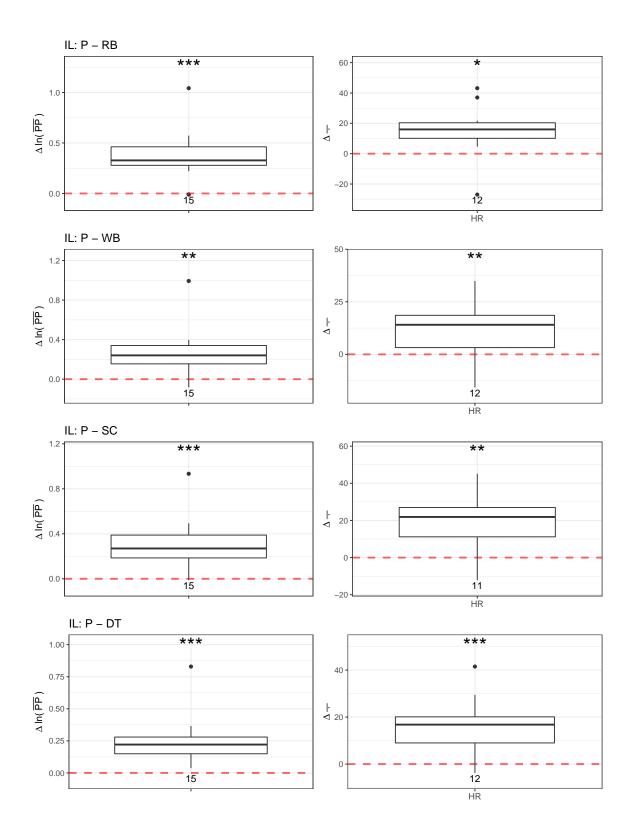
```
## Writing Baseline - Resting Baseline
## t-test p = 0.0086 < 0.01 **
##
## Stress Condition - Resting Baseline
## t-test p = 0.0455 < 0.05 *
##
## StressCondition - Writing Baseline
## t-test p = 0.0933 > 0.05
##
## Dual Task - Resting Baseline
## t-test p = 0.2969 > 0.05
##
## Dual Task - Writing Baseline
## t-test p = 5e-04 < 0.001 ***
##
## Dual Task - Stress Condition
## t-test p = 0.3543 > 0.05
```

Intermittent-Low (IL)



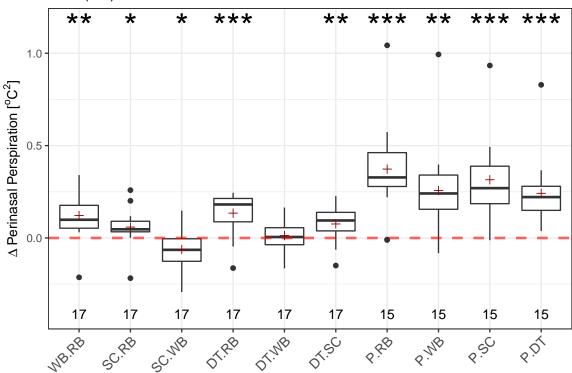






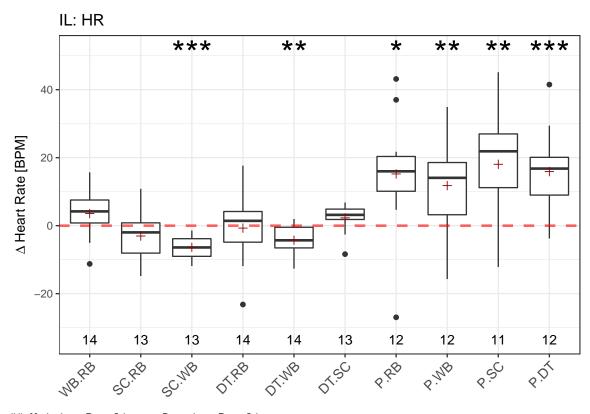
Sensor Channel across Session

IL: In(PP)



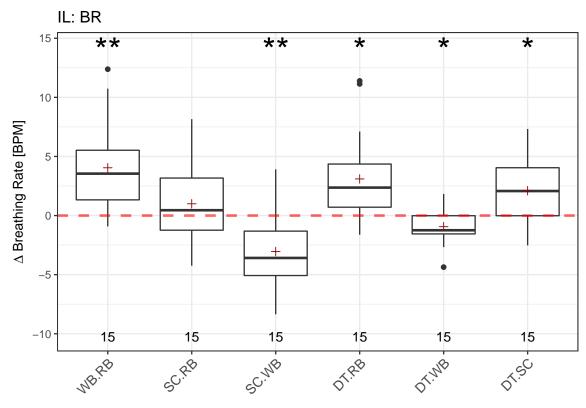
```
## Writing Baseline - Resting Baseline
## t-test p = 0.0012 < 0.01 **
##
## Stress Condition - Resting Baseline
## t-test p = 0.0261 < 0.05 *
##
## StressCondition - Writing Baseline
## t-test p = 0.0272 < 0.05 *
## Dual Task - Resting Baseline
## t-test p = 2e-04 < 0.001 ***
## Dual Task - Writing Baseline
## t-test p = 0.561 > 0.05
##
## Dual Task - Stress Condition
## t-test p = 0.0054 < 0.01 **
##
## Presentation - Resting Baseline
## t-test p = 0 < 0.001 ***
## Presentation - Writing Baseline
## t-test p = 0.0013 < 0.01 **
```

```
##
## Presentation - Stress Condition
## t-test p = 1e-04 < 0.001 ***
##
## Presentation - Dual Task
## t-test p = 2e-04 < 0.001 ***</pre>
```



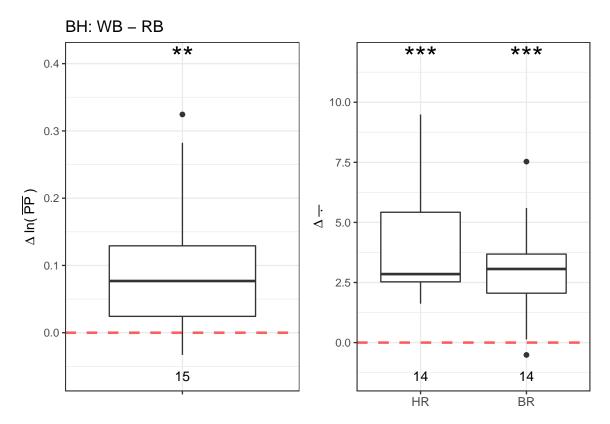
```
## Writing Baseline - Resting Baseline
## t-test p = 0.0689 > 0.05
##
## Stress Condition - Resting Baseline
## t-test p = 0.1422 > 0.05
## StressCondition - Writing Baseline
## t-test p = 0 < 0.001 ***
## Dual Task - Resting Baseline
## t-test p = 0.7837 > 0.05
##
## Dual Task - Writing Baseline
## t-test p = 0.0043 < 0.01 **
## Dual Task - Stress Condition
## t-test p = 0.0676 > 0.05
##
## Presentation - Resting Baseline
## t-test p = 0.0111 < 0.05 *
##
## Presentation - Writing Baseline
## t-test p = 0.0089 < 0.01 **
##
## Presentation - Stress Condition
## t-test p = 0.0027 < 0.01 **
```

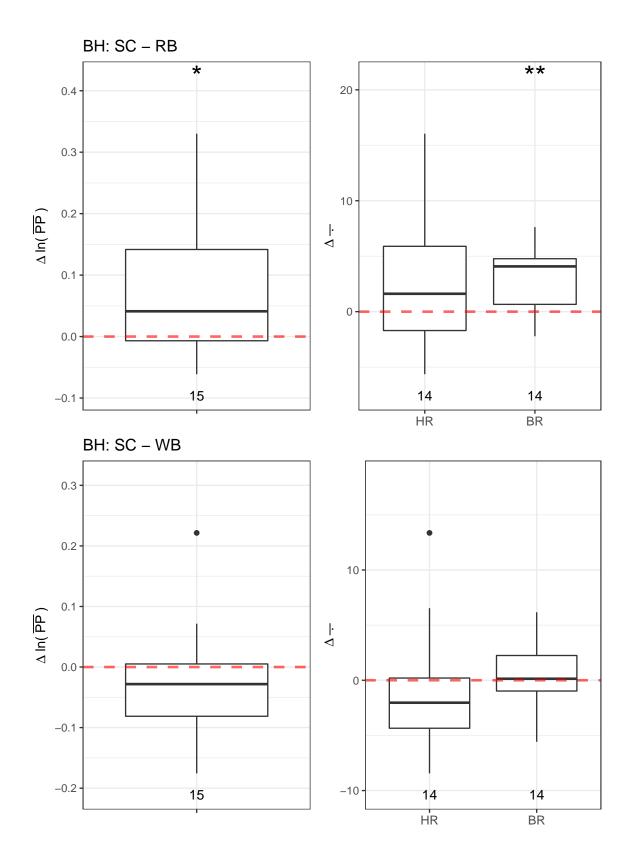
```
##
## Presentation - Dual Task
## t-test p = 0.001 < 0.001 ***</pre>
```

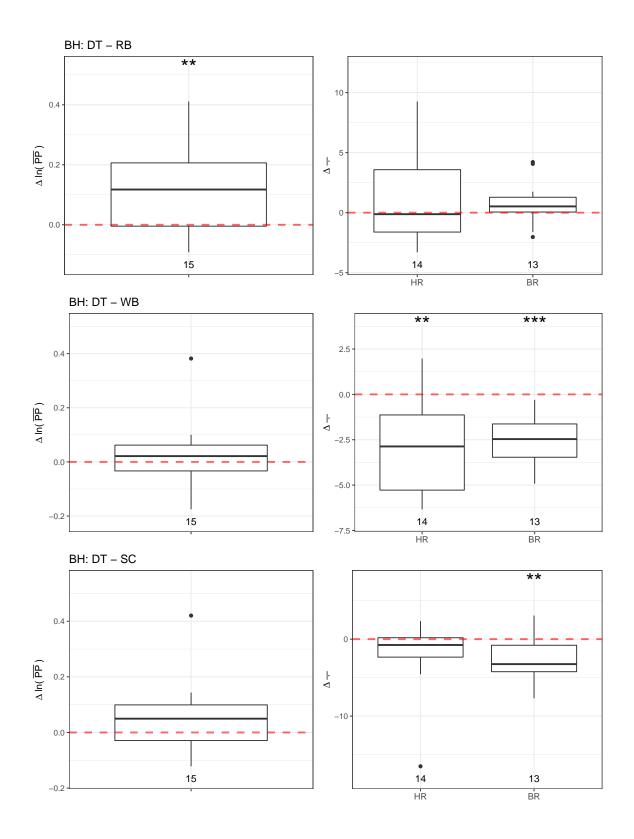


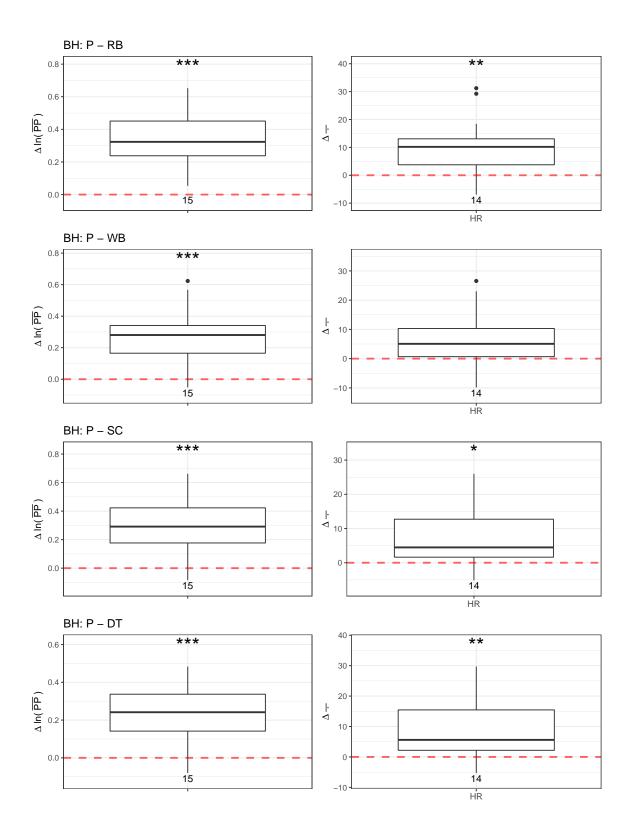
```
## Writing Baseline - Resting Baseline
## t-test p = 0.0011 < 0.01 **
##
## Stress Condition - Resting Baseline
## t-test p = 0.2825 > 0.05
##
## StressCondition - Writing Baseline
## t-test p = 0.003 < 0.01 **
##
## Dual Task - Resting Baseline
## t-test p = 0.0104 < 0.05 *
##
## Dual Task - Writing Baseline
## t-test p = 0.0371 < 0.05 *
##
## Dual Task - Stress Condition
## t-test p = 0.0181 < 0.05 *</pre>
```

Batch-High (BH)

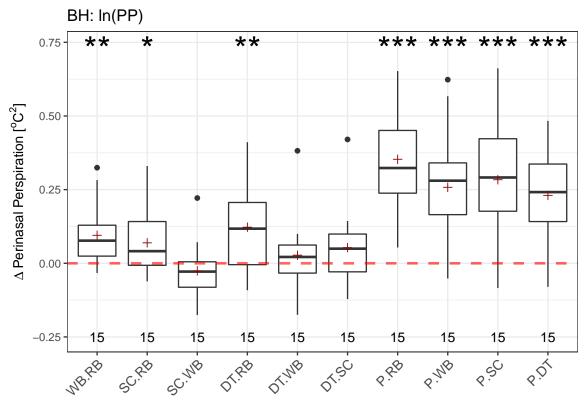








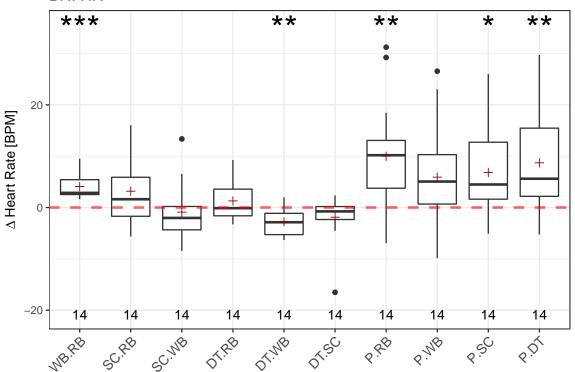
Sensor Channel across Session



```
## Writing Baseline - Resting Baseline
## t-test p = 0.0039 < 0.01 **
## Stress Condition - Resting Baseline
## t-test p = 0.0215 < 0.05 *
##
## StressCondition - Writing Baseline
## t-test p = 0.3011 > 0.05
## Dual Task - Resting Baseline
## t-test p = 0.0032 < 0.01 **
## Dual Task - Writing Baseline
## t-test p = 0.3915 > 0.05
##
## Dual Task - Stress Condition
## t-test p = 0.1264 > 0.05
##
## Presentation - Resting Baseline
## t-test p = 0 < 0.001 ***
## Presentation - Writing Baseline
## t-test p = 1e-04 < 0.001 ***
```

```
##
## Presentation - Stress Condition
## t-test p = 1e-04 < 0.001 ***
##
## Presentation - Dual Task
## t-test p = 0 < 0.001 ***</pre>
```





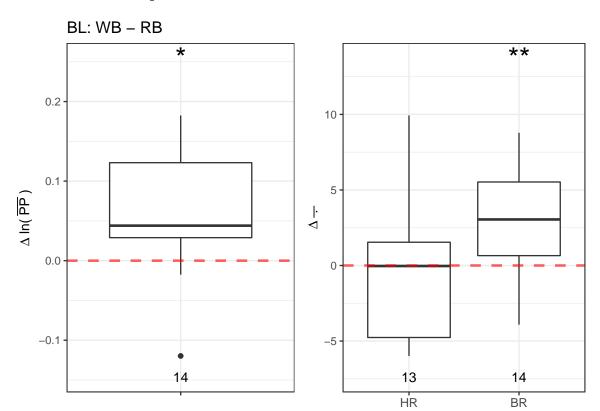
```
## Writing Baseline - Resting Baseline
## t-test p = 0 < 0.001 ***
##
## Stress Condition - Resting Baseline
## t-test p = 0.0805 > 0.05
## StressCondition - Writing Baseline
## t-test p = 0.559 > 0.05
## Dual Task - Resting Baseline
## t-test p = 0.2422 > 0.05
##
## Dual Task - Writing Baseline
## t-test p = 0.0017 < 0.01 **
## Dual Task - Stress Condition
## t-test p = 0.1489 > 0.05
## Presentation - Resting Baseline
## t-test p = 0.0051 < 0.01 **
##
## Presentation - Writing Baseline
## t-test p = 0.05 > 0.05
##
## Presentation - Stress Condition
## t-test p = 0.0136 < 0.05 *
```

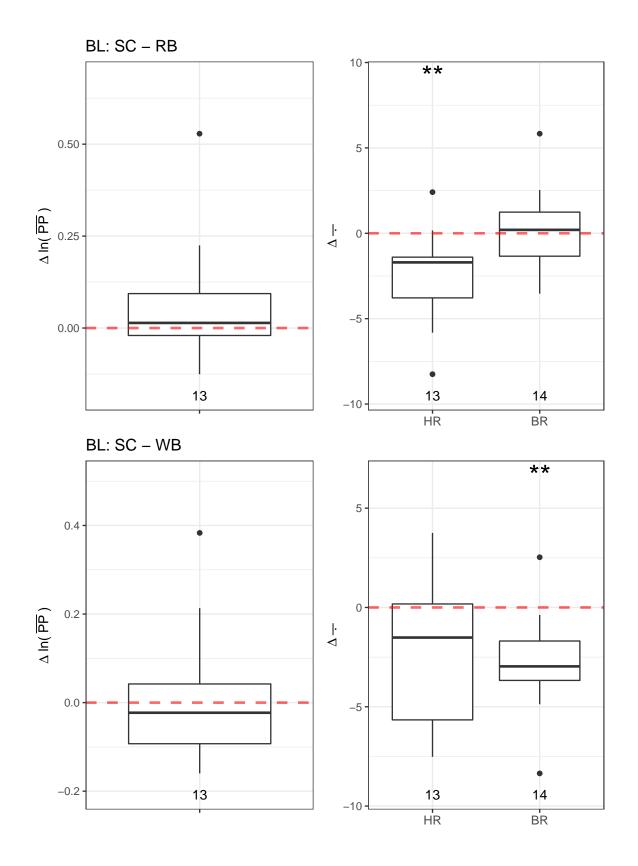
```
##
## Presentation - Dual Task
## t-test p = 0.0074 < 0.01 **</pre>
```

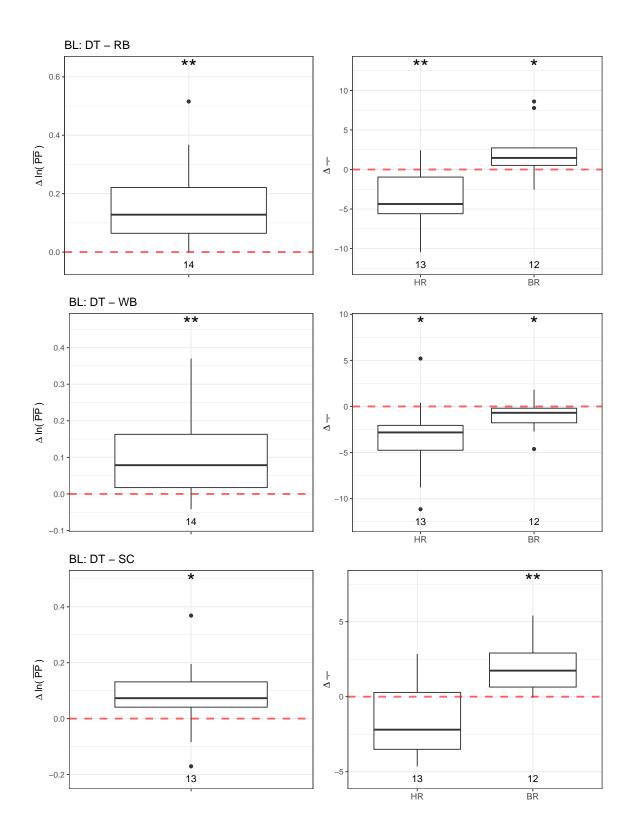


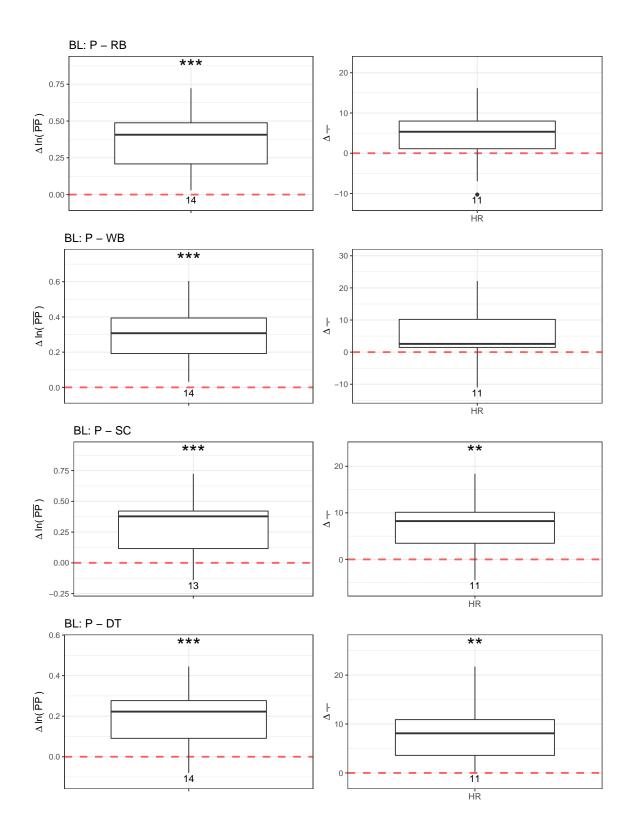
```
## Writing Baseline - Resting Baseline
## t-test p = 1e-04 < 0.001 ***
##
## Stress Condition - Resting Baseline
## t-test p = 0.0026 < 0.01 **
##
## StressCondition - Writing Baseline
## t-test p = 0.993 > 0.05
##
## Dual Task - Resting Baseline
## t-test p = 0.1451 > 0.05
##
## Dual Task - Writing Baseline
## t-test p = 0 < 0.001 ***
##
## Dual Task - Stress Condition
## t-test p = 0.0096 < 0.01 **</pre>
```

Batch-Low (BL)



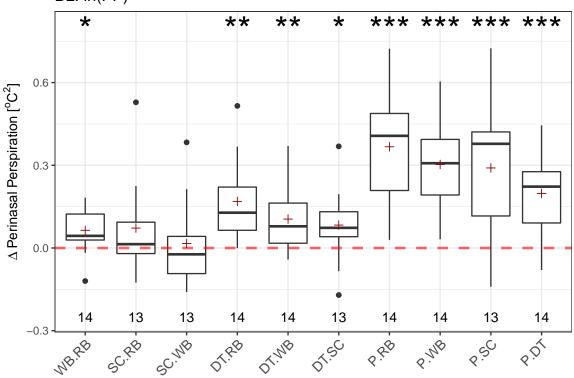






Sensor Channel across Session

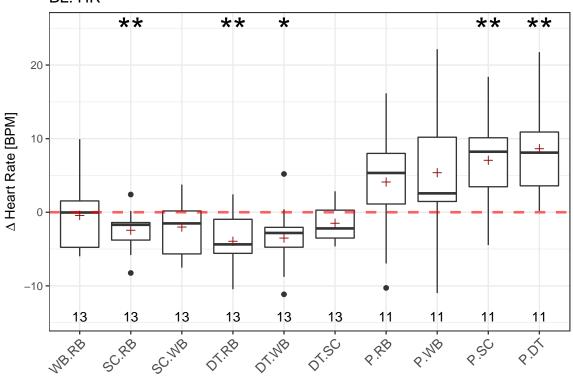
BL: In(PP)



```
## Writing Baseline - Resting Baseline
## t-test p = 0.0129 < 0.05 *
##
## Stress Condition - Resting Baseline
## t-test p = 0.1391 > 0.05
##
## StressCondition - Writing Baseline
## t-test p = 0.7092 > 0.05
## Dual Task - Resting Baseline
## t-test p = 0.001 < 0.01 **
## Dual Task - Writing Baseline
## t-test p = 0.0063 < 0.01 **
##
## Dual Task - Stress Condition
## t-test p = 0.0466 < 0.05 *
##
## Presentation - Resting Baseline
## t-test p = 0 < 0.001 ***
## Presentation - Writing Baseline
## t-test p = 0 < 0.001 ***
```

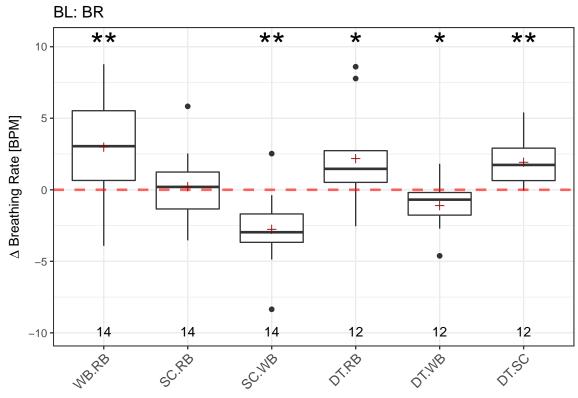
```
##
## Presentation - Stress Condition
## t-test p = 8e-04 < 0.001 ***
##
## Presentation - Dual Task
## t-test p = 3e-04 < 0.001 ***</pre>
```





```
## Writing Baseline - Resting Baseline
## t-test p = 0.7394 > 0.05
##
## Stress Condition - Resting Baseline
## t-test p = 0.0068 < 0.01 **
## StressCondition - Writing Baseline
## t-test p = 0.081 > 0.05
## Dual Task - Resting Baseline
## t-test p = 0.0028 < 0.01 **
##
## Dual Task - Writing Baseline
## t-test p = 0.0103 < 0.05 *
## Dual Task - Stress Condition
## t-test p = 0.0577 > 0.05
##
## Presentation - Resting Baseline
## t-test p = 0.1093 > 0.05
##
## Presentation - Writing Baseline
## t-test p = 0.0833 > 0.05
##
## Presentation - Stress Condition
## t-test p = 0.0069 < 0.01 **
```

```
##
## Presentation - Dual Task
## t-test p = 0.0019 < 0.01 **</pre>
```



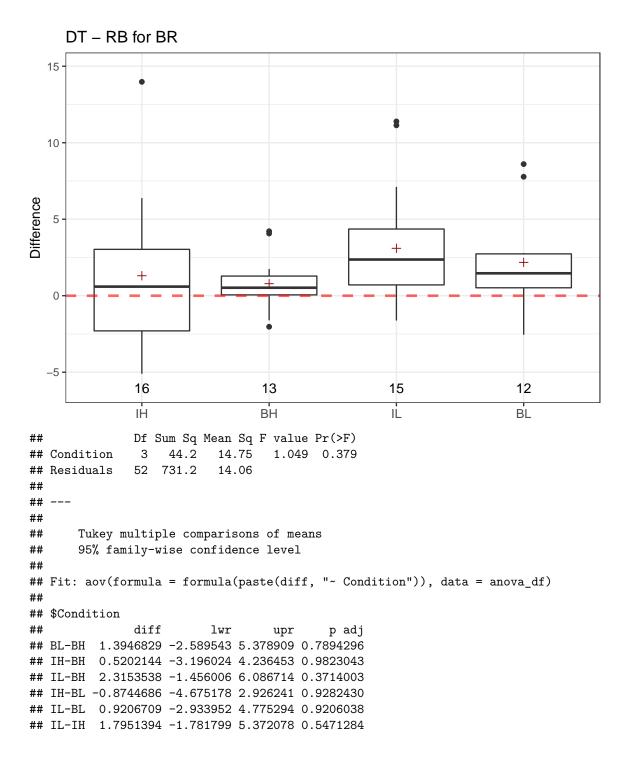
```
## Writing Baseline - Resting Baseline
## t-test p = 0.005 < 0.01 **
##
## Stress Condition - Resting Baseline
## t-test p = 0.7386 > 0.05
##
## StressCondition - Writing Baseline
## t-test p = 0.0012 < 0.01 **
##
## Dual Task - Resting Baseline
## t-test p = 0.0373 < 0.05 *
##
## Dual Task - Writing Baseline
## t-test p = 0.0368 < 0.05 *
##
## Dual Task - Stress Condition
## t-test p = 0.002 < 0.01 **</pre>
```

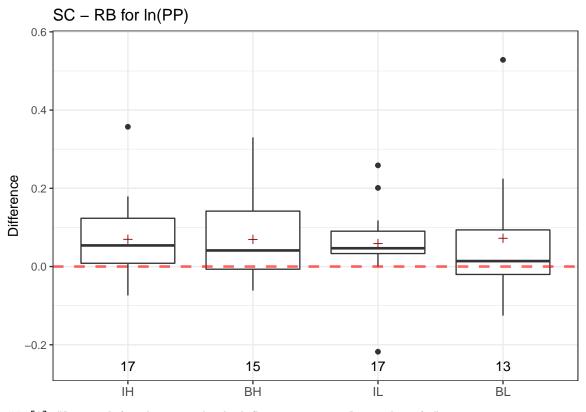
Across Sessions

DT - RB for In(PP) 0.4 Difference 0.2 0.0 -0.217 15 17 14 ıн ΙĹ вН ВL ## Df Sum Sq Mean Sq F value Pr(>F) 3 0.0371 0.01235 ## Condition 0.768 0.516 ## Residuals 59 0.9484 0.01607 ## ## ## ## Tukey multiple comparisons of means 95% family-wise confidence level ## ## ## Fit: aov(formula = formula(paste(diff, "~ Condition")), data = anova_df) ## ## \$Condition ## diff lwr upr p adj ## BL-BH 0.04655998 -0.07800001 0.17111997 0.7566681 ## IH-BH -0.02173941 -0.14047861 0.09699979 0.9623489 ## IL-BH 0.01182058 -0.10691862 0.13055978 0.9935469 ## IH-BL -0.06829939 -0.18927048 0.05267170 0.4483409 ## IL-BL -0.03473940 -0.15571048 0.08623169 0.8723476 ## IL-IH 0.03355999 -0.08140874 0.14852873 0.8668803

DT - RB for HR 20 10 Difference -10 -20 12 14 14 13 ιΉ вн ΙĹ ВL ## Df Sum Sq Mean Sq F value Pr(>F) 3 196.9 65.62 ## Condition 2.061 0.118 49 1559.9 ## Residuals 31.83 ## ## ## ## Tukey multiple comparisons of means ## 95% family-wise confidence level ## ## Fit: aov(formula = formula(paste(diff, "~ Condition")), data = anova_df) ## ## \$Condition diff lwr upr p adj ## BL-BH -5.2299412 -11.009325 0.5494428 0.0891252 ## IH-BH -1.3023021 -7.205229 4.6006247 0.9356236 ## IL-BH -2.0060477 -7.677396 3.6653009 0.7831604

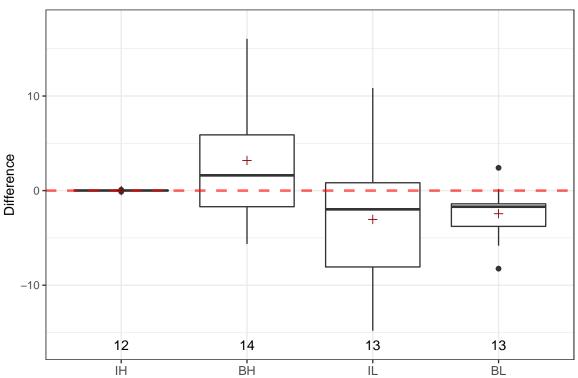
IH-BL 3.9276391 -2.079159 9.9344376 0.3150719 ## IL-BL 3.2238935 -2.555490 9.0032775 0.4550405 ## IL-IH -0.7037456 -6.606672 5.1991811 0.9888315





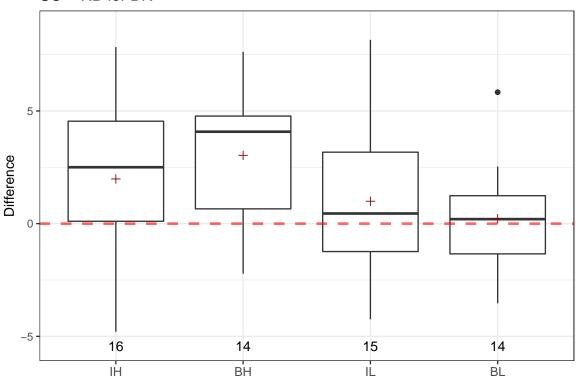
```
## [1] "Removed O subjects who had Stroop scores less than O."
##
##
##
                Df Sum Sq Mean Sq F value Pr(>F)
               3 0.0017 0.000581
## Condition
                                    0.042 0.989
## Residuals
               58 0.8071 0.013916
##
## ---
##
##
       Tukey multiple comparisons of means
##
       95% family-wise confidence level
##
## Fit: aov(formula = formula(paste(diff, "~ Condition")), data = anova_df)
##
## $Condition
##
                  diff
                              lwr
                                         upr
                                                 p adj
## BL-BH 0.0028961617 -0.1153422 0.12113454 0.9999012
## IH-BH 0.0002650717 -0.1102704 0.11080054 0.9999999
## IL-BH -0.0107075764 -0.1212430 0.09982789 0.9940359
## IH-BL -0.0026310900 -0.1175949 0.11233274 0.9999194
## IL-BL -0.0136037381 -0.1285676 0.10136009 0.9892655
## IL-IH -0.0109726481 -0.1179982 0.09605285 0.9929513
```

SC - RB for HR

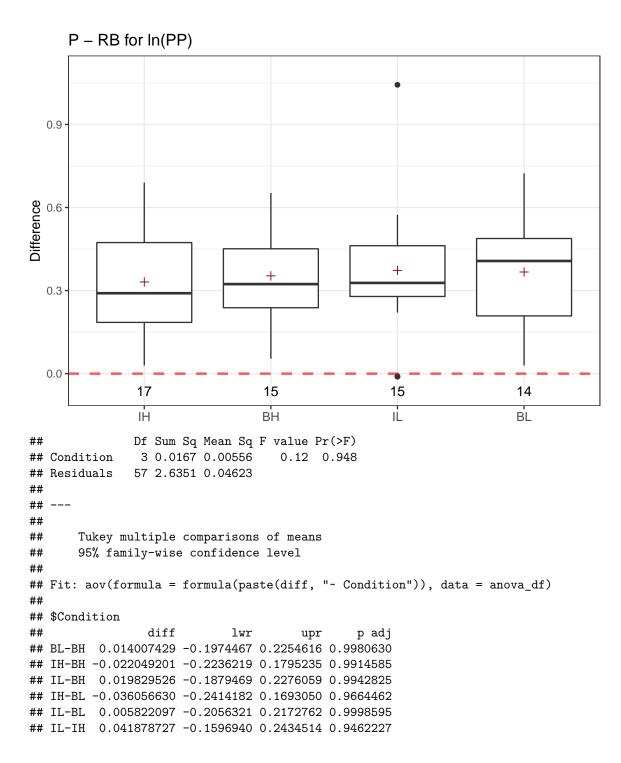


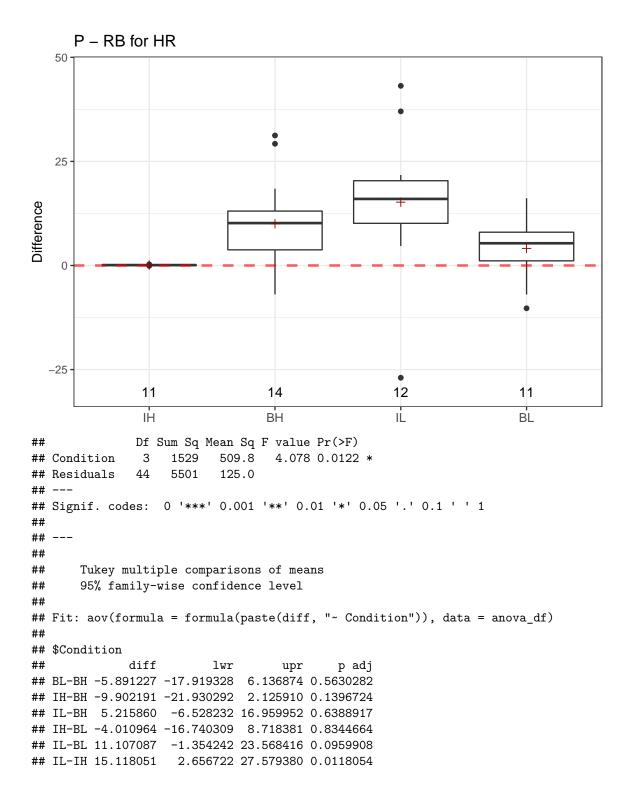
```
## [1] "Removed O subjects who had Stroop scores less than O."
##
## ---
##
                Df Sum Sq Mean Sq F value Pr(>F)
               3 326.3 108.75
                                 4.397 0.00821 **
## Condition
## Residuals
              48 1187.2
                          24.73
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.05 '.' 0.1 ' ' 1
##
## ---
##
      Tukey multiple comparisons of means
##
##
       95% family-wise confidence level
##
## Fit: aov(formula = formula(paste(diff, "~ Condition")), data = anova_df)
##
## $Condition
              diff
                          lwr
                                    upr
                                            p adj
## BL-BH -5.6268272 -10.724702 -0.528952 0.0252515
## IH-BH -3.1742515 -8.381101 2.032598 0.3759612
## IL-BH -6.2269809 -11.324856 -1.129106 0.0109623
## IH-BL 2.4525757 -2.845897 7.751049 0.6099621
## IL-BL -0.6001537 -5.791576 4.591268 0.9897684
## IL-IH -3.0527294 -8.351202 2.245743 0.4260203
```

SC - RB for BR



```
## [1] "Removed O subjects who had Stroop scores less than O."
##
## ---
##
                 Df Sum Sq Mean Sq F value Pr(>F)
## Condition
                3
                   63.3
                           21.09
                                    2.07 0.115
## Residuals
               55 560.5
                           10.19
##
## ---
##
##
       Tukey multiple comparisons of means
##
       95% family-wise confidence level
##
## Fit: aov(formula = formula(paste(diff, "~ Condition")), data = anova_df)
##
## $Condition
##
               diff
                          lwr
                                    upr
                                            p adj
## BL-BH -2.8155027 -6.012142 0.3811366 0.1028598
## IH-BH -1.0483755 -4.143508 2.0467572 0.8062112
## IL-BH -2.0379024 -5.180813 1.1050080 0.3243938
## IH-BL 1.7671272 -1.328005 4.8622598 0.4370443
## IL-BL 0.7776002 -2.365310 3.9205106 0.9131739
## IL-IH -0.9895270 -4.029137 2.0500831 0.8240506
```





Summary

Condition	Difference	Measure	р	Test	n	Significance
BH	WB - RB	PP	0.0038869	t-test	15	**
BH	WB - RB	HR	0.0000470	t-test	14	***
BH	WB - RB	BR	0.0000993	t-test	14	***
BH	SC - RB	PP	0.0215038	t-test	15	*
BH	SC - RB	HR	0.0805282	t-test	14	
BH	SC - RB	BR	0.0026189	t-test	14	**
BH	SC - WB	PP	0.3011111	t-test	15	
BH	SC - WB	HR	0.5589881	t-test	14	
BH	SC - WB	BR	0.9929885	t-test	14	
BH	DT - RB	PP	0.0031738	t-test	15	**
BH	DT - RB	HR	0.2421935	t-test	14	
BH	DT - RB	BR	0.1450731	t-test	13	
BH	DT - WB	PP	0.3915045	t-test	15	
BH	DT - WB	HR	0.0017455	t-test	14	**
BH	DT - WB	BR	0.0000109	t-test	13	***
BH	DT - SC	PP	0.1264163	t-test	15	
BH	DT - SC	HR	0.1489480	t-test	14	
BH	DT - SC	BR	0.0095733	t-test	13	**
BH	P - RB	PP	0.0000019	t-test	15	***
BH	P - RB	HR	0.0051343	t-test	14	**
BH	P - WB	PP	0.0001211	t-test	15	***
BH	P - WB	HR	0.0500403	t-test	14	
BH	P - SC	PP	0.0001008	t-test	15	***
BH	P - SC	HR	0.0135531	t-test	14	*
BH	P - DT	PP	0.0000374	t-test	15	***
BH	P - DT	HR	0.0073807	t-test	14	**
BL	WB - RB	PP	0.0129487	t-test	14	*
BL	WB - RB	HR	0.7393780	t-test	13	
BL	WB - RB	BR	0.0050298	t-test	14	**
BL	SC - RB	PP	0.1390646	t-test	13	
BL	SC - RB	HR	0.0068419	t-test	13	**
BL	SC - RB	BR	0.7386400	t-test	14	
BL	SC - WB	PP	0.7092246	t-test	13	
BL	SC - WB	HR	0.0810305	t-test	13	
BL	SC - WB	BR	0.0012367	t-test	14	**
BL	DT - RB	PP	0.0010125	t-test	14	**
BL	DT - RB	HR	0.0028318	t-test	13	**
BL	DT - RB	BR	0.0372882	t-test	12	*
BL	DT - WB	PP	0.0063266	t-test	14	**
BL	DT - WB	HR	0.0103391	t-test	13	*
BL	DT - WB	BR	0.0368129	t-test	12	*
BL	DT - SC	PP	0.0465502	t-test	13	*
BL	DT - SC	HR	0.0577026	t-test	13	
BL	DT - SC	BR	0.0020040	t-test	12	**
BL	P - RB	PP	0.0000257	t-test	14	***

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Condition	Difference	Measure	p	Test	n	Significance
BL	P - RB	HR	0.1092566	t-test	11	
BL	P - WB	PP	0.0000187	t-test	14	***
BL	P - WB	HR	0.0833217	t-test	11	
BL	P - SC	PP	0.0008398	t-test	13	***
BL	P - SC	HR	0.0068502	t-test	11	**
BL	P - DT	PP	0.0002748	t-test	14	***
BL	P - DT	HR	0.0019303	t-test	11	**
IH	WB - RB	PP	0.0000999	t-test	17	***
IH	WB - RB	HR	0.1185091	Transformed t-test	12	
IH	WB - RB	BR	0.0086109	t-test	16	**
IH	SC - RB	PP	0.0145060	t-test	17	*
IH	SC - RB	HR	0.6094900	Transformed t-test	12	
IH	SC - RB	BR	0.0454605	t-test	16	*
IH	SC - WB	PP	0.2084476	t-test	17	
IH	SC - WB	HR	0.2597084	Transformed t-test	12	
IH	SC - WB	BR	0.0933387	t-test	16	
IH	DT - RB	PP	0.0016239	t-test	17	**
IH	DT - RB	HR	0.5734584	Transformed t-test	12	
IH	DT - RB	BR	0.2969312	t-test	16	
TH	DT - WB	PP	0.9946474	t-test	17	
IH	DT - WB	HR	0.0171595	Transformed t-test	12	*
TH	DT - WB	BR	0.0005234	t-test	16	***
IH	DT - SC	PP	0.3697148	t-test	17	
TH	DT - SC	HR	0.2853287	Transformed t-test	12	
IH	DT - SC	BR	0.3543299	t-test	16	
TH	P - RB	PP	0.0000079	t-test	17	***
IH	P - RB	HR	0.0079289	Transformed t-test	11	**
TH	P - WB	PP	0.0002411	t-test	17	***
IH	P - WB	HR	0.0152592	Transformed t-test	11	*
TH .	P - SC	PP	0.0000697	t-test	17	***
IH	P - SC	HR	0.0026035	Transformed t-test	11	**
TH .	P - DT	PP	0.0001591	t-test	17	***
IH	P - DT	HR	0.0000458	Transformed t-test	11	***
IL	WB - RB	PP	0.0011525	t-test	17	**
IL	WB - RB	HR	0.0688632	t-test	14	
IL	WB - RB	BR	0.0011096	t-test	15	**
IL	SC - RB	PP	0.0261497	t-test	17	*
IL	SC - RB	HR	0.1422368	t-test	13	
IL	SC - RB	BR	0.2825139	t-test	15	
IL	SC - WB	PP	0.0272285	t-test	17	*
IL	SC - WB	HR	0.0000090	t-test	13	***
IL	SC - WB	BR	0.0029752	t-test	15	**
IL	DT - RB	PP	0.0001960	t-test	17	***
IL	DT - RB	HR	0.7836686	t-test	14	
IL	DT - RB	BR	0.0103798	t-test	15	*
IL	DT - WB	PP	0.5609825	t-test	17	
IL	DT - WB	HR	0.0043171	t-test	14	**
1L	מאי- דע	1111	0.0049111	0-0000	14	

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Condition	Difference	Measure	р	Test	n	Significance
IL	DT - WB	BR	0.0371126	t-test	15	*
IL	DT - SC	PP	0.0053685	t-test	17	**
IL	DT - SC	HR	0.0676031	t-test	13	
IL	DT - SC	BR	0.0180613	t-test	15	*
IL	P - RB	PP	0.0000487	t-test	15	***
IL	P - RB	HR	0.0110591	t-test	12	*
IL	P - WB	PP	0.0012790	t-test	15	**
IL	P - WB	HR	0.0089131	t-test	12	**
IL	P - SC	PP	0.0000712	t-test	15	***
IL	P - SC	HR	0.0026560	t-test	11	**
IL	P - DT	PP	0.0002236	t-test	15	***
IL	P - DT	HR	0.0009767	t-test	12	***