Data Analyses for Virtual Reality and Computer Screen Experiments

Rasmus Ahmt & Marta Topor

2023-06-08

# Introduction

This document presents the output for data analyses used in a methodological article titled: “Developing Virtual Reality and Computer Screen Experiments One to One Using Selective Attention as a Case Study”.  
The following analysis steps are included:

* Data Quality Assessment
* The Calculation of Indices
* Descriptive Statistics
* The Assessment of Assumptions for Inferential Analyses
* Inferential Results and Plots

# Data Quality

Reaction time data is very sensitive to biases and extreme values. Therefore it is important to ensure consistency in the calculation of RT values between different conditions.  
First we ensure that all conditions do not have great differences in the number of available trials and that a reasonable minimum number of trials per trial type (congruency x multisensory modality) and per condition (VR and PC) are retained. This will help us to ensure that the differences we observe are not too affected by different trial numbers.

The ideal would be to keep 9 trials per trial type and condition because that would ensure at least 56% accuracy on each trial type but this is not going to leave us with too many participants. In fact, the numbers do not look great.

9 correct trials per type = 8 participants left  
8 trials = 8 participants  
7 trials = 13 participants  
6 trials = 17 participants  
5 trials = 22 participants

There were 73 participants at the start. With the remaining 22 participants, this means that 51 participants were removed because they did not reach the threshold of 5 trials per trial type.  
The number of children who did not reach this number per condition is displayed below together with a two-proportions z-test result:

## # A tibble: 2 x 2  
## condition num\_ID\_4\_or\_lower  
## <chr> <int>  
## 1 PC 32  
## 2 VR 42

##   
## 2-sample test for equality of proportions with continuity correction  
##   
## data: proportion$num\_ID\_4\_or\_lower out of c(length(unique(ATTENTION\_base$ID)), length(unique(ATTENTION\_base$ID)))  
## X-squared = 2.2196, df = 1, p-value = 0.1363  
## alternative hypothesis: two.sided  
## 95 percent confidence interval:  
## -0.3113482 0.0373756  
## sample estimates:  
## prop 1 prop 2   
## 0.4383562 0.5753425

The number of children who did not reach this number in both conditions:

## # A tibble: 1 x 1  
## num\_shared\_IDs  
## <int>  
## 1 23

Additionally, we have to remove all participants with overall accuracy below 55% - this means 3 additional participants and we are only left with 19 in the end.

# Indices - Calculation of variables

There are some variables that had to be calculated from the data. These include:

* **Attentional Cost** - reaction time median difference between the incongruent and neutral trials. This is calculated per person and per sensory modality as incongruent reaction time median - neutral reaction time median. This is supposed to produce a positive number reflecting the magnitude of attentional reaction time cost in seconds in incongruent trials compared to neutral trials.
* **Attentional Benefit** - reaction time median difference between the neutral and congruent trials. This is calculated per person and per sensory modality as neutral reaction time median - congruent reaction time median. This is supposed to produce a positive number reflecting the magnitude of attentional reaction time benefit in seconds in congruent trials compared to neutral trials.
* **The Response Time Coefficient of Variability (RTCV)** - a measure of the variability in response times for a given task or stimulus. It is calculated as the ratio of the standard deviation of response times to the mean response time. Here kept in proportion values. The formula for calculating RTCV is: RTCV = standard deviation of response times / mean response time. A higher RTCV indicates that response times are more variable or inconsistent, while a lower RTCV indicates more consistent or predictable response times. <https://doi.org/10.3389/fpsyg.2013.00573>
* **Accuracy** - the proportion of correct responses per condition and per sensory and congruency. The original variable is in correct response counts (out of 16) and needs to be changed to proportions for easier interpretation and comparison

NOTE: There is one duplicate value in the dataset - participant 30053 has the same RT median in VR incongruent audio and VR neutral audio which gives the attentional cost value as 0. This is quite unlikely but after checking the RT variables for these conditions for these conditions for this participants, it is clear that these variables have different data and give a different mean. Therefore, it seems like a genuine co-incidence.

# Descriptive Statistics

There are five main variables in this study: *Reaction Time Median, Reaction Time Coefficient of Variance, Accuarcy, Attentional Cost and Attentional Benefit*.

These variables will be analysed with the consideration of different factors. The descriptive statistics are therefore provided for the relevant factor levels.  
The factor levels selected in these analyses will help us to understand the quality of responses based on the delivery of stimuli in different sensory modalities.

* **Reaction Time Median** will be compared between VR and PC across the stimuli type levels - auditory, visual and audio.visual.
* **Reaction Time Coefficient of Variance** will be compared between VR and PC only
* **Accuracy** will be compared between VR and PC across the stimuli type levels - auditory, visual and audio.visual.
* **Attentional Cost** and **Attentional Benefit** will be compared between VR and PC and across the three multisensory levels - auditory, visual and audio-visual.

**REACTION TIME MEDIAN**  
Note: n=57 because for each of the 19 participants, there were 3 RT median values - one from the congruent, one from the incongrunt and one from the neutral condition.

## # A tibble: 6 x 6  
## stimuli\_type condition variable n mean sd  
## <chr> <chr> <fct> <dbl> <dbl> <dbl>  
## 1 audio PC RT\_md 57 1.56 0.298  
## 2 audio.visual PC RT\_md 57 1.68 0.398  
## 3 visual PC RT\_md 57 1.68 0.378  
## 4 audio VR RT\_md 57 1.77 0.315  
## 5 audio.visual VR RT\_md 57 1.84 0.379  
## 6 visual VR RT\_md 57 1.86 0.419

**REACTION TIME COEFFICIENT OF COVARIANCE**  
Note: n=171 because for each of the 19 participants, there were 9 RTCV values - from 3 sensory levels (audio, visual and audio-visual) x 3 congruency levels (incongruent, congruent and neutral).

## # A tibble: 2 x 5  
## condition variable n mean sd  
## <chr> <fct> <dbl> <dbl> <dbl>  
## 1 PC RTCV 171 0.323 0.107  
## 2 VR RTCV 171 0.317 0.112

**ACCURACY**  
Note: n=57 because for each of the 19 participants, there were 3 RT median values - one from the congruent, one from the incongrunt and one from the neutral condition.

## # A tibble: 6 x 6  
## stimuli\_type condition variable n mean sd  
## <chr> <chr> <fct> <dbl> <dbl> <dbl>  
## 1 audio PC accuracy 57 0.837 0.124  
## 2 audio.visual PC accuracy 57 0.75 0.194  
## 3 visual PC accuracy 57 0.758 0.193  
## 4 audio VR accuracy 57 0.804 0.124  
## 5 audio.visual VR accuracy 57 0.714 0.141  
## 6 visual VR accuracy 57 0.704 0.161

**ATTENTIONAL COST**  
Note: n=19 because for each of the 19 participants, there is only one attentional cost value calculated from RT medians in incongruent and neutral trials.

## # A tibble: 6 x 6  
## stimuli\_type condition variable n mean sd  
## <chr> <chr> <fct> <dbl> <dbl> <dbl>  
## 1 audio PC cost\_ben\_val 19 -0.002 0.241  
## 2 audio.visual PC cost\_ben\_val 19 -0.17 0.406  
## 3 visual PC cost\_ben\_val 19 -0.053 0.266  
## 4 audio VR cost\_ben\_val 19 0.05 0.294  
## 5 audio.visual VR cost\_ben\_val 19 -0.076 0.302  
## 6 visual VR cost\_ben\_val 19 -0.039 0.384

**ATTENTIONAL BENEFIT**  
Note: n=19 because for each of the 19 participants, there is only one attentional benefit value calculated from RT medians in incongruent and neutral trials.

## # A tibble: 6 x 6  
## stimuli\_type condition variable n mean sd  
## <chr> <chr> <fct> <dbl> <dbl> <dbl>  
## 1 audio PC cost\_ben\_val 19 0.062 0.222  
## 2 audio.visual PC cost\_ben\_val 19 0.223 0.335  
## 3 visual PC cost\_ben\_val 19 0.072 0.244  
## 4 audio VR cost\_ben\_val 19 -0.021 0.243  
## 5 audio.visual VR cost\_ben\_val 19 0.098 0.309  
## 6 visual VR cost\_ben\_val 19 0.224 0.399

# Assumption Checks

In order to detect statsitically significant effects, we want to run either ANOVA or linear model tests. Both have similar assumption of normal distribution, homogeneity of variance and spehricity (particularly important for ANOVAs). However, a linear mixed model might be more robust in the face of violation of these assumptions <https://doi.org/10.1111/2041-210X.13434>

The assumptions are checked for all variables included in the analyses of this project on the same levels as the descriptive results presented above.

* **Normal distribution** is assessed using skewness and kurtosis values. Values at z-score > 1.96 or < -1.96 are interpreted as indicative of violation of normality.
* **Homogeneity of variance** is assessed using the Levene’s test. Violation of the assumption is detected with p-value <0.05.
* **Sphericity** is assessed using the Mauchly’s test.Violation of the assumption is detected with p-value <0.05.

#### **NORMAL DISTRIBUTION ASSESSMENT**

The results show that there are violations of the normality assumption for all variables.

Skewness and kurtosis z-values for RT medians and accuracy variables

|  | skew\_z\_RT\_md | kurt\_z\_RT\_md | skew\_z\_accuracy | kurt\_z\_accuracy |
| --- | --- | --- | --- | --- |
| PCaudio | 1.0292768 | -0.1576544 | -3.3745122 | 2.1813196 |
| PCaudio.visual | 2.1634826 | 1.1708235 | -2.4383387 | -0.6662666 |
| PCvisual | 2.2540472 | 1.5052334 | -2.2591954 | -1.0829143 |
| VRaudio | 0.6403630 | 1.7283750 | -0.6790196 | -1.4506617 |
| VRaudio.visual | -0.5252165 | -0.8569691 | -0.1991694 | -1.2907897 |
| VRvisual | 2.1875543 | 0.2316513 | -0.1584062 | -0.9296693 |

Skewness and kurtosis values for RTCV

|  | skew\_z | kurt\_z |
| --- | --- | --- |
| PC | 2.772931 | 0.0778061 |
| VR | 2.964326 | -0.5192055 |

Skewness and kurtosis z-values for attentional cost and benefits

|  | skew\_z\_cost | kurt\_z\_cost | skew\_z\_ben | kurt\_z\_ben |
| --- | --- | --- | --- | --- |
| PCaudiocost | 0.0833669 | -0.0803936 | 1.6703825 | 1.7143832 |
| PCaudio.visualcost | -2.6722092 | 2.9963002 | 0.1639293 | -0.5169438 |
| PCvisualcost | 0.8417022 | -0.8011025 | -0.4837269 | -0.2102484 |
| VRaudiocost | 1.3649835 | 0.9145318 | -2.6057459 | 1.9160631 |
| VRaudio.visualcost | -2.2622939 | 1.2344869 | -0.2372972 | 0.1989849 |
| VRvisualcost | -1.2336257 | 0.6425692 | 0.4895142 | -0.3310494 |

#### **HOMOGENEITY OF VARIANCE ASSUMPTION**

Only the attentional benefit variable in audio condition does not meet the assumption of homogeneity of variance

**REACTION TIME MEDIANS**

## # A tibble: 3 x 5  
## stimuli\_type df1 df2 statistic p  
## <chr> <int> <int> <dbl> <dbl>  
## 1 audio 1 112 0.0176 0.895  
## 2 audio.visual 1 112 0.000146 0.990  
## 3 visual 1 112 0.187 0.667

**REACTION TIME COEFFICIENT OF VARIANCE**

## # A tibble: 1 x 4  
## df1 df2 statistic p  
## <int> <int> <dbl> <dbl>  
## 1 1 340 0.596 0.441

**ACCURACY**

## # A tibble: 3 x 5  
## stimuli\_type df1 df2 statistic p  
## <chr> <int> <int> <dbl> <dbl>  
## 1 audio 1 112 0.135 0.714   
## 2 audio.visual 1 112 3.32 0.0710  
## 3 visual 1 112 0.957 0.330

**ATTENTIONAL COST**

## # A tibble: 3 x 5  
## stimuli\_type df1 df2 statistic p  
## <chr> <int> <int> <dbl> <dbl>  
## 1 audio 1 36 0.432 0.515  
## 2 audio.visual 1 36 0.185 0.670  
## 3 visual 1 36 0.763 0.388

**ATTENTIONAL BENEFIT**

## # A tibble: 3 x 5  
## stimuli\_type df1 df2 statistic p  
## <chr> <int> <int> <dbl> <dbl>  
## 1 audio 1 36 0.0968 0.758   
## 2 audio.visual 1 36 0.221 0.641   
## 3 visual 1 36 4.15 0.0490

#### **SPHERICITY ASSUMPTION**

This does not need to be measured for RTCV because it only has two levels (VR and PC).  
Otherwise, none of the remaining variables violate the sphericity assumption.

**REACTION TIME MEDIAN**

## ANOVA Table (type III tests)  
##   
## $ANOVA  
## Effect DFn DFd F p p<.05 ges  
## 1 condition 1 18 10.993 0.004 \* 0.077  
## 2 stimuli\_type 2 36 6.992 0.003 \* 0.022  
## 3 condition:stimuli\_type 2 36 0.839 0.440 0.002  
##   
## $`Mauchly's Test for Sphericity`  
## Effect W p p<.05  
## 1 stimuli\_type 0.874 0.319   
## 2 condition:stimuli\_type 0.809 0.165   
##   
## $`Sphericity Corrections`  
## Effect GGe DF[GG] p[GG] p[GG]<.05 HFe DF[HF]  
## 1 stimuli\_type 0.888 1.78, 31.98 0.004 \* 0.979 1.96, 35.24  
## 2 condition:stimuli\_type 0.840 1.68, 30.23 0.424 0.916 1.83, 32.98  
## p[HF] p[HF]<.05  
## 1 0.003 \*  
## 2 0.432

**ACCURACY**

## ANOVA Table (type III tests)  
##   
## $ANOVA  
## Effect DFn DFd F p p<.05 ges  
## 1 condition 1 18 1.989 1.75e-01 0.031  
## 2 stimuli\_type 2 36 32.144 9.80e-09 \* 0.117  
## 3 condition:stimuli\_type 2 36 0.360 7.00e-01 0.002  
##   
## $`Mauchly's Test for Sphericity`  
## Effect W p p<.05  
## 1 stimuli\_type 0.934 0.561   
## 2 condition:stimuli\_type 0.979 0.838   
##   
## $`Sphericity Corrections`  
## Effect GGe DF[GG] p[GG] p[GG]<.05 HFe DF[HF]  
## 1 stimuli\_type 0.938 1.88, 33.78 2.53e-08 \* 1.044 2.09, 37.57  
## 2 condition:stimuli\_type 0.980 1.96, 35.27 6.96e-01 1.098 2.2, 39.54  
## p[HF] p[HF]<.05  
## 1 9.8e-09 \*  
## 2 7.0e-01

**ATTENTIONAL COST**

## ANOVA Table (type III tests)  
##   
## $ANOVA  
## Effect DFn DFd F p p<.05 ges  
## 1 condition 1 18 0.816 0.378 0.007  
## 2 stimuli\_type 2 36 1.869 0.169 0.036  
## 3 condition:stimuli\_type 2 36 0.139 0.871 0.003  
##   
## $`Mauchly's Test for Sphericity`  
## Effect W p p<.05  
## 1 stimuli\_type 0.988 0.903   
## 2 condition:stimuli\_type 0.964 0.734   
##   
## $`Sphericity Corrections`  
## Effect GGe DF[GG] p[GG] p[GG]<.05 HFe DF[HF]  
## 1 stimuli\_type 0.988 1.98, 35.58 0.170 1.109 2.22, 39.94  
## 2 condition:stimuli\_type 0.965 1.93, 34.76 0.864 1.079 2.16, 38.85  
## p[HF] p[HF]<.05  
## 1 0.169   
## 2 0.871

**ATTENTIONAL BENEFIT**

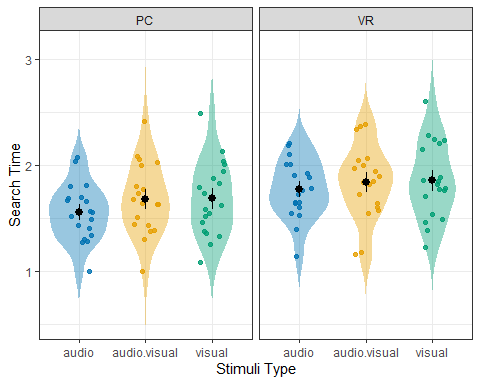
## ANOVA Table (type III tests)  
##   
## $ANOVA  
## Effect DFn DFd F p p<.05 ges  
## 1 condition 1 18 0.055 0.817 0.000996  
## 2 stimuli\_type 2 36 4.427 0.019 \* 0.045000  
## 3 condition:stimuli\_type 2 36 2.154 0.131 0.042000  
##   
## $`Mauchly's Test for Sphericity`  
## Effect W p p<.05  
## 1 stimuli\_type 1.000 1.000   
## 2 condition:stimuli\_type 0.899 0.403   
##   
## $`Sphericity Corrections`  
## Effect GGe DF[GG] p[GG] p[GG]<.05 HFe DF[HF]  
## 1 stimuli\_type 1.000 2, 36 0.019 \* 1.125 2.25, 40.5  
## 2 condition:stimuli\_type 0.908 1.82, 32.69 0.136 1.004 2.01, 36.15  
## p[HF] p[HF]<.05  
## 1 0.019 \*  
## 2 0.131

# **INFERENTIAL STATISTICS & PLOTS**

The plots are violin plots with jittered individual data points. The mean is marked with the black dot and confidence intervals of the mean are marked with uppoer and lower range lines. The only difference is the plotting of the attentional cost and benefit values which use bar plots for direct comparison with the previous results on a similar paradigm: <https://doi.org/10.1016/j.cognition.2019.01.013>

Linear Mixed Effects Models are used to test the effects of condition (VR and PC) and stimuli type (auditory, audio.visual and visual) on the outcome variables. ANOVAs were not suitable because of the violation of normal distribution of the data. LMs are more robust in the case of violation of this assumption. They rely on regression statistics rather than condition means.  
Because of the small sample size which could undermine the results of a linear model, I also tried to run a Bayesian Mixed model using the package Bayes Factor. There seems to be a bug in the package as it did not work. The error was related to a broken loop within the package’s calculation. The same package is implemented in the GUI statistics program JASP. I imported the data into that program to double check the functionality of the package for the current set up. The program ran a linear mixed model just fine but it also gave errors when trying to compute the Bayesian alternative.

**REACTION TIME MEDIAN**  
Here there is a significant effect of condition on RT median with p<.0001.



## Type III Analysis of Variance Table with Satterthwaite's method  
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)   
## condition 0.94314 0.94314 1 90 33.1102 1.187e-07 \*\*\*  
## stimuli\_type 0.25329 0.12664 2 90 4.4460 0.01441 \*   
## condition:stimuli\_type 0.01712 0.00856 2 90 0.3004 0.74123   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

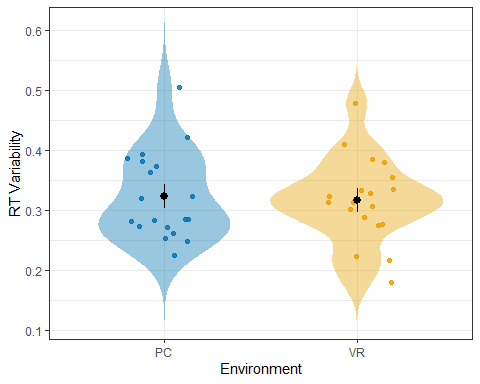
## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Eta2 (partial) | 95% CI  
## ------------------------------------------------------  
## condition | 0.27 | [0.15, 1.00]  
## stimuli\_type | 0.09 | [0.01, 1.00]  
## condition:stimuli\_type | 6.63e-03 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Omega2 (partial) | 95% CI  
## --------------------------------------------------------  
## condition | 0.26 | [0.14, 1.00]  
## stimuli\_type | 0.07 | [0.00, 1.00]  
## condition:stimuli\_type | 0.00 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

Bonfferroni corrected p-values:

* Condition Effect: 0.0000005934985 **(significant)**
* Sensory Distractor Effect: 0.0720469
* Interaction Effect: 3.7061733

**REACTION TIME COEFFICIENT OF VARIANCE**  
Here the effect of condition is non-significant.



## Type III Analysis of Variance Table with Satterthwaite's method  
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)  
## condition 0.00034127 0.00034127 1 18 0.0763 0.7855

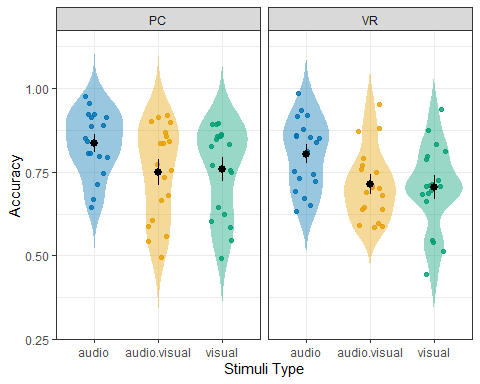
## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Eta2 (partial) | 95% CI  
## -----------------------------------------  
## condition | 4.22e-03 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Omega2 (partial) | 95% CI  
## -------------------------------------------  
## condition | 0.00 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

Bonfferroni corrected p-values:

* Condition Effect: 3.9275135

**ACCURACY**  
Here there is a significant effect of condition.  
The follow-up post-hoc test using the Tukey method shows a significant difference between audio & audio.visual conditions and audio & visual conditions but not between visual and audio.visual. This is irrespective of condition (VR vs PC).



## Type III Analysis of Variance Table with Satterthwaite's method  
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)   
## condition 0.047758 0.047758 1 90 6.4797 0.01261 \*   
## stimuli\_type 0.199858 0.099929 2 90 13.5581 7.131e-06 \*\*\*  
## condition:stimuli\_type 0.002383 0.001192 2 90 0.1617 0.85096   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Eta2 (partial) | 95% CI  
## ------------------------------------------------------  
## condition | 0.07 | [0.01, 1.00]  
## stimuli\_type | 0.23 | [0.11, 1.00]  
## condition:stimuli\_type | 3.58e-03 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Omega2 (partial) | 95% CI  
## --------------------------------------------------------  
## condition | 0.06 | [0.00, 1.00]  
## stimuli\_type | 0.21 | [0.09, 1.00]  
## condition:stimuli\_type | 0.00 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

## $emmeans  
## stimuli\_type emmean SE df lower.CL upper.CL  
## audio 0.820 0.0233 30.5 0.773 0.868  
## audio.visual 0.732 0.0233 30.5 0.684 0.779  
## visual 0.731 0.0233 30.5 0.683 0.778  
##   
## Results are averaged over the levels of: condition   
## Degrees-of-freedom method: kenward-roger   
## Confidence level used: 0.95   
##   
## $contrasts  
## contrast estimate SE df t.ratio p.value  
## audio - audio.visual 0.0883 0.0197 90 4.482 0.0001  
## audio - visual 0.0894 0.0197 90 4.537 0.0001  
## audio.visual - visual 0.0011 0.0197 90 0.056 0.9983  
##   
## Results are averaged over the levels of: condition   
## Degrees-of-freedom method: kenward-roger   
## P value adjustment: tukey method for comparing a family of 3 estimates

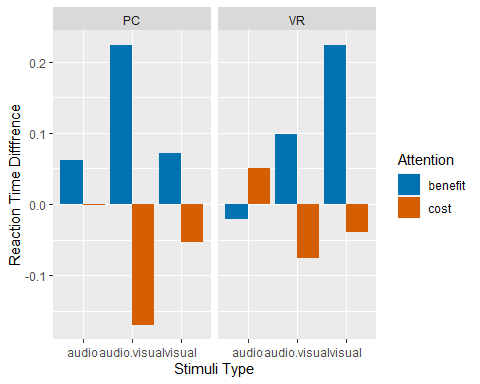
## contrast effect.size SE df lower.CL upper.CL  
## (audio - audio.visual) 1.0281 0.242 90 0.548 1.509  
## (audio - visual) 1.0409 0.242 90 0.560 1.522  
## (audio.visual - visual) 0.0128 0.229 90 -0.443 0.469  
##   
## Results are averaged over the levels of: condition   
## sigma used for effect sizes: 0.08585   
## Degrees-of-freedom method: inherited from kenward-roger when re-gridding   
## Confidence level used: 0.95

Bonfferroni corrected p-values:

* Condition Effect: 0.0630644
* Sensory Distractor Effect: 0.00003565454 **(significant)**
* Interaction Effect: 4.2547876

For the post-hoc analysis, the p-values are already adjusted.

**ATTENTIONAL COST AND BENEFIT**  
None of the effects are significant here.



## Type III Analysis of Variance Table with Satterthwaite's method  
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)  
## condition 0.08128 0.081275 1 108 0.7873 0.3769  
## stimuli\_type 0.41411 0.207055 2 108 2.0058 0.1395  
## condition:stimuli\_type 0.03083 0.015415 2 108 0.1493 0.8615

## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Eta2 (partial) | 95% CI  
## ------------------------------------------------------  
## condition | 7.24e-03 | [0.00, 1.00]  
## stimuli\_type | 0.04 | [0.00, 1.00]  
## condition:stimuli\_type | 2.76e-03 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Omega2 (partial) | 95% CI  
## --------------------------------------------------------  
## condition | 0.00 | [0.00, 1.00]  
## stimuli\_type | 0.02 | [0.00, 1.00]  
## condition:stimuli\_type | 0.00 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

## Type III Analysis of Variance Table with Satterthwaite's method  
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)   
## condition 0.00959 0.009589 1 108 0.1077 0.74344   
## stimuli\_type 0.45784 0.228921 2 108 2.5706 0.08116 .  
## condition:stimuli\_type 0.42524 0.212622 2 108 2.3876 0.09668 .  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Eta2 (partial) | 95% CI  
## ------------------------------------------------------  
## condition | 9.96e-04 | [0.00, 1.00]  
## stimuli\_type | 0.05 | [0.00, 1.00]  
## condition:stimuli\_type | 0.04 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

## # Effect Size for ANOVA (Type III)  
##   
## Parameter | Omega2 (partial) | 95% CI  
## --------------------------------------------------------  
## condition | 0.00 | [0.00, 1.00]  
## stimuli\_type | 0.03 | [0.00, 1.00]  
## condition:stimuli\_type | 0.02 | [0.00, 1.00]  
##   
## - One-sided CIs: upper bound fixed at [1.00].

Bonfferroni corrected p-values for COST:

* Condition Effect: 1.8843805
* Sensory Distractor Effect: 0.697657
* Interaction Effect: 4.3073115

Bonfferroni corrected p-values for BENEFIT:

* Condition Effect: 3.7172174
* Sensory Distractor Effect: 0.4058179
* Interaction Effect: 0.483424