Picture Naming Analysis

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1 Reading the Data File

2 Reading File

```
> pic = read.csv("CompiledPictureNaming_Degraded.csv", header = TRUE, sep = ",")
> pic_mainvariables = pic[, c(2,3,22,26,28,31,33,36,37,38)]
> colnames(pic_mainvariables) = c("Subject", "Session", "Trial", "Object",
+                    "PictureType", "RT", "ObjectNo",  "Accuracy",
+                    "InvalidTrial", "ItemCount")
>
```

3 Excluding Subjects

```
> ## we exclude some subjects from all further RT analyses here
> library(dplyr)
> numitems = group_by(pic_mainvariables, Subject, ItemCount)%>%
+     summarise(count = n())
> ## each subject has 201 items: see how many in each condition
>
> numitems_sub_type = group_by(pic_mainvariables, Subject, PictureType, ItemCount)%>%
+     summarise(count = n())
> agg_sub = group_by(pic_mainvariables, Subject)%>%
+     summarise_at(vars(Accuracy), mean)
> #which(agg_sub$Accuracy < 0.51) -- no subject scored less than 50%
```

4 Separating Intact and Degaraded

```
> #separating out full and degraded trials
>
> pic_intact_orig = pic_mainvariables %>% filter(PictureType == "FullPicture")
> pic_degraded_orig = pic_mainvariables %>% filter(PictureType == "DegradedPicture")
> ## removing error trials separately for intact and degraded
> pic_intact = pic_intact_orig %>% filter(InvalidTrial == "0" &
```

```
+                                          Accuracy == "1")
> ## removes 14.6% trials
> pic_degraded = pic_degraded_orig %>% filter(InvalidTrial == "0" &
+                                          Accuracy == "1")
> ## removes 16.07% trials
```

5 Making the z-scores

```
> library(dplyr)
> pic_firsttrim_intact = pic_intact %>% filter( RT > 250 & RT < 5000)
> # removes 0.24% trials
> pic_firsttrim_degraded = pic_degraded %>% filter( RT > 250 & RT < 5000)
> # removes 0.49% trials
```

For Intact

```
> ### FOR INTACT PICTURES
> ## aggregate per subject all IVs and DVs
> meanRT_intact = group_by(pic_firsttrim_intact, Subject) %>%
+   summarise_at(vars(RT), mean)
> colnames(meanRT_intact) = c("Subject", "MeanRT")
> sdRT_intact = group_by(pic_firsttrim_intact, Subject) %>%
+   summarise_at(vars(RT), sd)
> colnames(sdRT_intact) = c("Subject", "sdRT")
> RT_agg = merge(meanRT_intact, sdRT_intact, by = "Subject")
> ## merge aggregate info with long data
> pic_z_intact = merge(pic_firsttrim_intact, RT_agg, by = "Subject", all.x = T)
> ## person and grand-mean centered scores using original and aggregate
> library(dplyr)
> pic_z_intact = pic_z_intact %>% mutate(zRT = (RT - MeanRT)/sdRT)
> ## checking: subject level means should be zero
>
> sub_pic = group_by(pic_z_intact, Subject) %>%
+   summarise_at(vars(zRT), mean)
>
> #write.csv(pic_z, file="pic_z.csv")
```

For Degraded

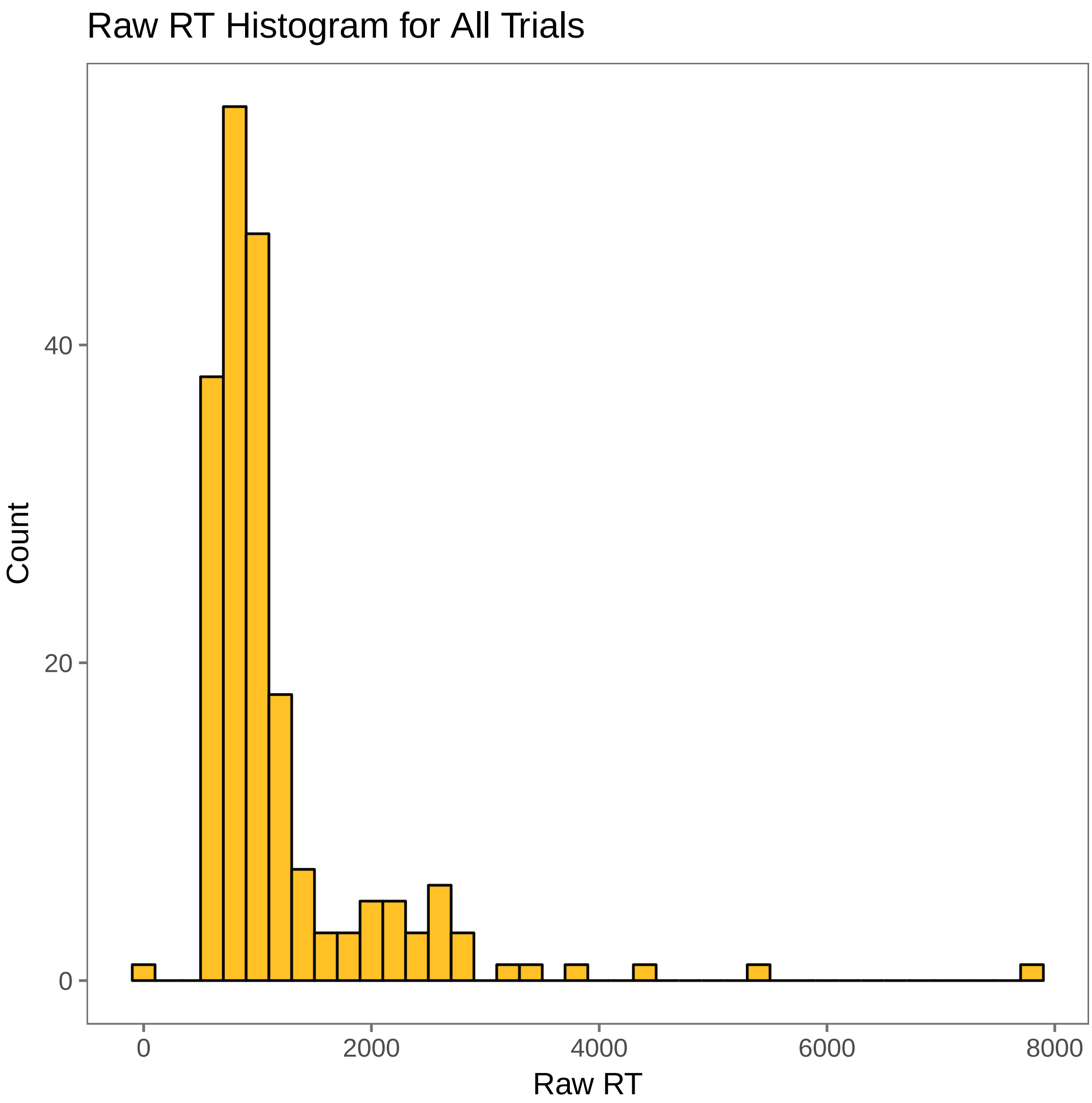
```
> ### FOR DEGRADED PICTURES
> ## aggregate per subject all IVs and DVs
> meanRT_degraded = group_by(pic_firsttrim_degraded, Subject) %>%
+   summarise_at(vars(RT), mean)
> colnames(meanRT_degraded) = c("Subject", "MeanRT")
```

```
> sdRT_degraded = group_by(pic_firsttrim_degraded, Subject) %>%
+   summarise_at(vars(RT), sd)
> colnames(sdRT_degraded) = c("Subject", "sdRT")
> RT_agg = merge(meanRT_degraded, sdRT_degraded, by = "Subject")
> ## merge aggregate info with long data
> pic_z_degraded = merge(pic_firsttrim_degraded, RT_agg, by = "Subject", all.x = T)
> ## person and grand-mean centered scores using original and aggregate
> library(dplyr)
> pic_z_degraded = pic_z_degraded %>% mutate(zRT = (RT - MeanRT)/sdRT)
> ## checking: subject level means should be zero
>
> sub_pic = group_by(pic_z_degraded, Subject) %>%
+   summarise_at(vars(zRT), mean)
>
> #write.csv(pic_z, file="pic_z.csv")
```

6 Histograms for raw and z-RT

Raw RT

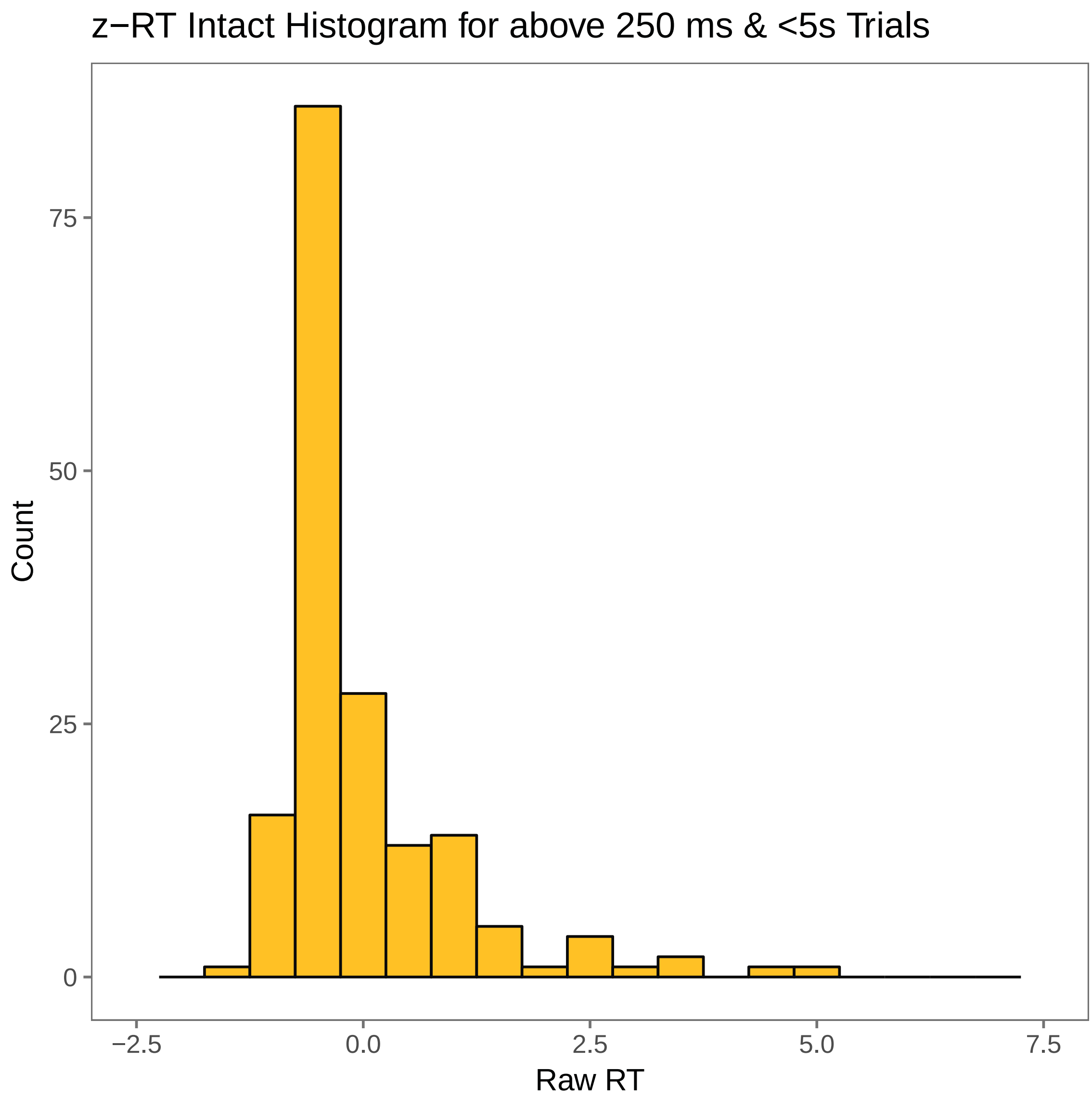
```
> library(ggplot2)
> library(ggthemes)
> ggplot(pic_degraded_orig, aes(x = RT))+
+ geom_histogram(binwidth = 200, color = "gray4", fill = "goldenrod1")+
+     theme_few()+
+   xlab("Raw RT") + ylab("Count") +
+   ggtitle("Raw RT Histogram for All Trials")
```



z RT

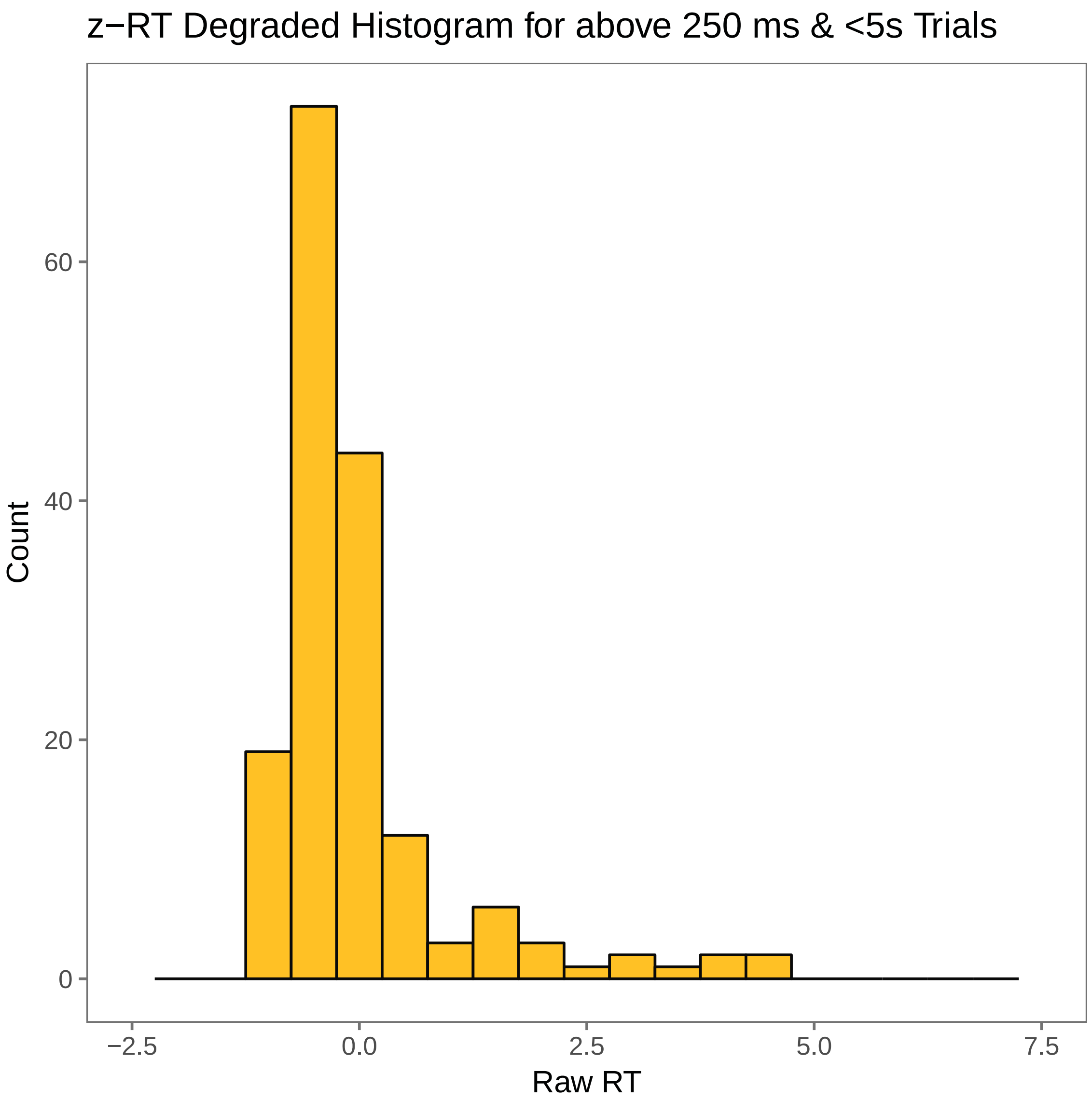
Intact

```
> ggplot(pic_z_intact, aes(x = zRT))+
+ geom_histogram(binwidth = 0.5, color = "gray4", fill = "goldenrod1")+
+     theme_few()+
+   xlim(-2.5,7.5)+
+   xlab("Raw RT") + ylab("Count") +
+   ggtitle("z-RT Intact Histogram for above 250 ms & <5s Trials")
```



Degraded

```
> ggplot(pic_z_degraded, aes(x = zRT))+
+ geom_histogram(binwidth = 0.5, color = "gray4", fill = "goldenrod1")+
+     theme_few()+
+   xlim(-2.5,7.5)+
+   xlab("Raw RT") + ylab("Count") +
+   ggtitle("z-RT Degraded Histogram for above 250 ms & <5s Trials")
```



Trimming zRT

```
> ## trimming above and below 3 s.d.
> pic_intact_trimmed = pic_z_intact %>% filter(zRT < 3 & zRT > -3)
> pic_degraded_trimmed = pic_z_degraded %>% filter(zRT < 3 & zRT > -3)
```

7 Repeat z-scoring after trimming

7.1 For Intact

```
> library(dplyr)
> ## aggregate per subject all IVs and DVs
> meanRT_trim_intact = group_by(pic_intact_trimmed, Subject) %>%
+   summarise_at(vars(RT), mean)
> colnames(meanRT_trim_intact) = c("Subject", "MeanRT_trim")
> sdRT_trim_intact = group_by(pic_intact_trimmed, Subject) %>%
+   summarise_at(vars(RT), sd)
> colnames(sdRT_trim_intact) = c("Subject", "sdRT_trim")
> RT_agg_trim = merge(meanRT_trim_intact, sdRT_trim_intact, by = "Subject")
> ## merge aggregate info with long data
> new_intact_z = merge(pic_intact_trimmed, RT_agg_trim, by = "Subject", all.x = T)
> ## person and grand-mean centered scores using original and aggregate
> library(dplyr)
> new_intact_z = new_intact_z %>% mutate(zRT_trim = (RT - MeanRT_trim)/sdRT_trim)
> ## checking: subject level means should be zero
>
> sub_pic = group_by(new_intact_z, Subject) %>%
+   summarise_at(vars(zRT_trim), mean)
>
> #write.csv(new_intact_z, file="final_pic_z.csv")
```

7.2 For Degraded

```
> library(dplyr)
> ## aggregate per subject all IVs and DVs
> meanRT_trim_degraded = group_by(pic_degraded_trimmed, Subject) %>%
+   summarise_at(vars(RT), mean)
> colnames(meanRT_trim_degraded) = c("Subject", "MeanRT_trim")
> sdRT_trim_degraded = group_by(pic_degraded_trimmed, Subject) %>%
+   summarise_at(vars(RT), sd)
> colnames(sdRT_trim_degraded) = c("Subject", "sdRT_trim")
> RT_agg_trim = merge(meanRT_trim_degraded, sdRT_trim_degraded, by = "Subject")
> ## merge aggregate info with long data
> new_degraded_z = merge(pic_degraded_trimmed, RT_agg_trim, by = "Subject", all.x = T)
> ## person and grand-mean centered scores using original and aggregate
> library(dplyr)
> new_degraded_z = new_degraded_z %>%
+     mutate(zRT_trim = (RT - MeanRT_trim)/sdRT_trim)
> ## checking: subject level means should be zero
>
> sub_pic = group_by(new_degraded_z, Subject) %>%
+   summarise_at(vars(zRT_trim), mean)
>
> #write.csv(new_intact_z, file="final_pic_z.csv")
```

8 Combining Separate z

```
> main_intact = new_intact_z[,c(1,3,4,5,6,7,8,16)]
> main_degraded = new_degraded_z[,c(1,3, 4,5, 6,7,8,16)]
>   final_pic_z = rbind(main_intact, main_degraded)
> final_pic_z = final_pic_z[order(final_pic_z$Subject),]
```

9 z-Scoring a different way

```
> pic_valid = pic_mainvariables %>% filter(InvalidTrial == "0" &
+                                  Accuracy == "1")
> pic_firsttrim = pic_valid %>% filter( RT > 250 & RT < 5000)
> meanRT = group_by(pic_firsttrim, Subject) %>%
+   summarise_at(vars(RT), mean)
> colnames(meanRT) = c("Subject", "MeanRT")
> sdRT = group_by(pic_firsttrim, Subject) %>%
+   summarise_at(vars(RT), sd)
> colnames(sdRT) = c("Subject", "sdRT")
> RT_agg = merge(meanRT, sdRT, by = "Subject")
> ## merge aggregate info with long data
> pic_z = merge(pic_firsttrim, RT_agg, by = "Subject", all.x = T)
> ## person and grand-mean centered scores using original and aggregate
> library(dplyr)
> pic_z = pic_z %>% mutate(zRT = (RT - MeanRT)/sdRT)
> ## checking: subject level means should be zero
>
> sub_pic = group_by(pic_z, Subject) %>%
+   summarise_at(vars(zRT), mean)
> pic_trimmed = pic_z %>% filter(zRT < 3 & zRT > -3)
> #### REPEATING Z SCORING ########
>
> ## aggregate per subject all IVs and DVs
> meanRT_trim = group_by(pic_trimmed, Subject) %>%
+   summarise_at(vars(RT), mean)
> colnames(meanRT_trim) = c("Subject", "MeanRT_trim")
> sdRT_trim = group_by(pic_trimmed, Subject) %>%
+   summarise_at(vars(RT), sd)
> colnames(sdRT_trim) = c("Subject", "sdRT_trim")
> RT_agg_trim = merge(meanRT_trim, sdRT_trim, by = "Subject")
> ## merge aggregate info with long data
> new_z = merge(pic_trimmed, RT_agg_trim, by = "Subject", all.x = T)
> ## person and grand-mean centered scores using original and aggregate
> library(dplyr)
> new_z = new_z %>% mutate(zRT_trim = (RT - MeanRT_trim)/sdRT_trim)
> ## checking: subject level means should be zero
>
```

```
> sub_pic = group_by(new_z, Subject) %>%
+   summarise_at(vars(zRT_trim), mean)
```

10 Aggregating RTs and Accuracy

```
> library(dplyr)
> agg_pic_validRT = group_by(new_z, Subject, PictureType)%>%
+     summarise_at(vars(Accuracy, zRT), mean)
> agg_pic_validRT$Subject <- as.factor(agg_pic_validRT$Subject)
> agg_pic_validRT$PictureType <- as.factor(agg_pic_validRT$PictureType)
> pic_RT_aov <- aov(zRT ~ PictureType + Error(Subject/PictureType),
+                   data = agg_pic_validRT )
> summary(pic_RT_aov)
```

```
Error: Subject
          Df   Sum Sq  Mean Sq F value Pr(>F)
Residuals  1 0.009747 0.009747

Error: Subject:PictureType
            Df  Sum Sq Mean Sq F value Pr(>F)
PictureType  1 0.01703 0.01703    0.16  0.757
Residuals    1 0.10618 0.10618
```

```
> pic_acc_aov <- aov(Accuracy ~ PictureType + Error(Subject/PictureType),
+                    data = agg_pic_validRT)
> summary(pic_acc_aov)
```

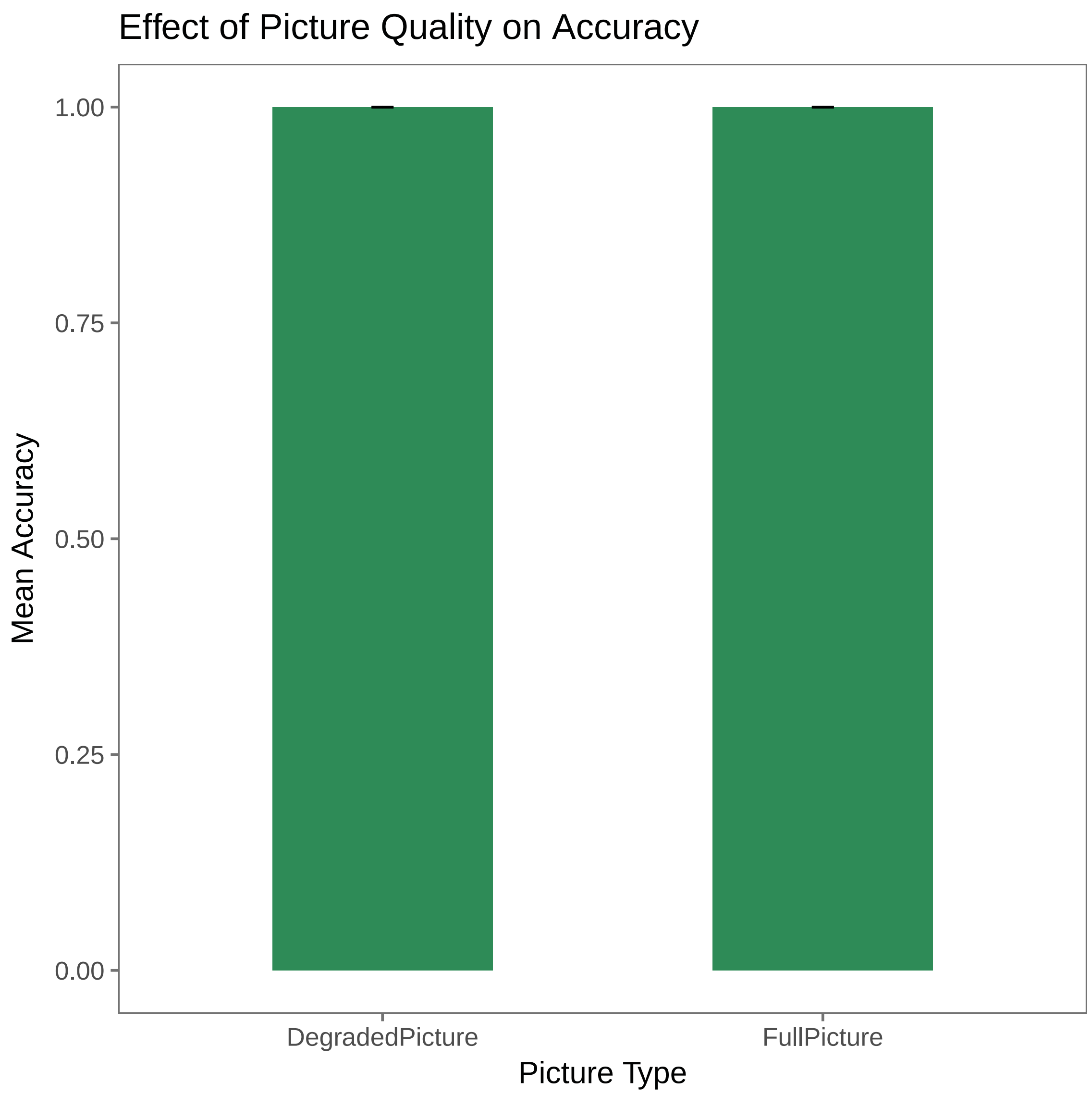
```
Error: Subject
          Df Sum Sq Mean Sq F value Pr(>F)
Residuals  1      0       0

Error: Subject:PictureType
            Df Sum Sq Mean Sq F value Pr(>F)
PictureType  1      0       0
Residuals    1      0       0
```

11 Plotting Accuracy and RT

Plotting Accuracy

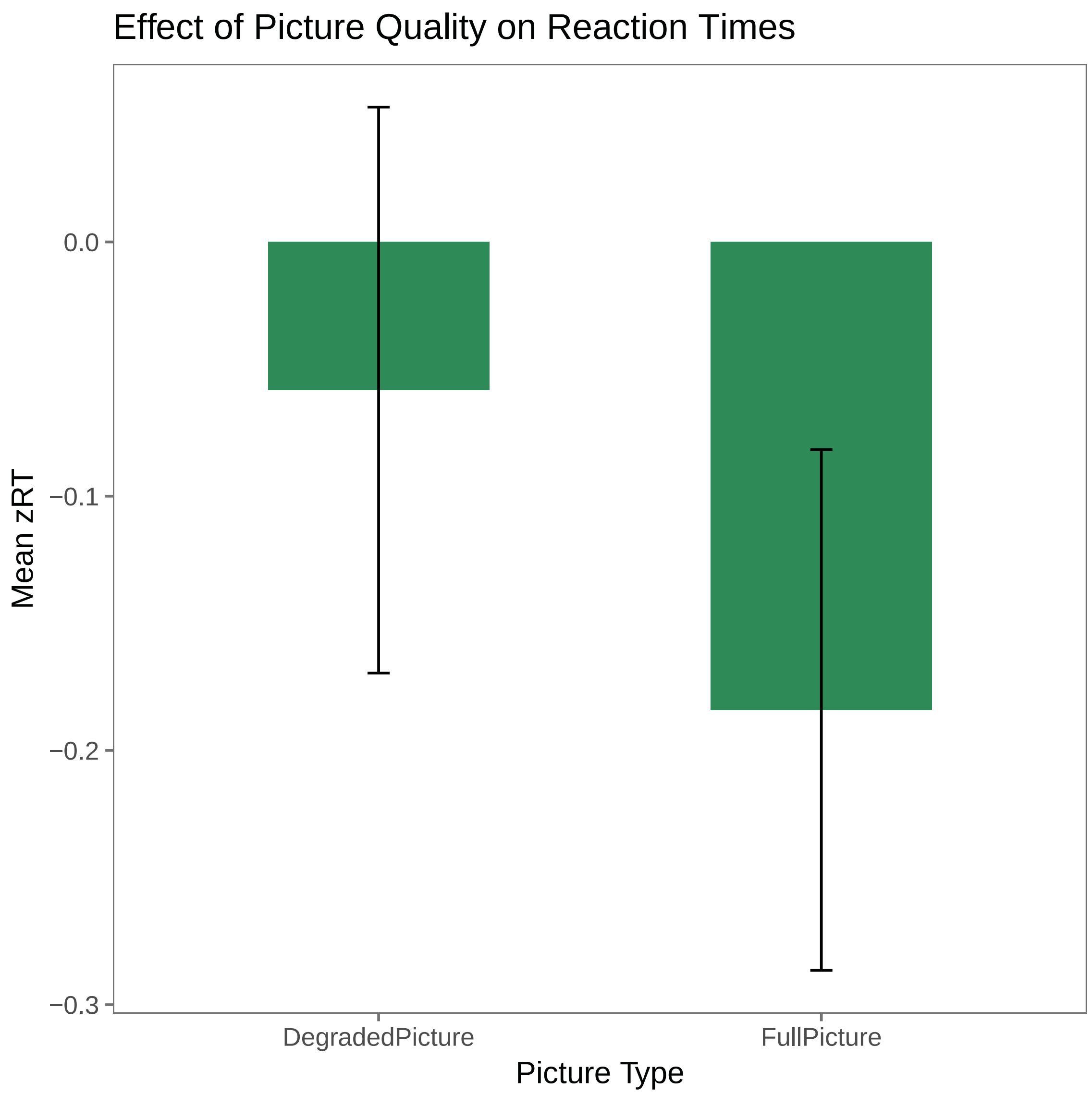
```
> library(Rmisc)
> agg_pic_plot_rmisc = summarySE(new_z,
+                        measurevar = "Accuracy",
+                        groupvars = c("PictureType"))
```

```
> ggplot(agg_pic_plot_rmisc, aes(x = PictureType, y = Accuracy))+
+  geom_bar(stat = "identity", position = "dodge", width = 0.5, fill = "seagreen")+
+   geom_errorbar(aes(ymin = Accuracy - ci, ymax = Accuracy + ci),
+                 width=.05, position=position_dodge(.5)) +
+   theme_few()+
+   xlab("Picture Type") + ylab("Mean Accuracy") +
+   ggtitle("Effect of Picture Quality on Accuracy")
```




```
> agg_pic_validRT_plot_rmisc = summarySE(new_z,
+                         measurevar = "zRT",
+                         groupvars = c("PictureType"))
```

```
> ggplot(agg_pic_validRT_plot_rmisc, aes(x = PictureType, y = zRT))+
+  geom_bar(stat = "identity", position = "dodge", width = 0.5, fill = "seagreen")+
+   geom_errorbar(aes(ymin = zRT - ci, ymax = zRT + ci),
+                 width=.05, position=position_dodge(.5)) +
+   theme_few()+
+   xlab("Picture Type") + ylab("Mean zRT") +
+   ggtitle("Effect of Picture Quality on Reaction Times")
```



12 Fetching AoA data and Merging

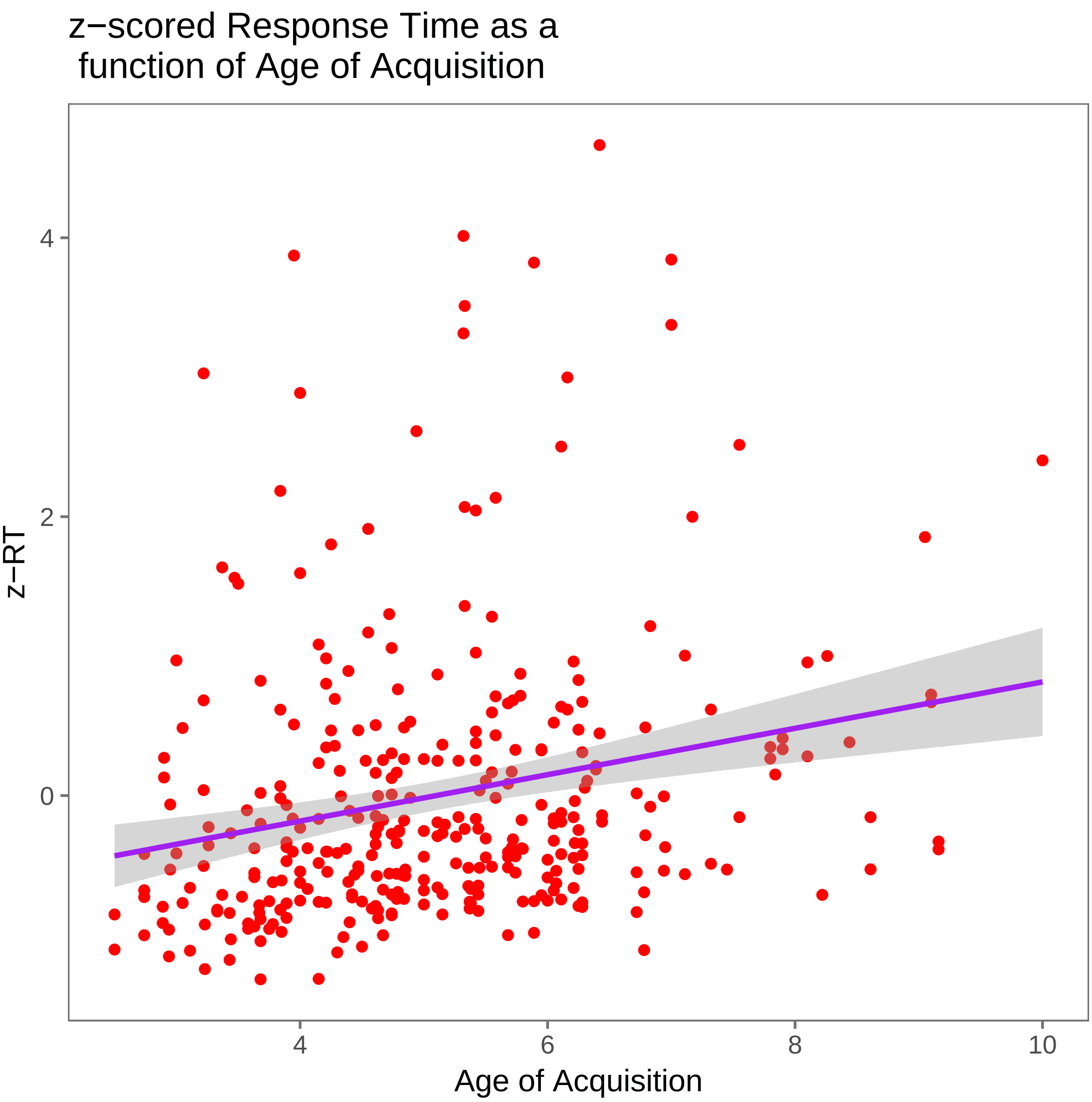
```
> AoA <- read.csv("AoA_51715_words.csv", header = TRUE, sep = ",")
```

```
> ### final_pic_z combines z-scores from separately z-scored intact and degraded
> pic_withAoA_z = merge(final_pic_z, AoA, by = "Object")
> pic_withAoA_z = pic_withAoA_z[, c(1:8, 18)]
> pic_withAoA_z = pic_withAoA_z[order(pic_withAoA_z$Subject),]
> ### ALSO MERGING WITH THE COMBINED Z SCORING DATA SET : new_z
>
> new_z_AoA = merge(new_z, AoA, by = "Object")
> new_z_AoA = new_z_AoA[, c(1:17, 26)]
> new_z_AoA = new_z_AoA[order(new_z_AoA$Subject),]
```

13 Actual Plots

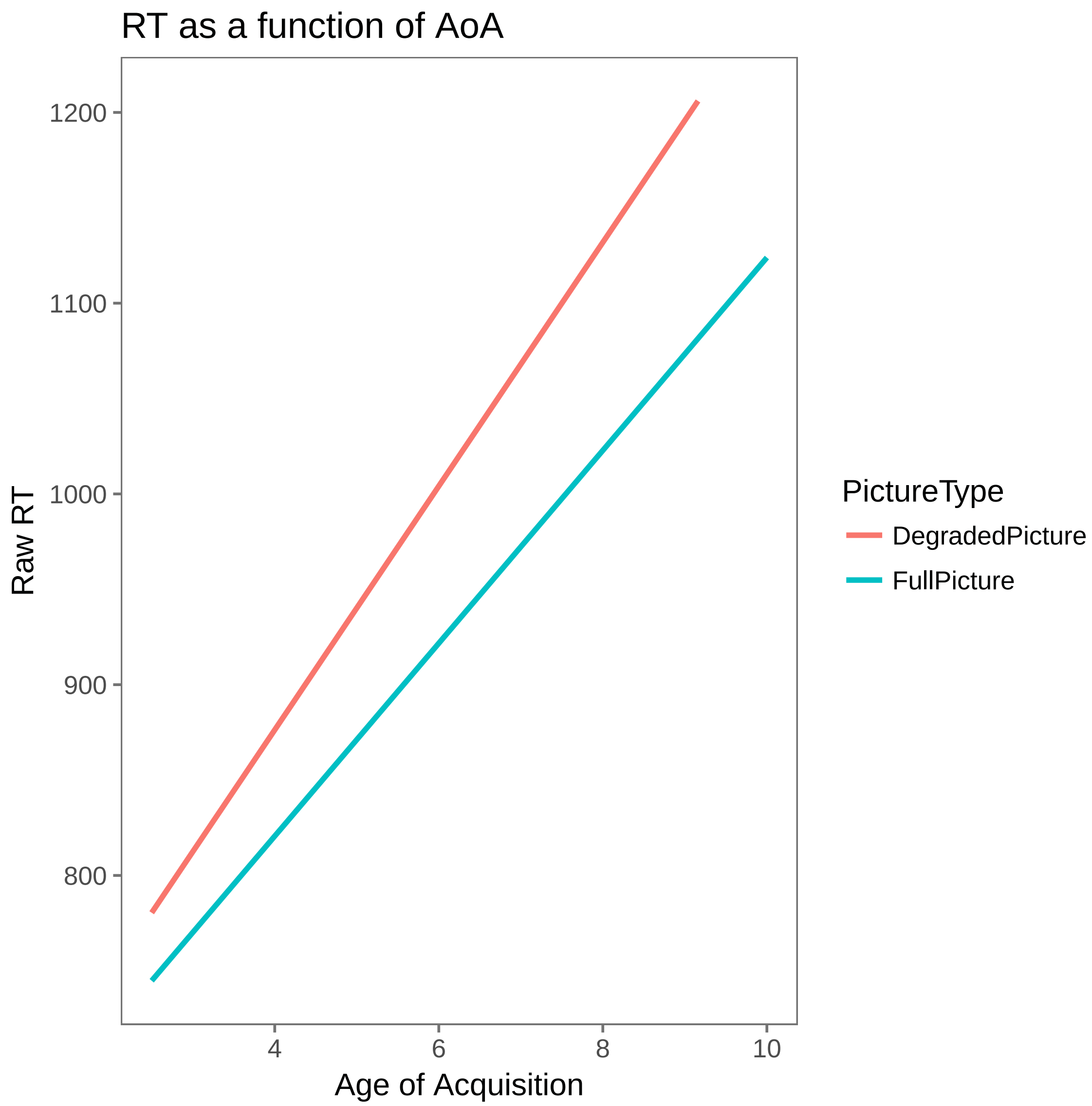
zRT and AoA

```
> ggplot(new_z_AoA, aes(x = AoA_Kup_lem, y = zRT_trim))+
+  geom_point(color = "red")+
+   geom_smooth(method = "lm", color = "purple")+
+  theme_few()+
+   xlab("Age of Acquisition") + ylab("z-RT") +
+   ggtitle("z-scored Response Time as a\n function of Age of Acquisition")
```



Raw Plot by Picture Type

```
> ggplot(new_z_AoA, aes(x = AoA_Kup_lem, y = RT,
+                          group = PictureType, color = PictureType))+
+   #geom_point(aes(color = PictureType))+
+    geom_smooth(method = "lm", se = FALSE)+
+   theme_few()+
+    xlab("Age of Acquisition") + ylab("Raw RT") +
+    ggtitle("RT as a function of AoA")
```



14 Regressions

```
> library(lme4)
> m0 = lmer (data = new_z_AoA, zRT_trim ~ AoA_Kup_lem +
+               (1|Subject) + (1|Trial) + (1|ObjectNo))
> summary(m0)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ AoA_Kup_lem + (1 | Subject) + (1 | Trial) + (1 | ObjectNo)
   Data: new_z_AoA
```

```
REML criterion at convergence: 902.2

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.6243 -0.4958 -0.2064  0.2625  4.1129

Random effects:
 Groups   Name        Variance  Std.Dev.
 Trial    (Intercept) 2.321e-15 4.818e-08
 ObjectNo (Intercept) 3.933e-01 6.272e-01
 Subject  (Intercept) 0.000e+00 0.000e+00
 Residual             5.581e-01 7.470e-01
Number of obs: 331, groups:  Trial, 194; ObjectNo, 188; Subject, 2

Fixed effects:
            Estimate Std. Error t value
(Intercept) -0.85831    0.23537  -3.647
AoA_Kup_lem  0.17028    0.04436   3.839

Correlation of Fixed Effects:
            (Intr)
AoA_Kup_lem -0.965
```

```
> m1 = lmer (data = new_z_AoA, RT ~ AoA_Kup_lem*PictureType +
+              (1|Subject)+ (1|Trial) + (1|ObjectNo))
> summary(m1)
```

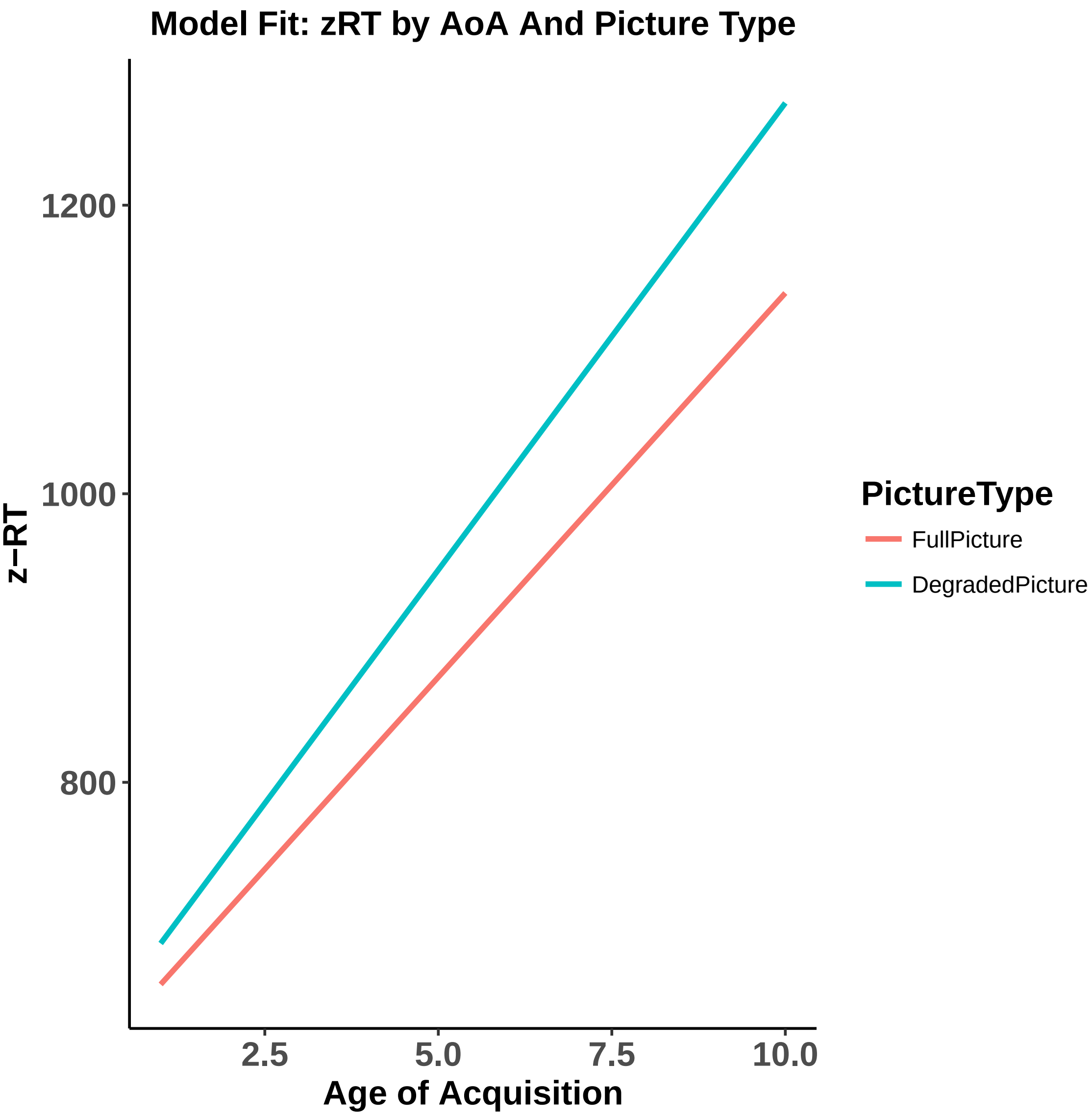
```
Linear mixed model fit by REML ['lmerMod']
Formula: RT ~ AoA_Kup_lem * PictureType + (1 | Subject) + (1 | Trial) +
    (1 | ObjectNo)
   Data: new_z_AoA

REML criterion at convergence: 4671

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.6446 -0.5015 -0.1844  0.2408  3.7344

Random effects:
 Groups   Name        Variance  Std.Dev.
 Trial    (Intercept) 3.150e-09 5.613e-05
 ObjectNo (Intercept) 3.998e+04 1.999e+02
 Subject  (Intercept) 2.151e+03 4.637e+01
 Residual             5.474e+04 2.340e+02
Number of obs: 331, groups:  Trial, 194; ObjectNo, 188; Subject, 2

Fixed effects:
```

```
                                    Estimate Std. Error t value
(Intercept)                          623.59      99.52   6.266
AoA_Kup_lem                           64.73      17.90   3.617
PictureTypeFullPicture               -16.88     103.80  -0.163
AoA_Kup_lem:PictureTypeFullPicture   -11.48      19.73  -0.582

Correlation of Fixed Effects:
            (Intr) AA_Kp_ PctTFP
AoA_Kup_lem -0.913
PctrTypFllP -0.575  0.595
AA_Kp_:PTFP  0.563 -0.621 -0.967
```

15 Plotting Model Fits

AOA and Picture Type

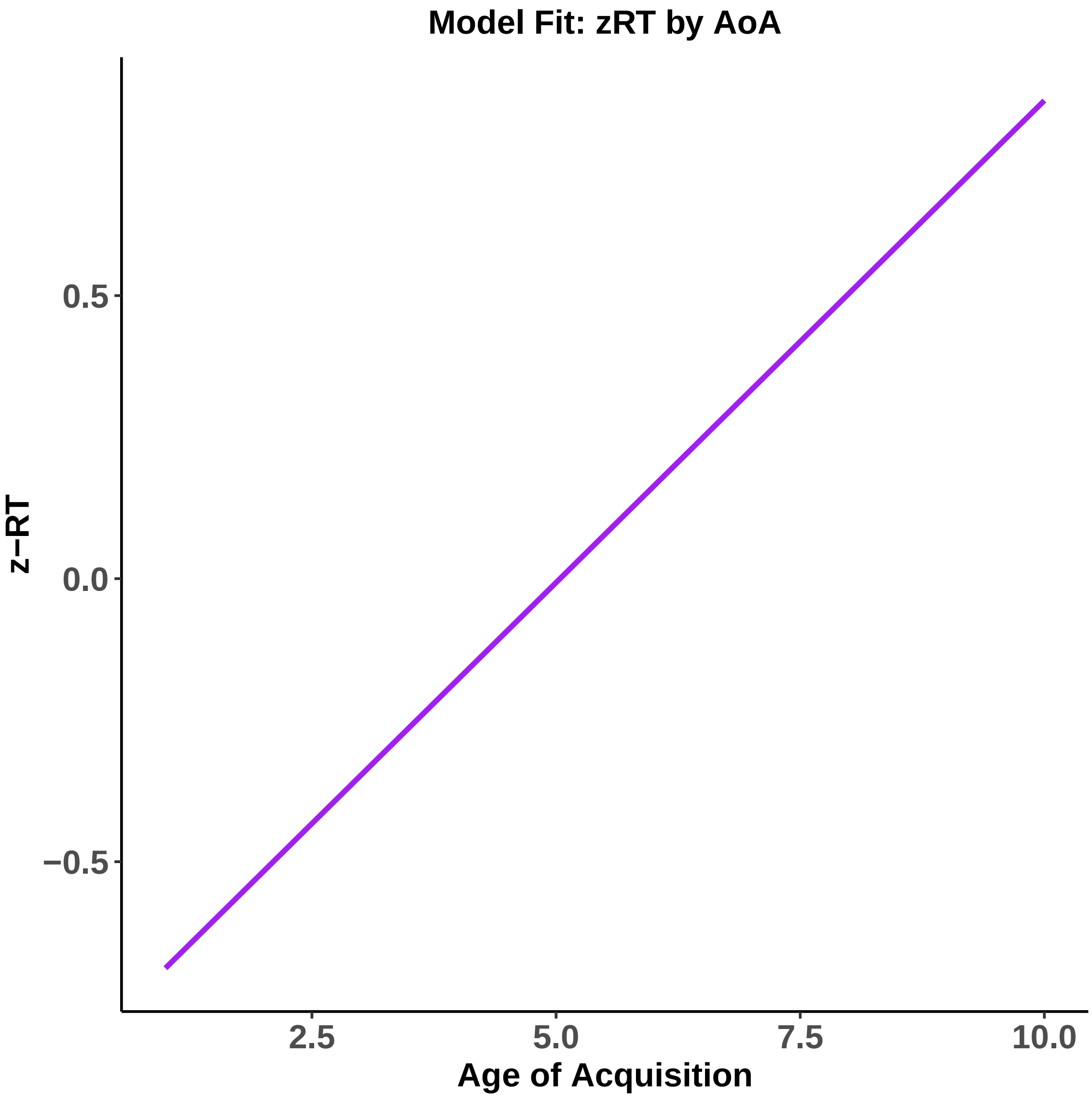
```
> fixed.frame <-
+   data.frame(expand.grid(AoA_Kup_lem = seq(1,10,0.5),
+              PictureType = c("FullPicture","DegradedPicture"))) %>%
+   mutate(pred = predict(m1, newdata = ., re.form = NA))
> fixed.frame %>%
+   mutate(AoA = AoA_Kup_lem) %>%
+   ggplot(aes(x = AoA, y = pred, color = PictureType)) +
+     geom_line(size = 1) +
+     xlab("Age of Acquisition") + ylab ("z-RT")+
+   ggtitle("Model Fit: zRT by AoA And Picture Type")+
+ theme_classic() +
+     theme(axis.text = element_text(face = "bold", size = rel(1.2)),
+           axis.title = element_text(face = "bold", size = rel(1.2)),
+           legend.title = element_text(face = "bold", size = rel(1.2)),
+           plot.title = element_text(face = "bold", size = rel(1.2), hjust = .5))
```



AOA Only

```
> fixed.frame ←
+   data.frame(expand.grid(AoA_Kup_lem = seq(1,10,0.5))) %>%
+   mutate(pred = predict(m0, newdata = ., re.form = NA))
> fixed.frame %>%
+   mutate(AoA = AoA_Kup_lem) %>%
+   ggplot(aes(x = AoA, y = pred)) +
+       geom_line(size = 1, color = "purple") +
+     xlab("Age of Acquisition") + ylab ("z-RT")+
```

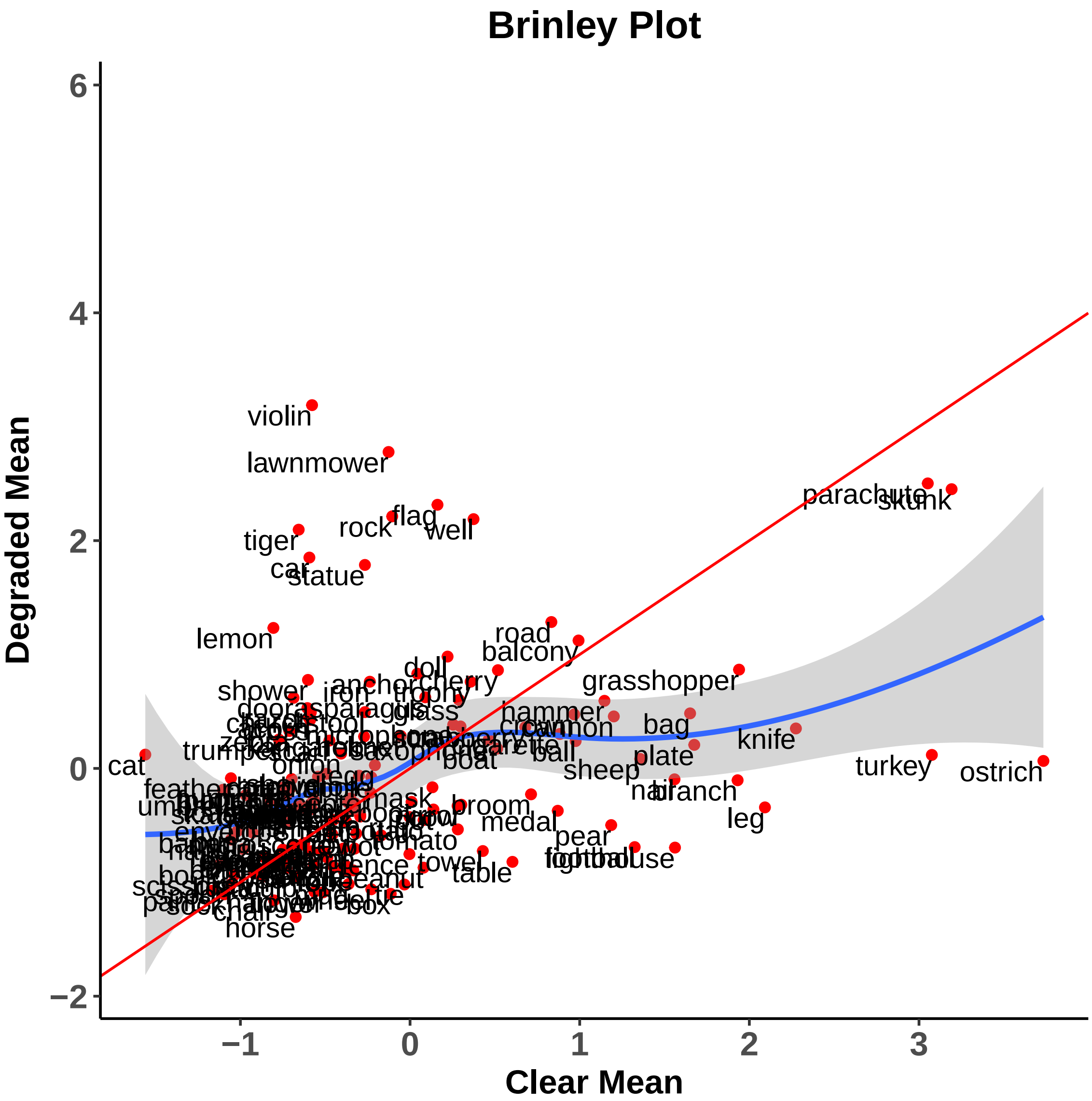
```
+   ggtitle("Model Fit: zRT by AoA")+
+ theme_classic() +
+     theme(axis.text = element_text(face = "bold", size = rel(1.2)),
+           axis.title = element_text(face = "bold", size = rel(1.2)),
+           legend.title = element_text(face = "bold", size = rel(1.2)),
+           plot.title = element_text(face = "bold", size = rel(1.2), hjust = .5))
```



16 Brinley Plot

```
> #item_acc contains zRT for degraded and full pictures for each item
```

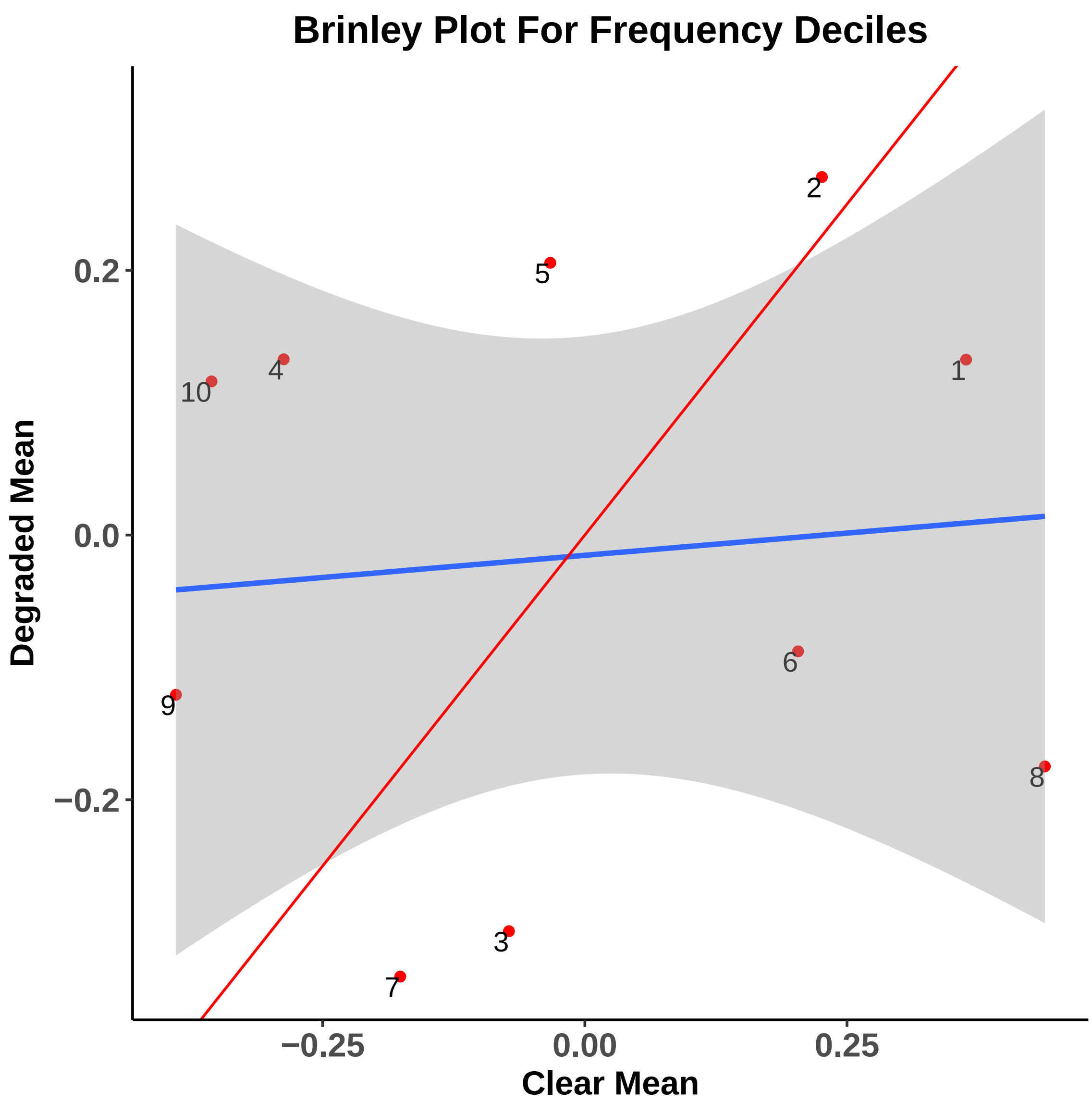
```
> item_brinley = group_by(final_pic_z, Object, PictureType )%>%
+      summarise_at(vars( zRT_trim), mean)
> library(tidyr)
> wide_item = item_brinley %>%
+    spread(PictureType, zRT_trim)
> # Now, we plot these in a brinley plot
> library(ggplot2)
> library(ggthemes)
>    ggplot(wide_item, aes(x = FullPicture, y = DegradedPicture, label = Object)) +
+      geom_point(color = "red")+
+      geom_smooth(method = "loess")+
+          geom_text(aes(label=Object, vjust = 1, hjust = 1))+
+      geom_abline(slope = 1, intercept = 0, color = "red")+
+      xlab("Clear Mean") + ylab ("Degraded Mean")+
+    ggtitle("Brinley Plot")+
+ theme_classic() +
+      theme(axis.text = element_text(face = "bold", size = rel(1.2)),
+            axis.title = element_text(face = "bold", size = rel(1.2)),
+            legend.title = element_text(face = "bold", size = rel(1.2)),
+            plot.title = element_text(face = "bold", size = rel(1.4), hjust = .5))
>
```



Frequency Decile Brinley Plot

```
> item_elp = read.csv("DegradedItems_ELP.csv", header = TRUE, sep = ",")
> item_elp_brinley = merge(item_elp, item_brinley, by  = c("Object"))
> # 398 rows: dropped wheelbarrow
>
> item_elp_brinley$Decile = ntile(item_elp_brinley$Log_Freq_HAL, 10)
> elp_decile_data = group_by(item_elp_brinley, Decile, PictureType) %>%
+   summarize_at(vars(zRT_trim), mean)
> library(tidyr)
```

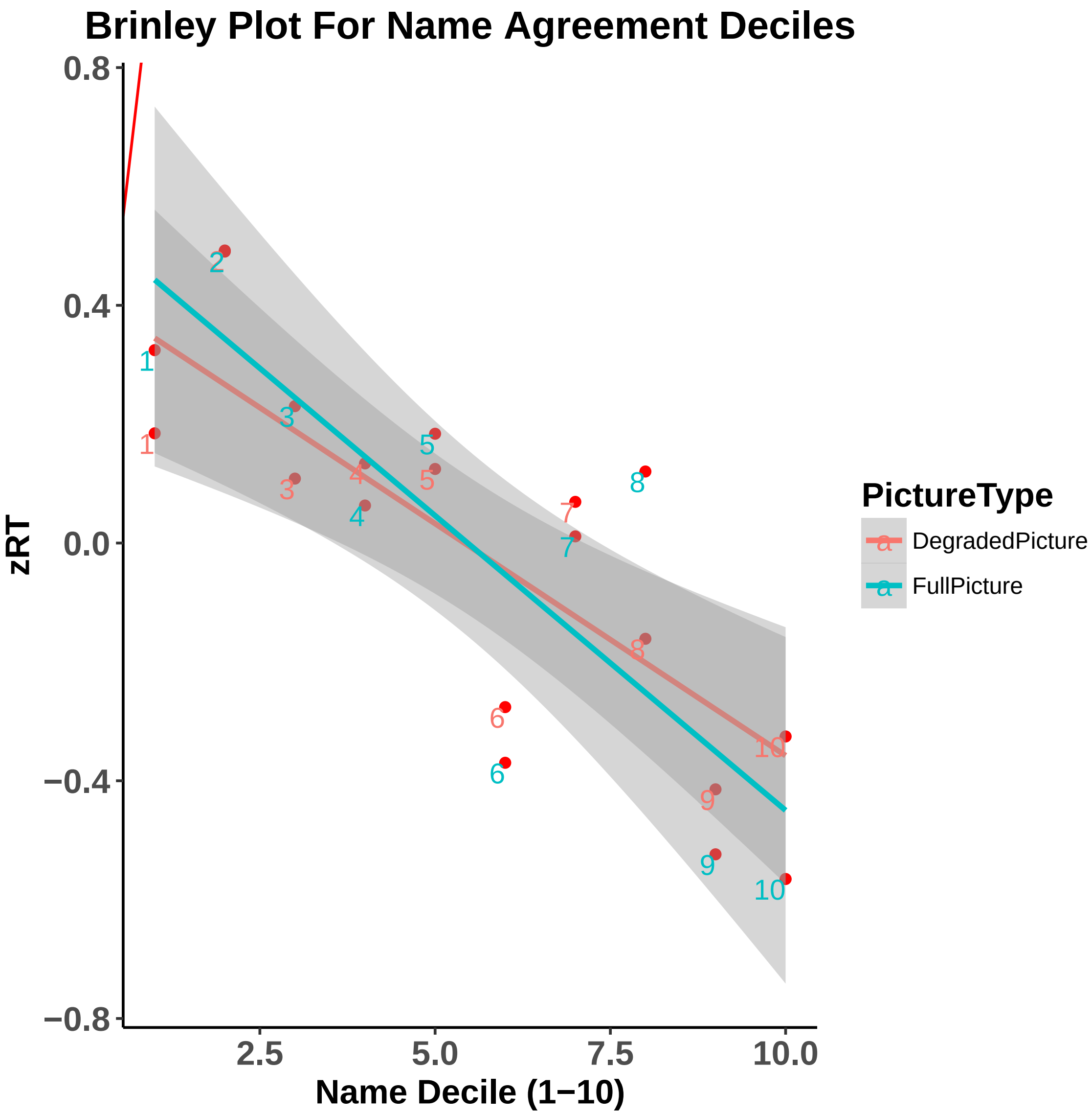
```
> elp_decile_wide = elp_decile_data %>%
+   spread(PictureType, zRT_trim)
> # Now, we plot these in a brinley plot
> library(ggplot2)
> library(ggthemes)
>   ggplot(elp_decile_wide, aes(x = FullPicture, y = DegradedPicture)) +
+     geom_point(color = "red")+
+                 geom_text(aes(label=Decile, vjust = 1, hjust = 1))+
+     geom_smooth(method = "lm")+
+     geom_abline(slope = 1, intercept = 0, color = "red")+
+     xlab("Clear Mean") + ylab ("Degraded Mean")+
+  #    xlim(-0.5,0.5)+
+   ggtitle("Brinley Plot For Frequency Deciles")+
+ theme_classic() +
+     theme(axis.text = element_text(face = "bold", size = rel(1.2)),
+           axis.title = element_text(face = "bold", size = rel(1.2)),
+           legend.title = element_text(face = "bold", size = rel(1.2)),
+           plot.title = element_text(face = "bold", size = rel(1.4), hjust = .5))
>
```



H-Statistic Decile Brinley Plot

```
> marcnorms = read.csv("590MarcNorms.csv", header = TRUE, sep = ",")
>   ## lower H statistic means greater name agreement. So we reverse code
>   marcnorms$NameAgreement = 3.19 - marcnorms$H.statistic
>   # Thus, higher NameAgreement, means higher name agreement
>
> item_marc_brinley = merge(marcnorms, item_brinley, by  = c("Object"))
> # 390 rows: dropped castle, pillow, radio, shower, tank: used anti_join
>
```

```
> item_marc_brinley$Decile = ntile(item_marc_brinley$NameAgreement , 10)
> marc_decile_data = group_by(item_marc_brinley , Decile , PictureType) %>%
+   summarize_at(vars(zRT_trim), mean)
> library(tidyr)
> marc_decile_wide = marc_decile_data %>%
+   spread(PictureType , zRT_trim)
> # Now , we plot these in a brinley plot
> library(ggplot2)
> library(ggthemes)
>   ggplot(marc_decile_data , aes(x = Decile , y = zRT_trim ,
+                                 group = PictureType , color = PictureType)) +
+     geom_point(color = "red")+
+     geom_smooth(method = "lm")+
+            geom_text(aes(label=Decile , vjust = 1, hjust = 1))+
+     geom_abline(slope = 1, intercept = 0, color = "red")+
+     xlab("Name Decile (1-10)") + ylab ("zRT")+
+    # xlim(-0.6 ,0.5)+
+   ggtitle("Brinley Plot For Name Agreement Deciles")+
+ theme_classic() +
+     theme(axis.text = element_text(face = "bold", size = rel(1.2)),
+           axis.title = element_text(face = "bold", size = rel(1.2)),
+           legend.title = element_text(face = "bold", size = rel(1.2)),
+           plot.title = element_text(face = "bold", size = rel(1.4), hjust = .5))
>
```



17 Picture Variables

We first create a combined excel file with ALL the relevant variables, so that we can run a regression model eventually.

Combining

```
> marc590 = read.csv("590MarcNorms.csv", header = TRUE, sep = ",")
> ipnp = read.csv("IPNPnorms.csv", header = TRUE, sep = ",")
> ipnp = ipnp[,c(2,3, 5)]
> multipic = read.csv("MultipicNorms.csv", header = TRUE, sep = ",")
```

```
> item_elp = read.csv("DegradedItems_ELP.csv", header = TRUE, sep = ",")
> multipic = multipic[,c(3,11)]
> AoA_main = AoA[,c(1,11)]
> item_all = Reduce(function(x, y) merge(x, y, all=TRUE),
+                   list(marc590, ipnp, item_elp, multipic, AoA_main))
> items = read.csv("Degraded_ItemList.csv", header = TRUE, sep = ",")
> item_final = dplyr::inner_join(items, item_all)
> ## this file currently has many duplicates so we remove these in excel
> ## note that some objects had multiple values for Visual Complexity, in
> ## which case a mean value was chosen.
> write.csv(item_final, file = "item_duplicates.csv")
```

Variable Correlations

```
> item_descriptives = read.csv("item_finaldescriptives.csv",
+                              header = TRUE, sep = ",")
> x = item_descriptives[complete.cases(item_descriptives),]
> cor_table = Hmisc::rcorr(as.matrix(x[,c(4,7,8,10,11,12)]))
```

Merging with Experiment Data

```
> ## final data is in pic_withAoA_z (for separate z-scoring) and in new_z_AOA for combin
> ## need to merge with item_descriptives
>
> final_pic_data_1 = merge(pic_withAoA_z, item_descriptives, by = "Object")
> final_pic_data_1= final_pic_data_1[order(final_pic_data_1$Subject),]
> final_pic_data_2 = merge(new_z_AoA, item_descriptives, by = "Object")
> final_pic_data_2= final_pic_data_2[order(final_pic_data_2$Subject),]
>
```

18 HLMs

z-RT

Basic Variables

```
> library(lme4)
> p0 = lmer(data = final_pic_data_2, zRT_trim ~ 1 + (1|Subject) + (1|Trial))
> summary(p0)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ 1 + (1 | Subject) + (1 | Trial)
   Data: final_pic_data_2

REML criterion at convergence: 941.3
```

```
Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.3198 -0.6707 -0.2770  0.3324  4.6720

Random effects:
 Groups   Name        Variance  Std.Dev.
 Trial    (Intercept) 1.902e-14 1.379e-07
 Subject  (Intercept) 1.650e-17 4.062e-09
 Residual             9.970e-01 9.985e-01
Number of obs: 331, groups:  Trial, 194; Subject, 2

Fixed effects:
              Estimate Std. Error t value
(Intercept) -2.140e-16  5.488e-02       0
```

```
> reghelper::ICC(p0)
```

```
[1] 1.909888e-14
```

```
> p1 = lmer(data = final_pic_data_2, zRT_trim ~ H.statistic +
+              (1|Subject) + (1|Trial))
> summary(p1)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ H.statistic + (1 | Subject) + (1 | Trial)
   Data: final_pic_data_2

REML criterion at convergence: 898.8

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.5335 -0.6192 -0.2566  0.3692  4.7985

Random effects:
 Groups   Name        Variance  Std.Dev.
 Trial    (Intercept) 3.977e-16 1.994e-08
 Subject  (Intercept) 0.000e+00 0.000e+00
 Residual             9.233e-01 9.609e-01
Number of obs: 324, groups:  Trial, 194; Subject, 2

Fixed effects:
            Estimate Std. Error t value
(Intercept) -0.29512    0.07880  -3.745
H.statistic  0.40618    0.08233   4.934

Correlation of Fixed Effects:
            (Intr)
```

```
H.statistic -0.736
```

```
> p2 = lmer(data = final_pic_data_2, zRT_trim ~ H.statistic + VISUAL_COMPLEXITY +
+              (1|Subject) + (1|Trial))
> summary(p2)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ H.statistic + VISUAL_COMPLEXITY + (1 | Subject) +
    (1 | Trial)
   Data: final_pic_data_2

REML criterion at convergence: 890.6

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.8611 -0.6455 -0.2541  0.3393  4.6702

Random effects:
 Groups   Name        Variance  Std.Dev.
 Trial    (Intercept) 3.789e-14 1.947e-07
 Subject  (Intercept) 0.000e+00 0.000e+00
 Residual             8.952e-01 9.462e-01
Number of obs: 324, groups:  Trial, 194; Subject, 2

Fixed effects:
                  Estimate Std. Error t value
(Intercept)       -1.13305    0.26332  -4.303
H.statistic        0.40842    0.08107   5.038
VISUAL_COMPLEXITY  0.32844    0.09863   3.330

Correlation of Fixed Effects:
            (Intr) H.stts
H.statistic -0.225
VISUAL_COMP -0.956  0.008
```

```
> p3 = lmer(data = final_pic_data_2, zRT_trim ~ H.statistic + VISUAL_COMPLEXITY +
+                              Length +
+              (1|Subject) + (1|Trial))
> summary(p3)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ H.statistic + VISUAL_COMPLEXITY + Length + (1 | Subject) +
    (1 | Trial)
   Data: final_pic_data_2

REML criterion at convergence: 886

Scaled residuals:
```

```
    Min      1Q  Median      3Q     Max 
-1.7925 -0.6436 -0.2362  0.3303  4.6801 

Random effects:
 Groups   Name        Variance  Std.Dev. 
 Trial    (Intercept) 9.578e-15 9.787e-08
 Subject  (Intercept) 0.000e+00 0.000e+00
 Residual             8.854e-01 9.410e-01
Number of obs: 322, groups:  Trial, 194; Subject, 2

Fixed effects:
                  Estimate Std. Error t value
(Intercept)       -1.20170    0.28649  -4.195
H.statistic        0.39734    0.08117   4.895
VISUAL_COMPLEXITY  0.31314    0.09894   3.165
Length             0.02014    0.02720   0.740

Correlation of Fixed Effects:
            (Intr) H.stts VISUAL
H.statistic -0.166              
VISUAL_COMP -0.823  0.023       
Length      -0.402 -0.101 -0.115
```

Adding Degradation

```
> p4 = lmer(data = final_pic_data_2, zRT_trim ~ H.statistic + VISUAL_COMPLEXITY +
+                              Length + PictureType +
+             (1|Subject) + (1|Trial))
> summary(p4)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ H.statistic + VISUAL_COMPLEXITY + Length + PictureType +
    (1 | Subject) + (1 | Trial)
   Data: final_pic_data_2

REML criterion at convergence: 887.1

Scaled residuals:
    Min      1Q  Median      3Q     Max 
-1.7272 -0.6113 -0.2336  0.2995  4.7512 

Random effects:
 Groups   Name        Variance Std.Dev.
 Trial    (Intercept) 0.0000   0.0000  
 Subject  (Intercept) 0.0000   0.0000  
 Residual             0.8837   0.9401  
Number of obs: 322, groups:  Trial, 194; Subject, 2
```

```
Fixed effects:
                      Estimate Std. Error t value
(Intercept)           -1.14370    0.28983  -3.946
H.statistic            0.39789    0.08109   4.907
VISUAL_COMPLEXITY      0.31598    0.09887   3.196
Length                 0.02063    0.02718   0.759
PictureTypeFullPicture -0.13331   0.10485  -1.271

Correlation of Fixed Effects:
            (Intr) H.stts VISUAL Length
H.statistic -0.164
VISUAL_COMP -0.809  0.024
Length      -0.395 -0.101 -0.114
PctrTypFllP -0.157 -0.005 -0.023 -0.014
```

Adding Freq and AoA

```
> p5 = lmer(data = final_pic_data_2, zRT_trim ~ H.statistic + VISUAL_COMPLEXITY +
+                             Length + PictureType + AoA_Kup_lem.x +
+              (1|Subject) + (1|Trial))
> summary(p5)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ H.statistic + VISUAL_COMPLEXITY + Length + PictureType +
    AoA_Kup_lem.x + (1 | Subject) + (1 | Trial)
   Data: final_pic_data_2

REML criterion at convergence: 885.1

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.6010 -0.6109 -0.2359  0.2399  4.7227

Random effects:
 Groups   Name        Variance Std.Dev.
 Trial    (Intercept) 0.0000   0.0000
 Subject  (Intercept) 0.0000   0.0000
 Residual             0.8689   0.9321
Number of obs: 322, groups:  Trial, 194; Subject, 2

Fixed effects:
                      Estimate Std. Error t value
(Intercept)           -1.38556    0.30286  -4.575
H.statistic            0.34283    0.08330   4.115
VISUAL_COMPLEXITY      0.27637    0.09928   2.784
Length                -0.01333    0.03011  -0.443
```

```
PictureTypeFullPicture -0.13785    0.10398  -1.326
AoA_Kup_lem.x           0.11209    0.04429   2.531

Correlation of Fixed Effects:
            (Intr) H.stts VISUAL Length PctTFP
H.statistic -0.067
VISUAL_COMP -0.709  0.064
Length      -0.195  0.029 -0.031
PctrTypFllP -0.144 -0.001 -0.020 -0.005
AoA_Kp_lm.x -0.316 -0.261 -0.158 -0.446 -0.017
```

```
> p6 = lmer(data = final_pic_data_2, zRT_trim ~ H.statistic + VISUAL_COMPLEXITY +
+                             Length + PictureType*Log_Freq_HAL +
+              (1|Subject) + (1|Trial))
> summary(p6)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ H.statistic + VISUAL_COMPLEXITY + Length + PictureType *
    Log_Freq_HAL + (1 | Subject) + (1 | Trial)
   Data: final_pic_data_2

REML criterion at convergence: 893.7

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.6372 -0.6217 -0.2486  0.3201  4.6314

Random effects:
 Groups   Name        Variance Std.Dev.
 Trial    (Intercept) 0.0000   0.000
 Subject  (Intercept) 0.0000   0.000
 Residual             0.8855   0.941
Number of obs: 322, groups:  Trial, 194; Subject, 2

Fixed effects:
                                    Estimate Std. Error t value
(Intercept)                         -1.43706    0.64485  -2.229
H.statistic                          0.39291    0.08276   4.747
VISUAL_COMPLEXITY                    0.31273    0.09943   3.145
Length                               0.01841    0.03212   0.573
PictureTypeFullPicture               0.56499    0.61053   0.925
Log_Freq_HAL                         0.03652    0.05488   0.665
PictureTypeFullPicture:Log_Freq_HAL -0.08053    0.06936  -1.161

Correlation of Fixed Effects:
            (Intr) H.stts VISUAL Length PctTFP L_F_HA
H.statistic -0.203
VISUAL_COMP -0.425  0.042
```

```
Length       -0.552  0.019 -0.046
PctrTypFllP -0.462 -0.036 -0.024 -0.016
Log_Frq_HAL -0.882  0.125  0.059  0.400  0.629
PTFP:L_F_HA  0.457  0.036  0.020  0.014 -0.985 -0.638
```

```
> p7 = lmer(data = final_pic_data_2, zRT_trim ~ H.statistic + VISUAL_COMPLEXITY +
+                      Length + PictureType + AoA_Kup_lem.x + Log_Freq_HAL +
+            (1|Subject) + (1|Trial))
> summary(p7)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ H.statistic + VISUAL_COMPLEXITY + Length + PictureType +
    AoA_Kup_lem.x + Log_Freq_HAL + (1 | Subject) + (1 | Trial)
   Data: final_pic_data_2

REML criterion at convergence: 889.4

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.6191 -0.6083 -0.2269  0.2406  4.7529

Random effects:
 Groups   Name        Variance Std.Dev.
 Trial    (Intercept) 0.000    0.0000
 Subject  (Intercept) 0.000    0.0000
 Residual             0.871    0.9333
Number of obs: 322, groups:  Trial, 194; Subject, 2

Fixed effects:
                        Estimate Std. Error t value
(Intercept)            -1.629719   0.605799  -2.690
H.statistic             0.348053   0.084157   4.136
VISUAL_COMPLEXITY       0.279125   0.099583   2.803
Length                 -0.006661   0.033375  -0.200
PictureTypeFullPicture -0.138100   0.104114  -1.326
AoA_Kup_lem.x           0.116724   0.045448   2.568
Log_Freq_HAL            0.019991   0.042939   0.466

Correlation of Fixed Effects:
            (Intr) H.stts VISUAL Length PctTFP AA_K_.
H.statistic -0.149
VISUAL_COMP -0.405  0.071
Length      -0.460  0.083 -0.002
PctrTypFllP -0.068 -0.001 -0.020 -0.007
AoA_Kp_lm.x -0.344 -0.223 -0.141 -0.299 -0.018
Log_Frq_HAL -0.866  0.133  0.059  0.429 -0.005  0.219
```

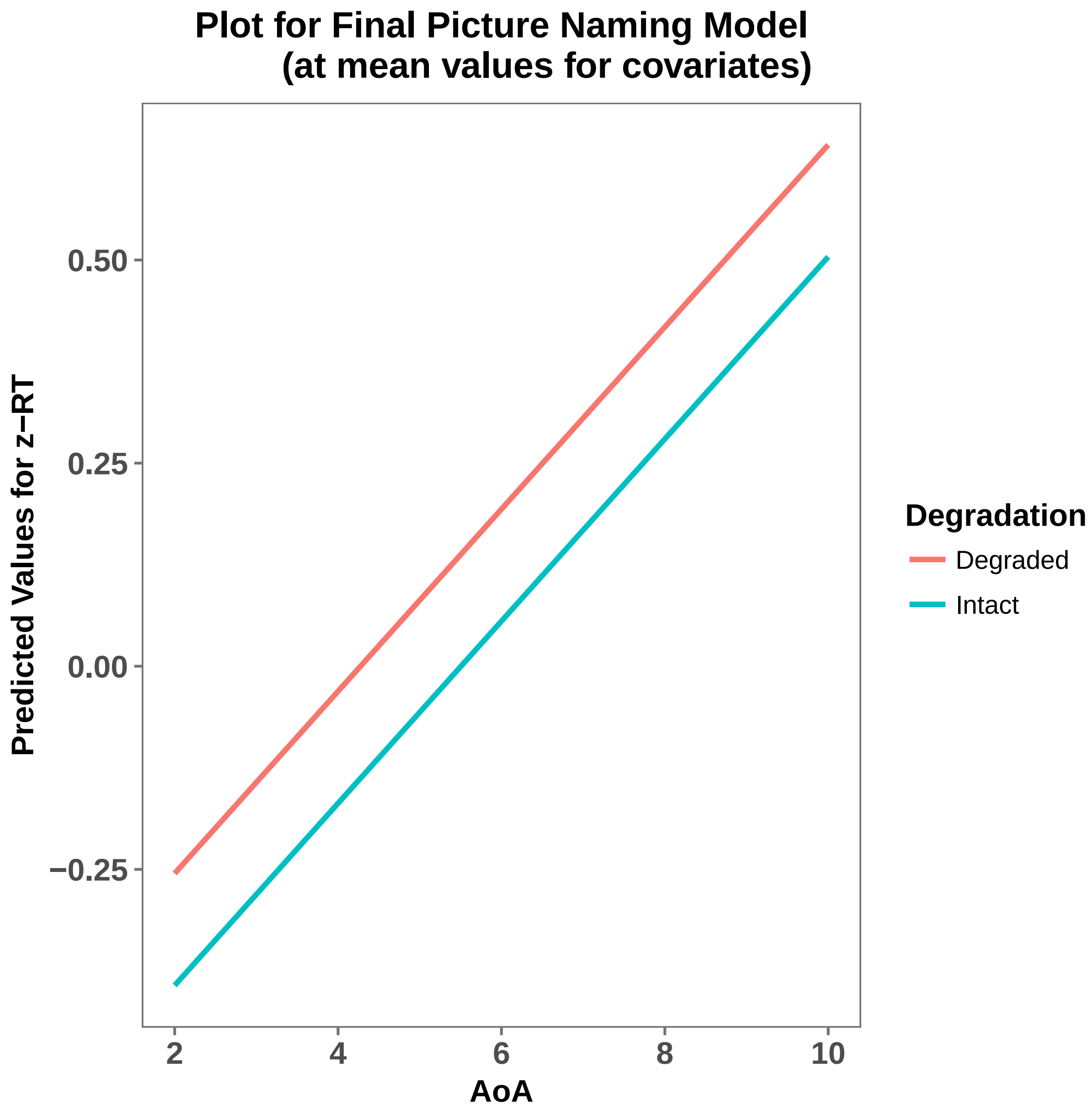
```
> ## interaction models: not sig: tried all 2-ways and 3-ways
```

```
>
> p8 = lmer(data = final_pic_data_2, zRT_trim ~ H.statistic + VISUAL_COMPLEXITY +
+                               Length + PictureType*AoA_Kup_lem.x*Log_Freq_HAL +
+              (1|Subject) + (1|Trial))
> summary(p8)
```

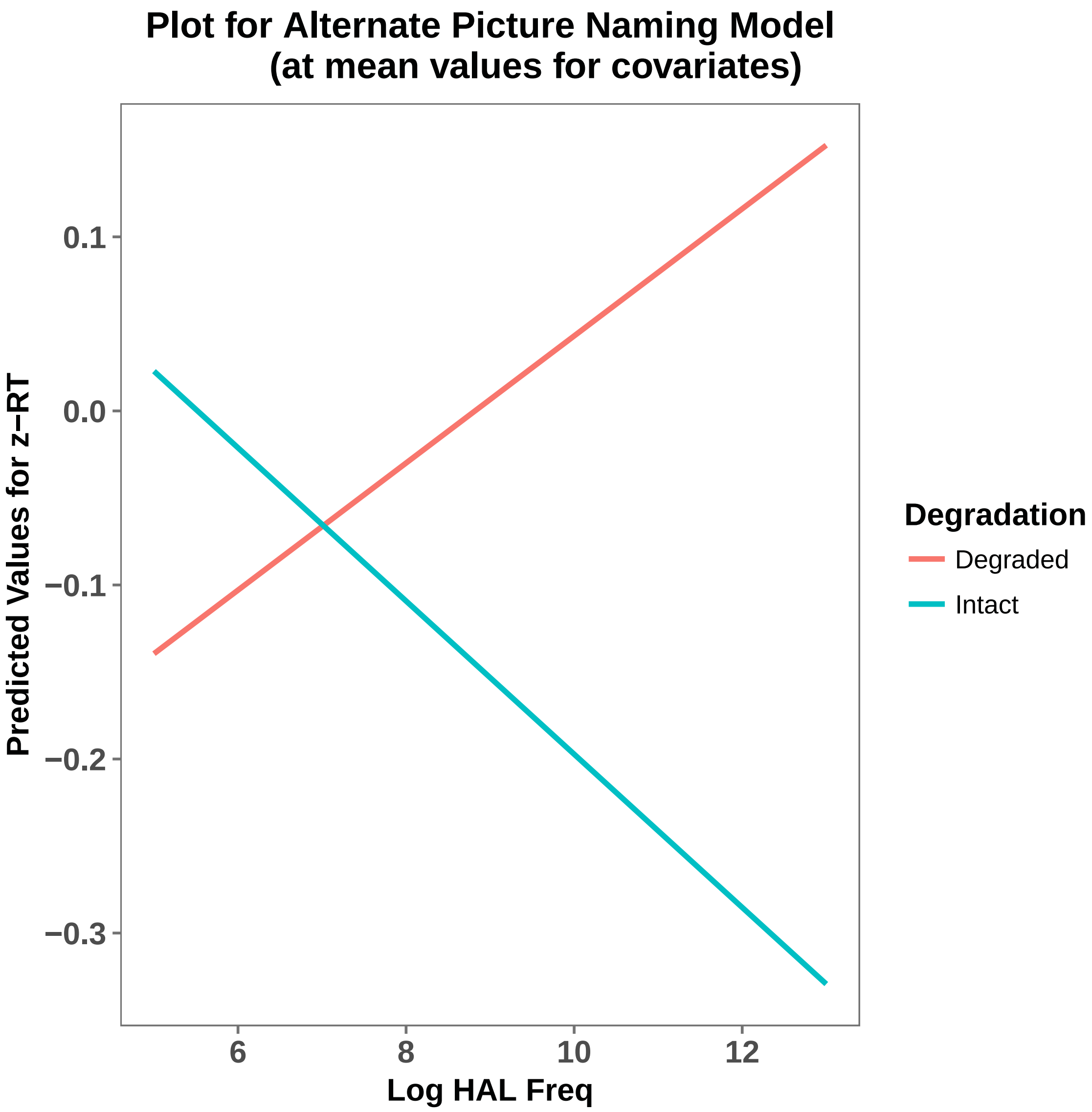
```
Linear mixed model fit by REML ['lmerMod']
Formula: zRT_trim ~ H.statistic + VISUAL_COMPLEXITY + Length + PictureType *
    AoA_Kup_lem.x * Log_Freq_HAL + (1 | Subject) + (1 | Trial)
   Data: final_pic_data_2

REML criterion at convergence: 901.4

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.6619 -0.6018 -0.2170  0.2844  4.5915

Random effects:
 Groups   Name        Variance Std.Dev.
 Trial    (Intercept) 0.0000   0.0000
 Subject  (Intercept) 0.0000   0.0000
 Residual             0.8702   0.9328
Number of obs: 322, groups:  Trial, 194; Subject, 2

Fixed effects:
                                             Estimate Std. Error t value
(Intercept)                                 -1.375405   1.786295  -0.770
H.statistic                                  0.349809   0.084224   4.153
VISUAL_COMPLEXITY                            0.278261   0.099590   2.794
Length                                      -0.006813   0.033492  -0.203
PictureTypeFullPicture                      -1.040222   2.311075  -0.450
AoA_Kup_lem.x                               -0.039750   0.329624  -0.121
Log_Freq_HAL                                -0.042611   0.198919  -0.214
PictureTypeFullPicture:AoA_Kup_lem.x         0.381178   0.421325   0.905
PictureTypeFullPicture:Log_Freq_HAL          0.173746   0.262260   0.662
AoA_Kup_lem.x:Log_Freq_HAL                   0.025173   0.038607   0.652
PictureTypeFullPicture:AoA_Kup_lem.x:Log_Freq_HAL -0.058926   0.050165  -1.175

Correlation of Fixed Effects:
            (Intr) H.stts VISUAL Length PctTFP AA_Kp_. L_F_HA PcTFP:AA_K_.
H.statistic -0.050
VISUAL_COMP -0.129  0.072
Length      -0.073  0.082 -0.002
PctrTypFllP -0.747 -0.018 -0.026 -0.058
AoA_Kp_lm.x -0.930 -0.028 -0.024 -0.126  0.737
Log_Frq_HAL -0.973  0.024  0.006  0.008  0.750  0.957
PcTFP:AA_K_. 0.731  0.013  0.020  0.057 -0.957 -0.777  -0.749
PTFP:L_F_HA  0.729  0.024  0.024  0.056 -0.981 -0.735  -0.757  0.963
```

```
AA_K_.:L_F_    0.902  0.001  0.003  0.084 -0.707 -0.981  -0.957  0.764
PTFP:AA_K_.:  -0.692 -0.019 -0.018 -0.052  0.912  0.754   0.736 -0.980
              PTFP:L AA_K_.:
H.statistic
VISUAL_COMP
Length
PctrTypFllP
AoA_Kp_lm.x
Log_Frq_HAL
PcTFP:AA_K_.
PTFP:L_F_HA
AA_K_.:L_F_    0.731
PTFP:AA_K_.:  -0.956 -0.769
```

19 Plotting Final Model: p5



20 Plotting Final Model: p6



21 Plotting Final Model: p7