**General statistical analysis (CogSci 2017 conf paper)**

Stepwise mixed effects modeling of the event-related potentials per time window. This is a printout of the code with the output rendered via rmarkdown::render().

**KEY:**

*# This is a comment*.

**this** and this **are commands**

## This is output.

Plot output is unmarked.

# Thanks to Sean Roberts (MPI Psycholinguistics) for advice on these models.  
# Also consulted:  
# Winter, B. (2013). Linear models and linear mixed effects models in R  
# with linguistic applications. arXiv:1308.5499. Retrieved from  
# http://arxiv.org/pdf/1308.5499.pdf  
  
# MODELING METHOD:   
# These are random slope models with random intercepts and slopes for sub-  
# jects. Both the RT and the EEG data are modeled with the most optimal   
# method as of today. The main characteristic is the maximal, data-driven   
# incorporation of effects, whereby the critical variables of interest are   
# analyzed on the basis of a null model. This null model contains all pos-  
# sible random intercepts and slopes, including interactions, as well as all  
# possible fixed effects and interactions, insofar as they add significantly   
# to that null model (Barr, Levy, Scheepers, & Tily, 2013: J Mem Lang). Both   
# random and fixed effects are analyzed one by one, stepwise, always keeping  
# the degrees of freedom as similar as possible in the two models compared.  
# The null hypothesis significance test is then the Chi-Square based on the   
# Likelihood Ratio Test. Note that a separate Akaike Information Criterion   
# (AIC) is sometimes provided too, for further information, but it is never   
# binding. This method is valid with the number of subjects and items of   
# this study (Luke, 2016: Behav Res).  
# IMPORTANT: Models are named ad-hoc. Their numbers are NOT ordinal.  
  
install.packages('lme4')

## package 'lme4' successfully unpacked and MD5 sums checked  
##   
## The downloaded binary packages are in  
## C:\Users\Pablo\AppData\Local\Temp\RtmpM1UJHA\downloaded\_packages

install.packages('doBy')

## package 'doBy' successfully unpacked and MD5 sums checked  
##   
## The downloaded binary packages are in  
## C:\Users\Pablo\AppData\Local\Temp\RtmpM1UJHA\downloaded\_packages

install.packages('dae')

## package 'dae' successfully unpacked and MD5 sums checked  
##   
## The downloaded binary packages are in  
## C:\Users\Pablo\AppData\Local\Temp\RtmpM1UJHA\downloaded\_packages

install.packages('MuMIn')

## package 'MuMIn' successfully unpacked and MD5 sums checked  
##   
## The downloaded binary packages are in  
## C:\Users\Pablo\AppData\Local\Temp\RtmpM1UJHA\downloaded\_packages

install.packages('merTools')

## package 'merTools' successfully unpacked and MD5 sums checked  
##   
## The downloaded binary packages are in  
## C:\Users\Pablo\AppData\Local\Temp\RtmpM1UJHA\downloaded\_packages

library(lme4)

## Loading required package: Matrix

library(doBy)  
library(dae)

## Loading required package: ggplot2

## Need help? Try the ggplot2 mailing list:  
## http://groups.google.com/group/ggplot2.

library(MuMIn)  
library(merTools)

## Loading required package: arm

## Loading required package: MASS

##   
## arm (Version 1.9-3, built: 2016-11-21)

## Working directory is C:/Users/Pablo/Dropbox/STUDIES/R/Experiment Data/Modality-switching experiment/ERPs/Export Files

## Loading required package: dplyr

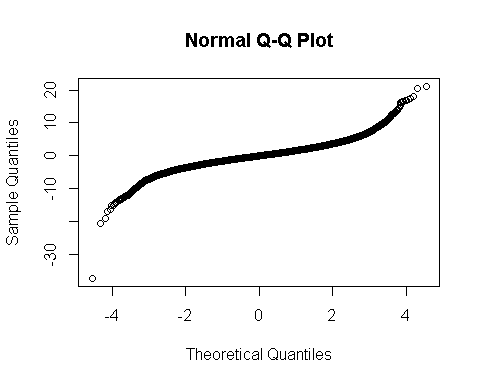
##   
## Attaching package: 'dplyr'

## The following object is masked from 'package:MASS':  
##   
## select

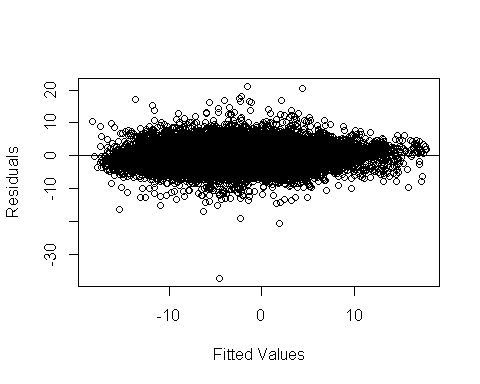
## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

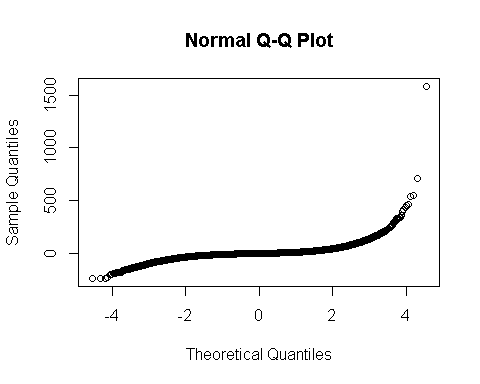
# read in key objects  
EEG.window1 = readRDS('EEG.window1.rds')  
EEG.window2 = readRDS('EEG.window2.rds')  
EEG.window3 = readRDS('EEG.window3.rds')  
EEG.window4 = readRDS('EEG.window4.rds')  
  
  
# Mixed models residuals (further below) are extremely non-normal.   
# Perhaps transform DV. First check several methods. Note: +74 is  
# added in order to turn DV positive, avoiding non-values. Note  
# also that the transformation is checked on window 3 because it   
# is large and contains the fundamental ERP N400.  
  
# Window 3  
EEG.window3 <- cbind(EEG.window3, EEG.window3$microvolts^2)  
EEG.window3 <- cbind(EEG.window3, sqrt(EEG.window3$microvolts +74))  
EEG.window3 <- cbind(EEG.window3, log(EEG.window3$microvolts +74))  
EEG.window3 <- cbind(EEG.window3, 1/(EEG.window3$microvolts +74))  
EEG.window3 <- cbind(EEG.window3, 1/sqrt(EEG.window3$microvolts +74))  
EEG.window3$sqmicrovolts <- EEG.window3$microvolts^2  
EEG.window3$sqrtmicrovolts <- sqrt(EEG.window3$microvolts +74)  
EEG.window3$logmicrovolts <- log(EEG.window3$microvolts +74)  
EEG.window3$recmicrovolts <- 1/(EEG.window3$microvolts +74)  
EEG.window3$recsqrtmicrovolts <- 1/sqrt(EEG.window3$microvolts +74)  
  
# Compare residuals when using original variable with those when using trans-  
# formed versions. This is done with the final model from the most important   
# window, namely window 3.  
# First, w/ original variable  
orig = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| RT.based\_Groups: time)+ (1| electrode: participant:   
 condition)+ location+ condition + RT.based\_Groups : location,  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(orig))



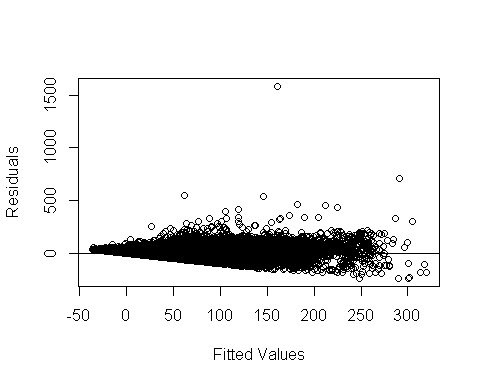
# Plot of Residuals vs. Fitted values:  
plot(fitted(orig),resid(orig),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



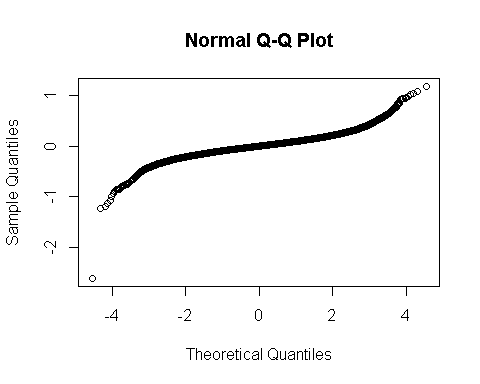
# Second, with squaring transformation  
sq\_t = lmer(sqmicrovolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| RT.based\_Groups: time)+ (1| electrode: participant:   
 condition)+ location+ condition + RT.based\_Groups : location,  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(sq\_t))



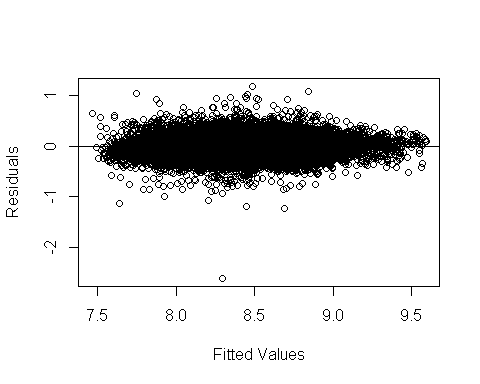
# Plot of Residuals vs. Fitted values:  
plot(fitted(sq\_t),resid(sq\_t),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



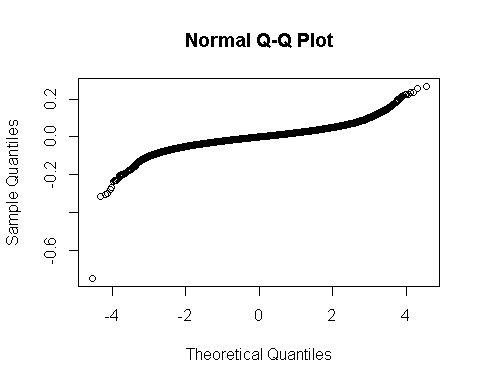
# Third, with square root transformation  
sqrt\_t = lmer(sqrtmicrovolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| RT.based\_Groups: time)+ (1| electrode: participant:   
 condition)+ location+ condition + RT.based\_Groups : location,  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(sqrt\_t))



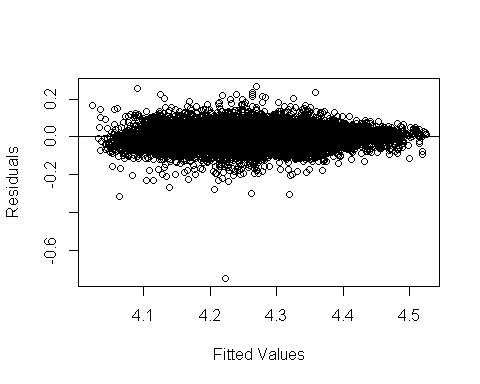
# Plot of Residuals vs. Fitted values:  
plot(fitted(sqrt\_t),resid(sqrt\_t),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



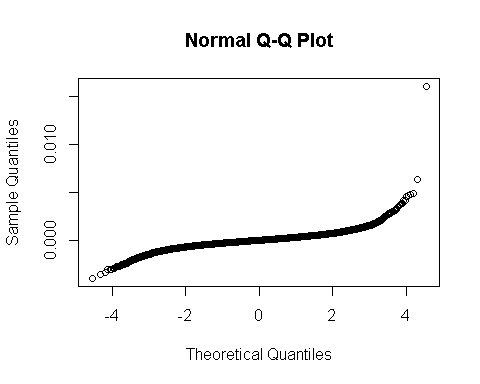
# Fourth, with log transformation  
log\_t = lmer(logmicrovolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| RT.based\_Groups: time)+ (1| electrode: participant:   
 condition)+ location+ condition + RT.based\_Groups : location,  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(log\_t))



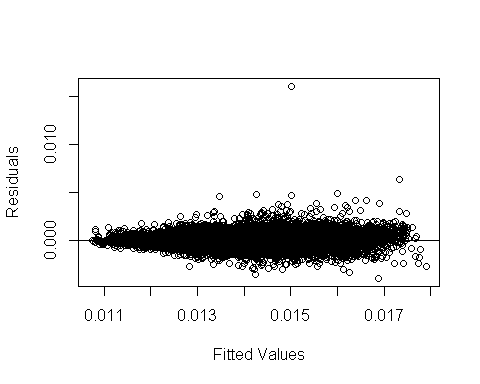
# Plot of Residuals vs. Fitted values:  
plot(fitted(log\_t),resid(log\_t),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



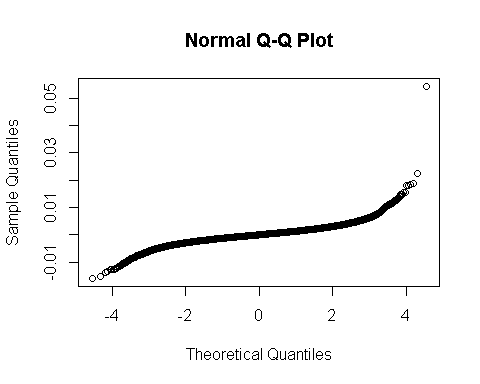
# Fifth, with reciprocal transformation  
rec\_t = lmer(recmicrovolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| RT.based\_Groups: time)+ (1| electrode: participant:   
 condition)+ location+ condition + RT.based\_Groups : location,  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(rec\_t))



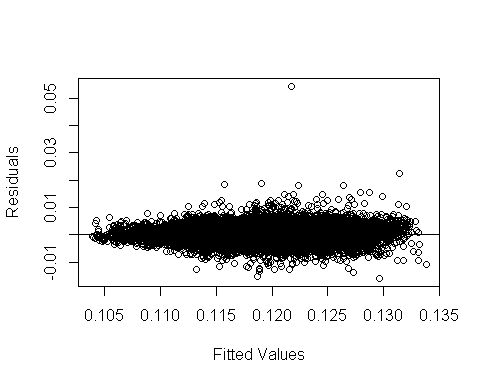
# Plot of Residuals vs. Fitted values:  
plot(fitted(rec\_t),resid(rec\_t),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



# Sixth, with reciprocal of the square root transformation  
recsq\_t = lmer(recsqrtmicrovolts ~ (1|participant)+ time+ (1|participant:   
 time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| RT.based\_Groups: time)+ (1| electrode: participant:   
 condition)+ location+ condition + RT.based\_Groups : location,  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(recsq\_t))



# Plot of Residuals vs. Fitted values:  
plot(fitted(recsq\_t),resid(recsq\_t),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



# CONCLUSION TRANSFORMATIONS: No transformation is applied because   
# none improve the residuals of the mixed models.  
  
  
# Later, must compare levels of the condition factor. Set contrasts.  
# (1) visual2visual vs others; (2) haptic2visual vs auditory2visual  
# For Quick RT.based\_Groups: contrast 1 expected sig, 2 expected non-sig  
# For Self-paced RT.based\_Groups: contrast 1 expected sig, 2 expected sig  
EEG.window1$conditionc = EEG.window1$condition  
contrasts(EEG.window1$conditionc) <- cbind(c(2,-1,-1), c(0,1,-1))  
contrasts(EEG.window1$conditionc)

## [,1] [,2]  
## visual2visual 2 0  
## auditory2visual -1 1  
## haptic2visual -1 -1

EEG.window2$conditionc = EEG.window2$condition  
contrasts(EEG.window2$conditionc) <- cbind(c(2,-1,-1), c(0,1,-1))  
contrasts(EEG.window2$conditionc)

## [,1] [,2]  
## visual2visual 2 0  
## auditory2visual -1 1  
## haptic2visual -1 -1

EEG.window3$conditionc = EEG.window3$condition  
contrasts(EEG.window3$conditionc) <- cbind(c(2,-1,-1), c(0,1,-1))  
contrasts(EEG.window3$conditionc)

## [,1] [,2]  
## visual2visual 2 0  
## auditory2visual -1 1  
## haptic2visual -1 -1

EEG.window4$conditionc = EEG.window4$condition  
contrasts(EEG.window4$conditionc) <- cbind(c(2,-1,-1), c(0,1,-1))  
contrasts(EEG.window4$conditionc)

## [,1] [,2]  
## visual2visual 2 0  
## auditory2visual -1 1  
## haptic2visual -1 -1

# In regard to these contrasts, note that no adjustment is necessary for   
# multiple comparisons because the main effect is only taken into account  
# in the mixed effects model. The aov is only used for the level contrasts.  
  
# save key objects for later  
saveRDS(EEG.window1, 'EEG.window1.rds')  
saveRDS(EEG.window2, 'EEG.window2.rds')  
saveRDS(EEG.window3, 'EEG.window3.rds')  
saveRDS(EEG.window4, 'EEG.window4.rds')  
  
# read in key objects  
EEG.window1 = readRDS('EEG.window1.rds')  
EEG.window2 = readRDS('EEG.window2.rds')  
EEG.window3 = readRDS('EEG.window3.rds')  
EEG.window4 = readRDS('EEG.window4.rds')  
  
# Note on EEG models:  
# Unlike with the RTs, in the EEG models there are no linguistic controls.  
# This is due to two reasons. First, letters and frequency were directly   
# controlled on the property words, where EEG is measured. Second, another  
# variable--semantic (LSA) distance--simply does not obtain with the EEG   
# precisely because this measurement starts and stops at the property word.   
# This last point, the location of the EEG measurement, indeed constitutes   
# one of the main enhancements of this design w/r to previous studies, as it  
# constrains the location of the effect--which clearly is core to word proc.  
  
# Different effect sizes are computed (not on the follow-ups per factor   
# level). First are marginal and conditional R^2 (MuMIn package):  
# r.squaredGLMM(m)  
  
# The second effect size is O^2(0) calculated as:  
# 1-var(residuals(m))/(var(model.response(model.frame(m))))  
  
# Last, in the follow-ups into condition, the t-statistic serves as eff size  
  
# Further, for each final model, a goodness of fit index is provided, by  
# means of the root mean squared error (RMSE.merMod(m, scale=))  
  
  
# WINDOW 1 (160-216 ms)  
summaryBy(microvolts ~ c(location, RT.based\_Groups, condition), EEG.window1)

## location RT.based\_Groups condition microvolts.mean  
## 1 anterior Quick visual2visual 0.4955634  
## 2 anterior Quick auditory2visual 0.3186655  
## 3 anterior Quick haptic2visual 0.4419782  
## 4 anterior Slow visual2visual 0.3027275  
## 5 anterior Slow auditory2visual 0.1523188  
## 6 anterior Slow haptic2visual 0.8017720  
## 7 posterior Quick visual2visual 1.5627811  
## 8 posterior Quick auditory2visual 1.2553707  
## 9 posterior Quick haptic2visual 1.3094691  
## 10 posterior Slow visual2visual 1.2164877  
## 11 posterior Slow auditory2visual 0.8368295  
## 12 posterior Slow haptic2visual 0.9310552

# First, setting in random effects structure  
m0 = lmer(microvolts ~ 1+ (1| participant),  
 data=EEG.window1,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0) # Departing from random intercepts Participant.  
 # Will be adding & commenting one by one.  
  
m0.01 = lmer(microvolts ~ 1+ (1| participant)+ (1|time),  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.01)  
anova(m0, m0.01) # random intercepts Time: IN (no random slopes because

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m0: microvolts ~ 1 + (1 | participant)  
## m0.01: microvolts ~ 1 + (1 | participant) + (1 | time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0 3 306626 306653 -153310 306620   
## m0.01 4 304884 304920 -152438 304876 1744.3 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

# all time points belong to a coherent window already)  
  
m0.010 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant:time), data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.010)  
anova(m0.01, m0.010) # random intercepts Time per ppt: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m0.01: microvolts ~ 1 + (1 | participant) + (1 | time)  
## m0.010: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.01 4 304884 304920 -152438 304876   
## m0.010 5 299195 299240 -149592 299185 5691 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.01, m0.010)

## df AIC  
## m0.01 4 304884.1  
## m0.010 5 299195.1

m0.1 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant:time)+ (1| electrode), data=EEG.window1,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.1)  
anova(m0.010, m0.1) # random intercepts Electrode: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m0.010: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time)  
## m0.1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1: (1 | electrode)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.010 5 299195 299240 -149592 299185   
## m0.1 6 294973 295027 -147480 294961 4224 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.010, m0.1)

## df AIC  
## m0.010 5 299195.1  
## m0.1 6 294973.0

m0.1b = lmer(microvolts ~ 1+ (1|participant) +(1|time)+   
 (1|participant:time)+ (1| electrode)+ (1|electrode: participant),  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.1, m0.1b) # random intercepts Electrode\*participant: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m0.1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1: (1 | electrode)  
## m0.1b: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1b: (1 | electrode) + (1 | electrode:participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.1 6 294973 295027 -147480 294961   
## m0.1b 7 264271 264334 -132129 264257 30703 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.1, m0.1b)

## df AIC  
## m0.1 6 294973.0  
## m0.1b 7 264271.6

m0.12 = lmer(microvolts ~ 1+ (1|participant) +(1|time) +  
 (1|participant:time) +(1| electrode)+ (1|electrode:participant)   
 + (1| condition: participant), data=EEG.window1,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.1b, m0.12)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m0.1b: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1b: (1 | electrode) + (1 | electrode:participant)  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.12: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.1b 7 264271 264334 -132129 264257   
## m0.12 8 253736 253807 -126860 253720 10538 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.1b, m0.12) # intercepts cond by participant: IN

## df AIC  
## m0.1b 7 264271.6  
## m0.12 8 253736.0

m0.121 = lmer(microvolts ~ 1+ (1|time)+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)   
 + (0+ condition| participant), data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m0.121) # slopes condition by participant: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.12: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant)  
## m0.121: microvolts ~ 1 + (1 | time) + (1 | participant:time) + (1 | electrode) +   
## m0.121: (1 | electrode:participant) + (0 + condition | participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m0.12 8 253736 253807 -126860 253720   
## m0.121 12 253743 253850 -126859 253719 0.924 4 0.9211

m1 = lmer(microvolts ~ 1+ (1|participant) +(1|time)+ (1|participant:time)  
 + (1| electrode)+ (1|electrode:participant)+ (1| condition:   
 participant)+ (1| RT.based\_Groups: time), data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m1) # intercepts RT.based\_Groups by time: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.12: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant)  
## m1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m1: (1 | RT.based\_Groups:time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m0.12 8 253736 253807 -126860 253720   
## m1 9 253738 253818 -126860 253720 0 1 1

m2.02 = lmer(microvolts ~ 1+ (1|participant) +(1|time)+ (1|participant:  
 time) +(1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode:participant:condition),   
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m2.02)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.12: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant)  
## m2.02: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m2.02: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.02: (1 | electrode:participant:condition)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.12 8 253736 253807 -126860 253720   
## m2.02 9 248061 248141 -124021 248043 5677.3 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.12, m2.02) # intercepts interaction elec\*ppt\*cond: IN

## df AIC  
## m0.12 8 253736.0  
## m2.02 9 248060.7

# Random effs structure set: m2.02. On to main effects:  
m2.022 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition),   
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m2.02, m2.022) # ME time: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m2.02: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m2.02: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.02: (1 | electrode:participant:condition)  
## m2.022: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m2.022: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.022: (1 | electrode:participant:condition)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m2.02 9 248061 248141 -124021 248043   
## m2.022 15 248047 248182 -124009 248017 25.143 6 0.0003213 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m2.02, m2.022)

## df AIC  
## m2.02 9 248060.7  
## m2.022 15 248056.7

m3 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location,   
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m2.022, m3)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m2.022: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m2.022: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.022: (1 | electrode:participant:condition)  
## m3: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m2.022 15 248047 248182 -124009 248017   
## m3 16 248039 248182 -124003 248007 10.495 1 0.001197 \*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m2.022, m3) # ME location: IN

## df AIC  
## m2.022 15 248056.7  
## m3 16 248049.4

m3.1 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + s\_Age\_months, data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.1)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.1: (1 | electrode:participant:condition) + location + s\_Age\_months  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3 16 248039 248182 -124003 248007   
## m3.1 17 248038 248190 -124002 248004 3.2473 1 0.07154 .  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m3, m3.1) # ME age: out

## df AIC  
## m3 16 248049.4  
## m3.1 17 248049.0

m3.4 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded, data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.4)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.4: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.4: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.4: (1 | electrode:participant:condition) + location + Lefthanded  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3 16 248039 248182 -124003 248007   
## m3.4 17 248034 248186 -124000 248000 6.7175 1 0.009547 \*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m3, m3.4) # ME handedness: IN

## df AIC  
## m3 16 248049.4  
## m3.4 17 248043.5

m3.42 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded + Gender,   
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.4, m3.42) # ME participant gender: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3.4: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.4: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.4: (1 | electrode:participant:condition) + location + Lefthanded  
## m3.42: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.42: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.42: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.42: Gender  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.4 17 248034 248186 -124000 248000   
## m3.42 18 248036 248197 -124000 248000 0.0216 1 0.8832

AIC(m3.4, m3.42)

## df AIC  
## m3.4 17 248043.5  
## m3.42 18 248044.4

# Maximal null model set: m3.4  
  
# ...and finally the critical variables...  
  
# CONDITION  
m3.50 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded + condition,   
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.4, m3.50) # ME cond: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3.4: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.4: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.4: (1 | electrode:participant:condition) + location + Lefthanded  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.50: condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.4 17 248034 248186 -124000 248000   
## m3.50 19 248037 248207 -123999 247999 1.3961 2 0.4976

# GROUP  
m3.7 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded +RT.based\_Groups,  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.4, m3.7) # ME RT.based\_Groups: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3.4: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.4: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.4: (1 | electrode:participant:condition) + location + Lefthanded  
## m3.7: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.7: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.7: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.7: RT.based\_Groups  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.4 17 248034 248186 -124000 248000   
## m3.7 18 248036 248197 -124000 248000 0.1407 1 0.7076

m3.8 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded + location : RT.based\_Groups,  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.4, m3.8) # int location \* RT.based\_Groups: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3.4: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.4: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.4: (1 | electrode:participant:condition) + location + Lefthanded  
## m3.8: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.8: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.8: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.8: location:RT.based\_Groups  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.4 17 248034 248186 -124000 248000   
## m3.8 19 248034 248204 -123998 247996 4.4068 2 0.1104

AIC(m3.4, m3.8)

## df AIC  
## m3.4 17 248043.5  
## m3.8 19 248044.1

m3.851 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded + condition: location,  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.4, m3.851) # int condition\*location: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3.4: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.4: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.4: (1 | electrode:participant:condition) + location + Lefthanded  
## m3.851: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.851: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.851: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.851: condition:location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3.4 17 248034 248186 -124000 248000   
## m3.851 21 247994 248182 -123976 247952 48.594 4 7.095e-10 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

# interactions w/ condition  
m3.86 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded + location : condition +   
 condition : Lefthanded,  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.851, m3.86)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3.851: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.851: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.851: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.851: condition:location  
## m3.86: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.86: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.86: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.86: location:condition + condition:Lefthanded  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.851 21 247994 248182 -123976 247952   
## m3.86 23 247996 248203 -123975 247950 1.0839 2 0.5816

AIC(m3.851, m3.86) # int condition \* handedness: out

## df AIC  
## m3.851 21 248012.3  
## m3.86 23 248013.3

m3.87 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+  
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded + location : condition +   
 condition : s\_Age\_months,  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.851, m3.87)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3.851: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.851: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.851: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.851: condition:location  
## m3.87: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.87: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.87: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.87: location:condition + condition:s\_Age\_months  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3.851 21 247994 248182 -123976 247952   
## m3.87 24 247992 248207 -123972 247944 7.721 3 0.05214 .  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m3.851, m3.87) # int condition \* age: out

## df AIC  
## m3.851 21 248012.3  
## m3.87 24 248014.2

m3.88 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded + location : condition +   
 condition: Gender,  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.851, m3.88)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3.851: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.851: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.851: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.851: condition:location  
## m3.88: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.88: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.88: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.88: location:condition + condition:Gender  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.851 21 247994 248182 -123976 247952   
## m3.88 24 247999 248214 -123975 247951 0.8291 3 0.8425

AIC(m3.851, m3.88) # int condition \* gender: out

## df AIC  
## m3.851 21 248012.3  
## m3.88 24 248015.2

# CONDITION \* GROUP  
m3.9 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded + location : condition +  
 condition: RT.based\_Groups,  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.851, m3.9) # int RT.based\_Groups \* condition: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window1  
## Models:  
## m3.851: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.851: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.851: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.851: condition:location  
## m3.9: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.9: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.9: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.9: location:condition + condition:RT.based\_Groups  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.851 21 247994 248182 -123976 247952   
## m3.9 24 247999 248214 -123975 247951 0.5845 3 0.9

AIC(m3.851, m3.9)

## df AIC  
## m3.851 21 248012.3  
## m3.9 24 248016.8

# ...int w/ location  
m3.91 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded + location : condition +   
 condition: RT.based\_Groups: location,  
 data=EEG.window1,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.851, m3.91) # int RT.based\_Groups \* condition \* location: IN

## refitting model(s) with ML (instead of REML)

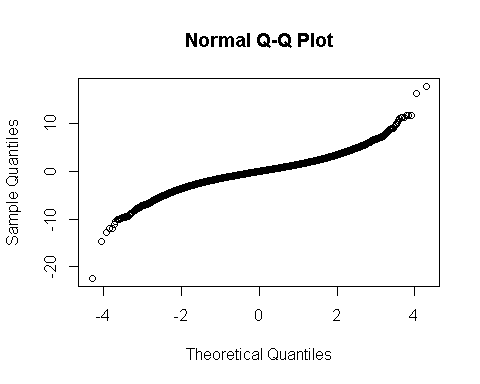
## Data: EEG.window1  
## Models:  
## m3.851: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.851: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.851: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.851: condition:location  
## m3.91: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.91: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.91: (1 | electrode:participant:condition) + location + Lefthanded +   
## m3.91: location:condition + condition:RT.based\_Groups:location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3.851 21 247994 248182 -123976 247952   
## m3.91 27 247982 248224 -123964 247928 23.63 6 0.0006108 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

# Conclusion window 1 overall. Model m3.91 chosen:   
summary(m3.91)

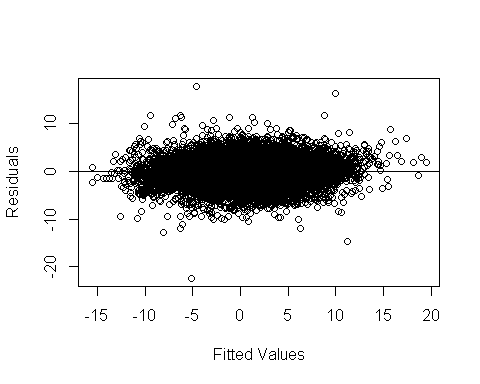
## Linear mixed model fit by REML ['lmerMod']  
## Formula: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## (1 | electrode:participant:condition) + location + Lefthanded +   
## location:condition + condition:RT.based\_Groups:location  
## Data: EEG.window1  
## Control: lmerControl(optCtrl = list(maxfun = 1e+07))  
##   
## REML criterion at convergence: 247951.7  
##   
## Scaled residuals:   
## Min 1Q Median 3Q Max   
## -12.4382 -0.5260 0.0057 0.5330 9.9012   
##   
## Random effects:  
## Groups Name Variance Std.Dev.  
## electrode:participant:condition (Intercept) 1.1499 1.0723   
## electrode:participant (Intercept) 4.5726 2.1384   
## participant:time (Intercept) 1.5606 1.2493   
## condition:participant (Intercept) 1.3069 1.1432   
## electrode (Intercept) 0.5602 0.7485   
## participant (Intercept) 2.4286 1.5584   
## Residual 3.2673 1.8076   
## Number of obs: 57408, groups:   
## electrode:participant:condition, 7176; electrode:participant, 2392; participant:time, 368; condition:participant, 138; electrode, 52; participant, 46  
##   
## Fixed effects:  
## Estimate Std. Error t value  
## (Intercept) -0.46396 0.49302 -0.941  
## time168 0.20692 0.26223 0.789  
## time176 0.21642 0.26223 0.825  
## time184 0.25992 0.26223 0.991  
## time192 0.65548 0.26223 2.500  
## time200 0.97118 0.26223 3.704  
## time208 1.47777 0.26223 5.635  
## time216 1.77135 0.26223 6.755  
## locationposterior 1.06722 0.25218 4.232  
## LefthandedY 2.02891 0.77791 2.608  
## locationanterior:conditionauditory2visual -0.17690 0.34475 -0.513  
## locationposterior:conditionauditory2visual -0.30741 0.34475 -0.892  
## locationanterior:conditionhaptic2visual -0.05359 0.34475 -0.155  
## locationposterior:conditionhaptic2visual -0.25331 0.34475 -0.735  
## locationanterior:conditionvisual2visual:RT.based\_GroupsSlow -0.19284 0.60191 -0.320  
## locationposterior:conditionvisual2visual:RT.based\_GroupsSlow -0.34629 0.60191 -0.575  
## locationanterior:conditionauditory2visual:RT.based\_GroupsSlow -0.16635 0.60191 -0.276  
## locationposterior:conditionauditory2visual:RT.based\_GroupsSlow -0.41854 0.60191 -0.695  
## locationanterior:conditionhaptic2visual:RT.based\_GroupsSlow 0.35979 0.60191 0.598  
## locationposterior:conditionhaptic2visual:RT.based\_GroupsSlow -0.37841 0.60191 -0.629

##   
## Correlation matrix not shown by default, as p = 20 > 12.  
## Use print(x, correlation=TRUE) or  
## vcov(x) if you need it

# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(m3.91))



# Plot of Residuals vs. Fitted values:  
plot(fitted(m3.91),resid(m3.91),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



# Fit  
1-var(residuals(m3.91))/(var(model.response(model.frame(m3.91)))) # Omega^2

## [1] 0.8129712

r.squaredGLMM(m3.91) # R2m: fixed effs. R2c: fixed + random effs

## R2m R2c   
## 0.06529972 0.79429467

RMSE.merMod(m3.91, scale = FALSE) # Root MSE

## [1] 1.70711

png(file="Fixef win 1.png", units="in", width=7, height=5, res=500)  
plotFEsim(FEsim(m3.91))  
dev.off()

## png   
## 2

# Note for all follow-ups:  
# Handedness will not feature in the follow-up anovas because it is not  
# accepted due to insufficient variation (only 3 left-handed per RT.based\_Groups).   
  
# Freeing up workspace  
rm(list=setdiff(ls(), c("EEG", "EEG.window1", "EEG.window2",  
 "EEG.window3", "EEG.window4")))  
  
  
# Follow-up ANOVAs into condition in each RT.based\_Groups and location. Effects are  
# based on general window 1. See contrasts 1 and 2 at the bottom.  
# Contrast 1 = visual2visual - (haptic2visual + auditory2visual)  
# Contrast 2 = auditory2visual - haptic2visual  
  
# Anterior regions, Quick group:   
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window1[EEG.window1$location=='anterior'  
 & EEG.window1$RT.based\_Groups=='Quick',])  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window1[EEG.window1$location == "anterior" & EEG.window1$RT.based\_Groups ==   
## "Quick", ])  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -22.4582 -1.7861 0.0687 1.8530 18.2914   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 1.29464 0.17811 7.269 3.82e-13 \*\*\*  
## time168 0.38927 0.09607 4.052 5.10e-05 \*\*\*  
## time176 0.30771 0.09607 3.203 0.00136 \*\*   
## time184 0.29024 0.09607 3.021 0.00252 \*\*   
## time192 0.63784 0.09607 6.640 3.26e-11 \*\*\*  
## time200 0.83610 0.09607 8.703 < 2e-16 \*\*\*  
## time208 1.17493 0.09607 12.230 < 2e-16 \*\*\*  
## time216 1.31147 0.09607 13.652 < 2e-16 \*\*\*  
## participant12 1.55356 0.16289 9.538 < 2e-16 \*\*\*  
## participant13 0.46894 0.16289 2.879 0.00400 \*\*   
## participant17 -3.19200 0.16289 -19.596 < 2e-16 \*\*\*  
## participant18 -2.88302 0.16289 -17.699 < 2e-16 \*\*\*  
## participant20 -2.62650 0.16289 -16.124 < 2e-16 \*\*\*  
## participant26 -1.93698 0.16289 -11.891 < 2e-16 \*\*\*  
## participant27 -2.08581 0.16289 -12.805 < 2e-16 \*\*\*  
## participant28 -3.59261 0.16289 -22.056 < 2e-16 \*\*\*  
## participant3 0.99370 0.16289 6.100 1.08e-09 \*\*\*  
## participant30 -3.61048 0.16289 -22.165 < 2e-16 \*\*\*  
## participant31 2.24071 0.16289 13.756 < 2e-16 \*\*\*  
## participant32 3.10314 0.16289 19.051 < 2e-16 \*\*\*  
## participant36 -6.51331 0.16289 -39.986 < 2e-16 \*\*\*  
## participant38 4.30140 0.16289 26.407 < 2e-16 \*\*\*  
## participant40 0.68312 0.16289 4.194 2.76e-05 \*\*\*  
## participant44 0.75838 0.16289 4.656 3.26e-06 \*\*\*  
## participant46 -7.02807 0.16289 -43.146 < 2e-16 \*\*\*  
## participant47 -5.55453 0.16289 -34.100 < 2e-16 \*\*\*  
## participant48 -4.98084 0.16289 -30.578 < 2e-16 \*\*\*  
## participant49 4.26441 0.16289 26.180 < 2e-16 \*\*\*  
## participant50 -2.26382 0.16289 -13.898 < 2e-16 \*\*\*  
## participant8 -4.16187 0.16289 -25.550 < 2e-16 \*\*\*  
## electrodeC13 -0.16106 0.17319 -0.930 0.35239   
## electrodeC14 -0.55004 0.17319 -3.176 0.00150 \*\*   
## electrodeC19 -0.71467 0.17319 -4.127 3.70e-05 \*\*\*  
## electrodeC2 1.15883 0.17319 6.691 2.30e-11 \*\*\*  
## electrodeC20 -1.27940 0.17319 -7.387 1.58e-13 \*\*\*  
## electrodeC21 -1.66233 0.17319 -9.598 < 2e-16 \*\*\*  
## electrodeC24 -0.98709 0.17319 -5.700 1.22e-08 \*\*\*  
## electrodeC25 -1.47136 0.17319 -8.496 < 2e-16 \*\*\*  
## electrodeC31 0.90872 0.17319 5.247 1.57e-07 \*\*\*  
## electrodeC34 1.41362 0.17319 8.162 3.56e-16 \*\*\*  
## electrodeC38 1.03127 0.17319 5.955 2.67e-09 \*\*\*  
## electrodeC39 0.47699 0.17319 2.754 0.00589 \*\*   
## electrodeC44 0.75339 0.17319 4.350 1.37e-05 \*\*\*  
## electrodeC45 0.35132 0.17319 2.029 0.04252 \*   
## electrodeC46 -0.35968 0.17319 -2.077 0.03783 \*   
## electrodeC51 0.24340 0.17319 1.405 0.15993   
## electrodeC52 -0.15482 0.17319 -0.894 0.37137   
## electrodeC53 -0.97909 0.17319 -5.653 1.60e-08 \*\*\*  
## electrodeC56 -0.02252 0.17319 -0.130 0.89652   
## electrodeC57 0.20928 0.17319 1.208 0.22692   
## electrodeC58 0.10366 0.17319 0.599 0.54948   
## electrodeC59 -0.51331 0.17319 -2.964 0.00304 \*\*   
## electrodeC6 0.55687 0.17319 3.215 0.00131 \*\*   
## electrodeC60 -1.31651 0.17319 -7.602 3.11e-14 \*\*\*  
## electrodeC7 0.35590 0.17319 2.055 0.03990 \*   
## conditionc1 0.03841 0.01698 2.262 0.02371 \*   
## conditionc2 -0.06166 0.02941 -2.096 0.03609 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.877 on 14295 degrees of freedom  
## Multiple R-squared: 0.5791, Adjusted R-squared: 0.5774   
## F-statistic: 351.2 on 56 and 14295 DF, p-value: < 2.2e-16

# Anterior regions, Slow group:   
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window1[EEG.window1$location=='anterior'  
 & EEG.window1$RT.based\_Groups=='Slow',])  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window1[EEG.window1$location == "anterior" & EEG.window1$RT.based\_Groups ==   
## "Slow", ])  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -10.7339 -1.6618 -0.0136 1.6506 11.0105   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -4.31445 0.16223 -26.595 < 2e-16 \*\*\*  
## time168 0.29305 0.08750 3.349 0.000813 \*\*\*  
## time176 0.20051 0.08750 2.292 0.021947 \*   
## time184 -0.03029 0.08750 -0.346 0.729179   
## time192 0.12405 0.08750 1.418 0.156297   
## time200 0.53687 0.08750 6.136 8.70e-10 \*\*\*  
## time208 1.12441 0.08750 12.850 < 2e-16 \*\*\*  
## time216 1.57913 0.08750 18.047 < 2e-16 \*\*\*  
## participant11 7.33588 0.14836 49.445 < 2e-16 \*\*\*  
## participant14 6.46272 0.14836 43.560 < 2e-16 \*\*\*  
## participant15 7.20092 0.14836 48.535 < 2e-16 \*\*\*  
## participant16 4.72582 0.14836 31.853 < 2e-16 \*\*\*  
## participant19 4.24648 0.14836 28.622 < 2e-16 \*\*\*  
## participant2 3.57137 0.14836 24.072 < 2e-16 \*\*\*  
## participant21 1.09961 0.14836 7.412 1.32e-13 \*\*\*  
## participant22 0.91932 0.14836 6.196 5.94e-10 \*\*\*  
## participant23 2.76429 0.14836 18.632 < 2e-16 \*\*\*  
## participant24 8.05848 0.14836 54.316 < 2e-16 \*\*\*  
## participant29 7.29910 0.14836 49.197 < 2e-16 \*\*\*  
## participant34 6.21477 0.14836 41.889 < 2e-16 \*\*\*  
## participant35 -0.39813 0.14836 -2.683 0.007294 \*\*   
## participant37 3.84890 0.14836 25.942 < 2e-16 \*\*\*  
## participant39 5.85119 0.14836 39.438 < 2e-16 \*\*\*  
## participant4 3.74153 0.14836 25.219 < 2e-16 \*\*\*  
## participant41 6.80537 0.14836 45.869 < 2e-16 \*\*\*  
## participant42 4.94281 0.14836 33.315 < 2e-16 \*\*\*  
## participant45 3.77695 0.14836 25.457 < 2e-16 \*\*\*  
## participant5 2.60745 0.14836 17.575 < 2e-16 \*\*\*  
## participant6 3.01009 0.14836 20.289 < 2e-16 \*\*\*  
## participant9 6.85076 0.14836 46.175 < 2e-16 \*\*\*  
## electrodeC13 -0.16111 0.15774 -1.021 0.307112   
## electrodeC14 -0.46747 0.15774 -2.963 0.003047 \*\*   
## electrodeC19 -0.50955 0.15774 -3.230 0.001240 \*\*   
## electrodeC2 0.93031 0.15774 5.898 3.77e-09 \*\*\*  
## electrodeC20 -0.86497 0.15774 -5.483 4.24e-08 \*\*\*  
## electrodeC21 -1.32090 0.15774 -8.374 < 2e-16 \*\*\*  
## electrodeC24 -0.89729 0.15774 -5.688 1.31e-08 \*\*\*  
## electrodeC25 -1.11231 0.15774 -7.051 1.85e-12 \*\*\*  
## electrodeC31 1.08409 0.15774 6.872 6.57e-12 \*\*\*  
## electrodeC34 0.98376 0.15774 6.236 4.60e-10 \*\*\*  
## electrodeC38 1.24184 0.15774 7.873 3.72e-15 \*\*\*  
## electrodeC39 0.52559 0.15774 3.332 0.000865 \*\*\*  
## electrodeC44 0.42826 0.15774 2.715 0.006637 \*\*   
## electrodeC45 0.28146 0.15774 1.784 0.074399 .   
## electrodeC46 -0.38573 0.15774 -2.445 0.014485 \*   
## electrodeC51 -0.25622 0.15774 -1.624 0.104335   
## electrodeC52 -0.49231 0.15774 -3.121 0.001806 \*\*   
## electrodeC53 -1.18531 0.15774 -7.514 6.07e-14 \*\*\*  
## electrodeC56 -0.54269 0.15774 -3.440 0.000583 \*\*\*  
## electrodeC57 -0.64144 0.15774 -4.066 4.80e-05 \*\*\*  
## electrodeC58 0.22025 0.15774 1.396 0.162660   
## electrodeC59 -0.60966 0.15774 -3.865 0.000112 \*\*\*  
## electrodeC6 1.21715 0.15774 7.716 1.28e-14 \*\*\*  
## electrodeC60 -1.20110 0.15774 -7.614 2.82e-14 \*\*\*  
## electrodeC7 0.26223 0.15774 1.662 0.096453 .   
## conditionc1 -0.05811 0.01547 -3.757 0.000173 \*\*\*  
## conditionc2 -0.32473 0.02679 -12.121 < 2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.621 on 14295 degrees of freedom  
## Multiple R-squared: 0.5003, Adjusted R-squared: 0.4984   
## F-statistic: 255.6 on 56 and 14295 DF, p-value: < 2.2e-16

# Posterior regions, Quick group:   
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window1[EEG.window1$location=='posterior'  
 & EEG.window1$RT.based\_Groups=='Quick',])  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window1[EEG.window1$location == "posterior" &   
## EEG.window1$RT.based\_Groups == "Quick", ])  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -16.765 -1.966 0.061 1.948 22.320   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 3.00015 0.20124 14.908 < 2e-16 \*\*\*  
## time168 0.16571 0.10854 1.527 0.126846   
## time176 0.26986 0.10854 2.486 0.012922 \*   
## time184 0.58969 0.10854 5.433 5.64e-08 \*\*\*  
## time192 1.15820 0.10854 10.671 < 2e-16 \*\*\*  
## time200 1.55411 0.10854 14.318 < 2e-16 \*\*\*  
## time208 1.97549 0.10854 18.200 < 2e-16 \*\*\*  
## time216 2.22000 0.10854 20.453 < 2e-16 \*\*\*  
## participant12 -2.33184 0.18404 -12.670 < 2e-16 \*\*\*  
## participant13 -3.49137 0.18404 -18.971 < 2e-16 \*\*\*  
## participant17 -2.84950 0.18404 -15.483 < 2e-16 \*\*\*  
## participant18 0.76226 0.18404 4.142 3.47e-05 \*\*\*  
## participant20 -1.02547 0.18404 -5.572 2.56e-08 \*\*\*  
## participant26 -2.84011 0.18404 -15.432 < 2e-16 \*\*\*  
## participant27 0.91046 0.18404 4.947 7.62e-07 \*\*\*  
## participant28 -4.17505 0.18404 -22.686 < 2e-16 \*\*\*  
## participant3 -4.65609 0.18404 -25.299 < 2e-16 \*\*\*  
## participant30 -1.51231 0.18404 -8.217 2.26e-16 \*\*\*  
## participant31 -0.85038 0.18404 -4.621 3.86e-06 \*\*\*  
## participant32 -3.09164 0.18404 -16.799 < 2e-16 \*\*\*  
## participant36 -2.02072 0.18404 -10.980 < 2e-16 \*\*\*  
## participant38 0.47351 0.18404 2.573 0.010096 \*   
## participant40 -3.37717 0.18404 -18.350 < 2e-16 \*\*\*  
## participant44 -0.68688 0.18404 -3.732 0.000191 \*\*\*  
## participant46 -3.81579 0.18404 -20.733 < 2e-16 \*\*\*  
## participant47 1.64445 0.18404 8.935 < 2e-16 \*\*\*  
## participant48 -6.10524 0.18404 -33.173 < 2e-16 \*\*\*  
## participant49 0.63038 0.18404 3.425 0.000616 \*\*\*  
## participant50 -6.00077 0.18404 -32.606 < 2e-16 \*\*\*  
## participant8 -4.25680 0.18404 -23.130 < 2e-16 \*\*\*  
## electrodeC10 -0.80044 0.19567 -4.091 4.33e-05 \*\*\*  
## electrodeC15 0.45378 0.19567 2.319 0.020406 \*   
## electrodeC16 -0.56435 0.19567 -2.884 0.003931 \*\*   
## electrodeC17 -1.95585 0.19567 -9.995 < 2e-16 \*\*\*  
## electrodeC22 -0.91420 0.19567 -4.672 3.01e-06 \*\*\*  
## electrodeC23 -1.68109 0.19567 -8.591 < 2e-16 \*\*\*  
## electrodeC26 -0.48943 0.19567 -2.501 0.012386 \*   
## electrodeC27 -0.08144 0.19567 -0.416 0.677285   
## electrodeC28 0.10440 0.19567 0.534 0.593667   
## electrodeC29 0.11544 0.19567 0.590 0.555235   
## electrodeC3 0.13453 0.19567 0.688 0.491770   
## electrodeC33 0.16596 0.19567 0.848 0.396384   
## electrodeC35 0.14921 0.19567 0.763 0.445737   
## electrodeC36 -0.22410 0.19567 -1.145 0.252119   
## electrodeC4 -0.22464 0.19567 -1.148 0.250974   
## electrodeC40 0.18681 0.19567 0.955 0.339739   
## electrodeC41 -0.31327 0.19567 -1.601 0.109401   
## electrodeC42 -1.01029 0.19567 -5.163 2.46e-07 \*\*\*  
## electrodeC47 -0.36202 0.19567 -1.850 0.064317 .   
## electrodeC48 -1.62277 0.19567 -8.293 < 2e-16 \*\*\*  
## electrodeC49 -1.82595 0.19567 -9.332 < 2e-16 \*\*\*  
## electrodeC54 -0.86740 0.19567 -4.433 9.37e-06 \*\*\*  
## electrodeC55 -1.99134 0.19567 -10.177 < 2e-16 \*\*\*  
## electrodeC8 0.37953 0.19567 1.940 0.052451 .   
## electrodeC9 0.23911 0.19567 1.222 0.221730   
## conditionc1 0.09345 0.01919 4.871 1.12e-06 \*\*\*  
## conditionc2 -0.02705 0.03323 -0.814 0.415711   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 3.251 on 14295 degrees of freedom  
## Multiple R-squared: 0.364, Adjusted R-squared: 0.3615   
## F-statistic: 146.1 on 56 and 14295 DF, p-value: < 2.2e-16

# Posterior regions, Slow group:   
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window1[EEG.window1$location=='posterior'  
 & EEG.window1$RT.based\_Groups=='Slow',])  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window1[EEG.window1$location == "posterior" &   
## EEG.window1$RT.based\_Groups == "Slow", ])  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -16.0869 -1.8549 0.0346 1.8860 12.7423   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.984293 0.185440 5.308 1.13e-07 \*\*\*  
## time168 -0.020347 0.100019 -0.203 0.838800   
## time176 0.087602 0.100019 0.876 0.381124   
## time184 0.190039 0.100019 1.900 0.057449 .   
## time192 0.701841 0.100019 7.017 2.37e-12 \*\*\*  
## time200 0.957648 0.100019 9.575 < 2e-16 \*\*\*  
## time208 1.636252 0.100019 16.359 < 2e-16 \*\*\*  
## time216 1.974796 0.100019 19.744 < 2e-16 \*\*\*  
## participant11 0.104114 0.169590 0.614 0.539279   
## participant14 3.387269 0.169590 19.973 < 2e-16 \*\*\*  
## participant15 0.692945 0.169590 4.086 4.41e-05 \*\*\*  
## participant16 0.521430 0.169590 3.075 0.002111 \*\*   
## participant19 2.097581 0.169590 12.369 < 2e-16 \*\*\*  
## participant2 -0.019013 0.169590 -0.112 0.910737   
## participant21 -1.150274 0.169590 -6.783 1.23e-11 \*\*\*  
## participant22 -0.515077 0.169590 -3.037 0.002392 \*\*   
## participant23 -1.763322 0.169590 -10.398 < 2e-16 \*\*\*  
## participant24 0.006167 0.169590 0.036 0.970995   
## participant29 -0.617285 0.169590 -3.640 0.000274 \*\*\*  
## participant34 1.633168 0.169590 9.630 < 2e-16 \*\*\*  
## participant35 -0.226400 0.169590 -1.335 0.181903   
## participant37 -0.369686 0.169590 -2.180 0.029283 \*   
## participant39 -2.481665 0.169590 -14.633 < 2e-16 \*\*\*  
## participant4 -1.360071 0.169590 -8.020 1.14e-15 \*\*\*  
## participant41 0.470255 0.169590 2.773 0.005563 \*\*   
## participant42 -0.320170 0.169590 -1.888 0.059058 .   
## participant45 -0.023454 0.169590 -0.138 0.890008   
## participant5 0.113914 0.169590 0.672 0.501782   
## participant6 -0.269672 0.169590 -1.590 0.111825   
## participant9 -1.314730 0.169590 -7.752 9.62e-15 \*\*\*  
## electrodeC10 -0.481648 0.180311 -2.671 0.007567 \*\*   
## electrodeC15 0.555629 0.180311 3.081 0.002064 \*\*   
## electrodeC16 -0.283422 0.180311 -1.572 0.116008   
## electrodeC17 -1.579640 0.180311 -8.761 < 2e-16 \*\*\*  
## electrodeC22 -0.921785 0.180311 -5.112 3.23e-07 \*\*\*  
## electrodeC23 -1.626898 0.180311 -9.023 < 2e-16 \*\*\*  
## electrodeC26 -1.187400 0.180311 -6.585 4.70e-11 \*\*\*  
## electrodeC27 -0.132894 0.180311 -0.737 0.461120   
## electrodeC28 0.256501 0.180311 1.423 0.154891   
## electrodeC29 0.058835 0.180311 0.326 0.744206   
## electrodeC3 0.262042 0.180311 1.453 0.146169   
## electrodeC33 -0.051480 0.180311 -0.286 0.775262   
## electrodeC35 0.088817 0.180311 0.493 0.622319   
## electrodeC36 -0.235908 0.180311 -1.308 0.190780   
## electrodeC4 -0.235738 0.180311 -1.307 0.191100   
## electrodeC40 0.358999 0.180311 1.991 0.046501 \*   
## electrodeC41 -0.843550 0.180311 -4.678 2.92e-06 \*\*\*  
## electrodeC42 -1.184460 0.180311 -6.569 5.24e-11 \*\*\*  
## electrodeC47 -1.123054 0.180311 -6.228 4.84e-10 \*\*\*  
## electrodeC48 -2.195344 0.180311 -12.175 < 2e-16 \*\*\*  
## electrodeC49 -2.115393 0.180311 -11.732 < 2e-16 \*\*\*  
## electrodeC54 -1.911794 0.180311 -10.603 < 2e-16 \*\*\*  
## electrodeC55 -2.520541 0.180311 -13.979 < 2e-16 \*\*\*  
## electrodeC8 0.866339 0.180311 4.805 1.57e-06 \*\*\*  
## electrodeC9 0.078391 0.180311 0.435 0.663747   
## conditionc1 0.110848 0.017681 6.269 3.73e-10 \*\*\*  
## conditionc2 -0.047113 0.030624 -1.538 0.123970   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.996 on 14295 degrees of freedom  
## Multiple R-squared: 0.245, Adjusted R-squared: 0.242   
## F-statistic: 82.83 on 56 and 14295 DF, p-value: < 2.2e-16

# WINDOW 2 (270-370 ms)  
summaryBy(microvolts ~ c(location, RT.based\_Groups, condition), EEG.window2)

## location RT.based\_Groups condition microvolts.mean  
## 1 anterior Quick visual2visual -1.636597  
## 2 anterior Quick auditory2visual -2.124135  
## 3 anterior Quick haptic2visual -2.146497  
## 4 anterior Slow visual2visual -1.322524  
## 5 anterior Slow auditory2visual -1.683525  
## 6 anterior Slow haptic2visual -1.558184  
## 7 posterior Quick visual2visual 2.386898  
## 8 posterior Quick auditory2visual 1.592109  
## 9 posterior Quick haptic2visual 2.005750  
## 10 posterior Slow visual2visual 2.464641  
## 11 posterior Slow auditory2visual 2.059337  
## 12 posterior Slow haptic2visual 1.602282

# First, setting in random effects structure  
m0 = lmer(microvolts ~ 1+ (1| participant),  
 data=EEG.window2,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0) # Departing from random intercepts Participant.  
 # Will be adding & commenting one by one.  
  
m0.01 = lmer(microvolts ~ 1+ (1| participant)+ (1|time),  
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.01)  
anova(m0, m0.01) # random intercepts Time: IN (no random slopes because

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m0: microvolts ~ 1 + (1 | participant)  
## m0.01: microvolts ~ 1 + (1 | participant) + (1 | time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0 3 527290 527318 -263642 527284   
## m0.01 4 524521 524559 -262257 524513 2770.4 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

# all time points already belong to a coherent window)  
  
m0.010 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant:time), data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.010)  
anova(m0.01, m0.010) # random intercepts Time per ppt: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m0.01: microvolts ~ 1 + (1 | participant) + (1 | time)  
## m0.010: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.01 4 524521 524559 -262257 524513   
## m0.010 5 519893 519940 -259942 519883 4630 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.01, m0.010)

## df AIC  
## m0.01 4 524521.2  
## m0.010 5 519893.2

m0.1 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant:time)+ (1| electrode), data=EEG.window2,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.1)  
anova(m0.010, m0.1) # random intercepts Electrode: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m0.010: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time)  
## m0.1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1: (1 | electrode)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.010 5 519893 519940 -259942 519883   
## m0.1 6 488207 488263 -244097 488195 31689 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.010, m0.1)

## df AIC  
## m0.010 5 519893.2  
## m0.1 6 488206.3

m0.1b = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant:time)+ (1| electrode)+   
 (1| electrode:participant), data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.1, m0.1b) # random intercepts Electrode\*participant: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m0.1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1: (1 | electrode)  
## m0.1b: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1b: (1 | electrode) + (1 | electrode:participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.1 6 488207 488263 -244097 488195   
## m0.1b 7 427358 427424 -213672 427344 60851 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.1, m0.1b)

## df AIC  
## m0.1 6 488206.3  
## m0.1b 7 427357.7

m0.102 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)+   
 (1|participant:time)+ (1| electrode)+ (1| electrode:participant)   
 +(1+location |participant)+ (1| condition: participant),   
 data=EEG.window2,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.1b, m0.102)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m0.1b: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1b: (1 | electrode) + (1 | electrode:participant)  
## m0.102: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.102: (1 | electrode) + (1 | electrode:participant) + (1 + location |   
## m0.102: participant) + (1 | condition:participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.1b 7 427358 427424 -213672 427344   
## m0.102 11 409740 409844 -204859 409718 17626 4 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.1b, m0.102) # intercepts cond: IN

## df AIC  
## m0.1b 7 427357.7  
## m0.102 11 409739.8

m0.12 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)+   
 (1|participant:time)+ (1| electrode)+ (1| electrode:participant)  
 + (1| condition: participant), data=EEG.window2,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.102, m0.12)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.12: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant)  
## m0.102: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.102: (1 | electrode) + (1 | electrode:participant) + (1 + location |   
## m0.102: participant) + (1 | condition:participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.12 8 410839 410915 -205412 410823   
## m0.102 11 409740 409844 -204859 409718 1105.5 3 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.102, m0.12) # intercepts cond by participant: IN

## df AIC  
## m0.102 11 409739.8  
## m0.12 8 410838.8

m0.121 = lmer(microvolts ~ 1+ (1|time)+ (1|participant:time)+   
 (1| electrode)+ (1| electrode:participant)  
 +(1+ condition| participant), data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m0.121) # slopes condition by participant: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.12: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant)  
## m0.121: microvolts ~ 1 + (1 | time) + (1 | participant:time) + (1 | electrode) +   
## m0.121: (1 | electrode:participant) + (1 + condition | participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m0.12 8 410839 410915 -205412 410823   
## m0.121 12 410845 410958 -205410 410821 2.5199 4 0.6411

m1 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)+ (1|participant:  
 time)+ (1| electrode)+ (1| electrode:participant)+  
 (1| condition: participant)+ (1| RT.based\_Groups: time),  
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m1) # random intercepts RT.based\_Groups by time: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.12: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant)  
## m1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m1: (1 | RT.based\_Groups:time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m0.12 8 410839 410915 -205412 410823   
## m1 9 410841 410926 -205412 410823 0 1 1

m2.02 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)+ (1|participant:  
 time)+ (1| electrode)+ (1|electrode:participant)+ (1| condition:   
 participant)+ (1| electrode: participant: condition),  
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m2.02)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.12: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant)  
## m2.02: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m2.02: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.02: (1 | electrode:participant:condition)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.12 8 410839 410915 -205412 410823   
## m2.02 9 394058 394143 -197020 394040 16783 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.12, m2.02) # intercepts interaction elec\*ppt\*cond: IN

## df AIC  
## m0.12 8 410838.8  
## m2.02 9 394057.4

# Random effs structure set: m2.02. On to main effects:  
m2.022 = lmer(microvolts ~ 1+ (1| participant)+ time+ (1|participant:  
 time)+ (1| electrode)+ (1|electrode:participant)+ (1| condition:   
 participant)+ (1| electrode: participant: condition),  
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m2.02, m2.022) # ME time: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m2.02: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m2.02: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.02: (1 | electrode:participant:condition)  
## m2.022: microvolts ~ 1 + (1 | participant) + time + (1 | participant:time) +   
## m2.022: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.022: (1 | electrode:participant:condition)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m2.02 9 394058 394143 -197020 394040   
## m2.022 20 394031 394220 -196996 393991 48.625 11 1.104e-06 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m2.02, m2.022)

## df AIC  
## m2.02 9 394057.4  
## m2.022 20 394050.2

m3 = lmer(microvolts ~ 1+ (1| participant)+ time+ (1|participant: time)  
 + (1| electrode)+ (1|electrode:participant)+ (1| condition:   
 participant)+ (1| electrode: participant: condition)+ location,  
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m2.022, m3)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m2.022: microvolts ~ 1 + (1 | participant) + time + (1 | participant:time) +   
## m2.022: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.022: (1 | electrode:participant:condition)  
## m3: microvolts ~ 1 + (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m2.022 20 394031 394220 -196996 393991   
## m3 21 393949 394148 -196954 393907 83.909 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m2.022, m3) # ME location: IN

## df AIC  
## m2.022 20 394050.2  
## m3 21 393969.5

m3.1 = lmer(microvolts ~ 1+ (1| participant)+ time+ (1|participant:time)  
 + (1| electrode)+ (1|electrode:participant)+ (1| condition:   
 participant)+ (1| electrode: participant: condition)+ location  
 + s\_Age\_months, data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.1) # ME age: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3: microvolts ~ 1 + (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.1: microvolts ~ 1 + (1 | participant) + time + (1 | participant:time) +   
## m3.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.1: (1 | electrode:participant:condition) + location + s\_Age\_months  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3 21 393949 394148 -196954 393907   
## m3.1 22 393951 394159 -196954 393907 1e-04 1 0.9935

m3.4 = lmer(microvolts ~ 1+ (1| participant)+ time+ (1|participant:time)  
 + (1| electrode)+ (1|electrode:participant)+ (1| condition:   
 participant)+ (1| electrode: participant: condition)+ location  
 + Lefthanded, data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.4)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3: microvolts ~ 1 + (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.4: microvolts ~ 1 + (1 | participant) + time + (1 | participant:time) +   
## m3.4: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.4: (1 | electrode:participant:condition) + location + Lefthanded  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3 21 393949 394148 -196954 393907   
## m3.4 22 393951 394159 -196954 393907 0.1375 1 0.7108

AIC(m3, m3.4) # ME handedness: out

## df AIC  
## m3 21 393969.5  
## m3.4 22 393969.5

m3.42 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + Gender, data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.42) # ME participant gender: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3: microvolts ~ 1 + (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.42: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.42: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.42: (1 | electrode:participant:condition) + location + Gender  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3 21 393949 394148 -196954 393907   
## m3.42 22 393950 394158 -196953 393906 1.5356 1 0.2153

AIC(m3, m3.42)

## df AIC  
## m3 21 393969.5  
## m3.42 22 393968.4

# Maximal null model set: m3  
  
  
# ...and finally the critical variables...  
  
# CONDITION  
m3.50 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + condition, data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.50) # ME cond: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3: microvolts ~ 1 + (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3 21 393949 394148 -196954 393907   
## m3.50 23 393947 394164 -196950 393901 6.3979 2 0.0408 \*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m3, m3.50)

## df AIC  
## m3 21 393969.5  
## m3.50 23 393969.7

m3.5 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + condition + location: condition, data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.5) # int loc\*cond: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3.50 23 393947 394164 -196950 393901   
## m3.5 25 393940 394176 -196945 393890 10.885 2 0.004328 \*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m3.50, m3.5)

## df AIC  
## m3.50 23 393969.7  
## m3.5 25 393969.6

m3.51 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + condition + location: condition + Lefthanded:   
 + condition, data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.5, m3.51) # int handedness\*cond: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## m3.51: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.51: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.51: (1 | electrode:participant:condition) + location + condition +   
## m3.51: location:condition + Lefthanded:+condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.5 25 393940 394176 -196945 393890   
## m3.51 28 393946 394210 -196945 393890 0.1536 3 0.9847

# GROUP   
m3.7 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + condition + location: condition + RT.based\_Groups,  
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.5, m3.7) # ME RT.based\_Groups: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## m3.7: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.7: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.7: (1 | electrode:participant:condition) + location + condition +   
## m3.7: location:condition + RT.based\_Groups  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.5 25 393940 394176 -196945 393890   
## m3.7 26 393942 394187 -196945 393890 0.125 1 0.7236

m3.8 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + condition + location: condition + RT.based\_Groups : location,  
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.5, m3.8)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## m3.8: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.8: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.8: (1 | electrode:participant:condition) + location + condition +   
## m3.8: location:condition + RT.based\_Groups:location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.5 25 393940 394176 -196945 393890   
## m3.8 27 393940 394195 -196943 393886 4.1343 2 0.1265

AIC(m3.5, m3.8) # int location \* RT.based\_Groups: out

## df AIC  
## m3.5 25 393969.6  
## m3.8 27 393969.7

# Interactions w/ condition  
m3.86 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location +  
 condition + location:condition + condition: Lefthanded,   
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.5, m3.86) # int condition \* handedness: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## m3.86: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.86: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.86: (1 | electrode:participant:condition) + location + condition +   
## m3.86: location:condition + condition:Lefthanded  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.5 25 393940 394176 -196945 393890   
## m3.86 28 393946 394210 -196945 393890 0.1536 3 0.9847

m3.87 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + condition + location: condition + condition: s\_Age\_months,   
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.5, m3.87) # int condition \* age: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## m3.87: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.87: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.87: (1 | electrode:participant:condition) + location + condition +   
## m3.87: location:condition + condition:s\_Age\_months  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.5 25 393940 394176 -196945 393890   
## m3.87 28 393946 394210 -196945 393890 0.3799 3 0.9444

m3.88 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + condition + location: condition + condition: Gender,   
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.5, m3.88) # int condition \* gender: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## m3.88: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.88: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.88: (1 | electrode:participant:condition) + location + condition +   
## m3.88: location:condition + condition:Gender  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.5 25 393940 394176 -196945 393890   
## m3.88 28 393944 394209 -196944 393888 1.7353 3 0.6291

# CONDITION \* GROUP  
m3.9 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + condition + location: condition + RT.based\_Groups: condition,   
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.5, m3.9)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## m3.9: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.9: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.9: (1 | electrode:participant:condition) + location + condition +   
## m3.9: location:condition + RT.based\_Groups:condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.5 25 393940 394176 -196945 393890   
## m3.9 28 393945 394210 -196945 393889 0.8032 3 0.8487

AIC(m3.5, m3.9) # int RT.based\_Groups \* condition: out

## df AIC  
## m3.5 25 393969.6  
## m3.9 28 393973.4

# ...int w/ location  
m3.91 = lmer(microvolts ~ (1|participant)+ time+ (1|participant:time)+   
 (1| electrode)+ (1|electrode:participant)+ (1| condition:  
 participant)+ (1| electrode: participant: condition)+ location  
 + condition + location: condition + RT.based\_Groups : condition: location,   
 data=EEG.window2,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.5, m3.91)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window2  
## Models:  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## m3.91: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.91: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.91: (1 | electrode:participant:condition) + location + condition +   
## m3.91: location:condition + RT.based\_Groups:condition:location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3.5 25 393940 394176 -196945 393890   
## m3.91 31 393901 394193 -196919 393839 51.551 6 2.296e-09 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m3.5, m3.91) # int RT.based\_Groups \* condition \* location: IN

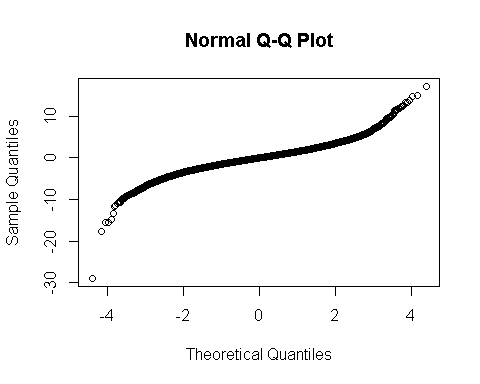
## df AIC  
## m3.5 25 393969.6  
## m3.91 31 393934.1

# Conclusion window 2 overall. Model m3.91 chosen:  
summary(m3.91)

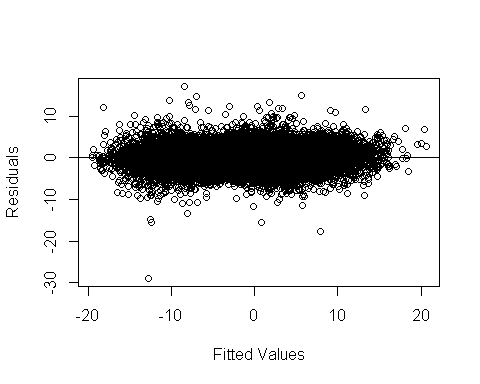
## Linear mixed model fit by REML ['lmerMod']  
## Formula: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## (1 | electrode:participant:condition) + location + condition +   
## location:condition + RT.based\_Groups:condition:location  
## Data: EEG.window2  
## Control: lmerControl(optCtrl = list(maxfun = 1e+07))  
##   
## REML criterion at convergence: 393872.1  
##   
## Scaled residuals:   
## Min 1Q Median 3Q Max   
## -16.3987 -0.5630 0.0028 0.5618 9.7465   
##   
## Random effects:  
## Groups Name Variance Std.Dev.  
## electrode:participant:condition (Intercept) 1.5401 1.2410   
## electrode:participant (Intercept) 5.3848 2.3205   
## participant:time (Intercept) 1.1882 1.0900   
## condition:participant (Intercept) 1.1901 1.0909   
## electrode (Intercept) 0.7594 0.8714   
## participant (Intercept) 5.2607 2.2936   
## Residual 3.1272 1.7684   
## Number of obs: 93288, groups:   
## electrode:participant:condition, 7176; electrode:participant, 2392; participant:time, 598; condition:participant, 138; electrode, 52; participant, 46  
##   
## Fixed effects:  
## Estimate Std. Error t value  
## (Intercept) -0.35658 0.59151 -0.603  
## time280 -0.27051 0.22920 -1.180  
## time288 -0.54203 0.22920 -2.365  
## time296 -0.85717 0.22920 -3.740  
## time304 -1.01406 0.22920 -4.424  
## time312 -1.21106 0.22920 -5.284  
## time320 -1.29569 0.22920 -5.653  
## time328 -1.45400 0.22920 -6.344  
## time336 -1.62454 0.22920 -7.088  
## time344 -1.78263 0.22920 -7.778  
## time352 -1.94536 0.22920 -8.488  
## time360 -2.19879 0.22920 -9.593  
## time368 -2.44437 0.22920 -10.665  
## locationposterior 4.02349 0.28702 14.018  
## conditionauditory2visual -0.48754 0.33082 -1.474  
## conditionhaptic2visual -0.50990 0.33082 -1.541  
## locationposterior:conditionauditory2visual -0.30725 0.10914 -2.815  
## locationposterior:conditionhaptic2visual 0.12875 0.10914 1.180  
## locationanterior:conditionvisual2visual:RT.based\_GroupsSlow 0.31407 0.76997 0.408  
## locationposterior:conditionvisual2visual:RT.based\_GroupsSlow 0.07774 0.76997 0.101  
## locationanterior:conditionauditory2visual:RT.based\_GroupsSlow 0.44061 0.76997 0.572  
## locationposterior:conditionauditory2visual:RT.based\_GroupsSlow 0.46723 0.76997 0.607  
## locationanterior:conditionhaptic2visual:RT.based\_GroupsSlow 0.58831 0.76997 0.764  
## locationposterior:conditionhaptic2visual:RT.based\_GroupsSlow -0.40347 0.76997 -0.524

##   
## Correlation matrix not shown by default, as p = 24 > 12.  
## Use print(x, correlation=TRUE) or  
## vcov(x) if you need it

# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(m3.91))



# Plot of Residuals vs. Fitted values:  
plot(fitted(m3.91),resid(m3.91),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



# Fit  
1-var(residuals(m3.91))/(var(model.response(model.frame(m3.91)))) # Omega^2

## [1] 0.8700485

r.squaredGLMM(m3.91) # R2m: fixed effs. R2c: fixed + random effs

## R2m R2c   
## 0.1833947 0.8615918

RMSE.merMod(m3.91, scale = FALSE) # Root MSE

## [1] 1.700223

png(file="Fixef win 2.png", units="in", width=7, height=6, res=500)  
plotFEsim(FEsim(m3.91))  
dev.off()

## png   
## 2

# Freeing up workspace  
rm(list=setdiff(ls(), c("EEG", "EEG.window1", "EEG.window2",  
 "EEG.window3", "EEG.window4")))  
  
  
# Follow-up ANOVAs into condition in each RT.based\_Groups and location. Effects are  
# based on general window 2. See contrasts 1 and 2 at the bottom.  
# Contrast 1 = visual2visual - (haptic2visual + auditory2visual)  
# Contrast 2 = auditory2visual - haptic2visual  
  
# Anterior regions, Quick group:  
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window2[EEG.window2$location=='anterior'  
 & EEG.window2$RT.based\_Groups=='Quick',])  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window2[EEG.window2$location == "anterior" & EEG.window2$RT.based\_Groups ==   
## "Quick", ])  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -31.5356 -1.7794 0.0405 1.8283 17.9213   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 4.10261 0.14916 27.505 < 2e-16 \*\*\*  
## time280 -0.26733 0.09819 -2.723 0.006480 \*\*   
## time288 -0.61938 0.09819 -6.308 2.88e-10 \*\*\*  
## time296 -0.91345 0.09819 -9.303 < 2e-16 \*\*\*  
## time304 -1.07195 0.09819 -10.917 < 2e-16 \*\*\*  
## time312 -1.29218 0.09819 -13.160 < 2e-16 \*\*\*  
## time320 -1.53517 0.09819 -15.635 < 2e-16 \*\*\*  
## time328 -1.66596 0.09819 -16.967 < 2e-16 \*\*\*  
## time336 -1.77880 0.09819 -18.116 < 2e-16 \*\*\*  
## time344 -1.99741 0.09819 -20.343 < 2e-16 \*\*\*  
## time352 -2.17137 0.09819 -22.114 < 2e-16 \*\*\*  
## time360 -2.31576 0.09819 -23.585 < 2e-16 \*\*\*  
## time368 -2.52924 0.09819 -25.759 < 2e-16 \*\*\*  
## participant12 -0.04037 0.13060 -0.309 0.757252   
## participant13 -0.49573 0.13060 -3.796 0.000148 \*\*\*  
## participant17 -6.70316 0.13060 -51.325 < 2e-16 \*\*\*  
## participant18 -4.22214 0.13060 -32.328 < 2e-16 \*\*\*  
## participant20 -0.04945 0.13060 -0.379 0.704971   
## participant26 -5.02683 0.13060 -38.490 < 2e-16 \*\*\*  
## participant27 -11.88947 0.13060 -91.036 < 2e-16 \*\*\*  
## participant28 -4.56115 0.13060 -34.924 < 2e-16 \*\*\*  
## participant3 -0.63036 0.13060 -4.827 1.40e-06 \*\*\*  
## participant30 -9.32457 0.13060 -71.397 < 2e-16 \*\*\*  
## participant31 -3.64992 0.13060 -27.947 < 2e-16 \*\*\*  
## participant32 2.10671 0.13060 16.131 < 2e-16 \*\*\*  
## participant36 -2.81027 0.13060 -21.518 < 2e-16 \*\*\*  
## participant38 2.12533 0.13060 16.273 < 2e-16 \*\*\*  
## participant40 -1.14438 0.13060 -8.762 < 2e-16 \*\*\*  
## participant44 0.40609 0.13060 3.109 0.001877 \*\*   
## participant46 -6.89654 0.13060 -52.806 < 2e-16 \*\*\*  
## participant47 -10.97381 0.13060 -84.025 < 2e-16 \*\*\*  
## participant48 -6.19816 0.13060 -47.458 < 2e-16 \*\*\*  
## participant49 -0.31636 0.13060 -2.422 0.015428 \*   
## participant50 -8.33346 0.13060 -63.808 < 2e-16 \*\*\*  
## participant8 -4.87980 0.13060 -37.364 < 2e-16 \*\*\*  
## electrodeC13 -0.83987 0.13886 -6.048 1.49e-09 \*\*\*  
## electrodeC14 -1.85845 0.13886 -13.384 < 2e-16 \*\*\*  
## electrodeC19 -0.50781 0.13886 -3.657 0.000256 \*\*\*  
## electrodeC2 -0.29396 0.13886 -2.117 0.034270 \*   
## electrodeC20 -1.52370 0.13886 -10.973 < 2e-16 \*\*\*  
## electrodeC21 -2.10174 0.13886 -15.136 < 2e-16 \*\*\*  
## electrodeC24 -0.53080 0.13886 -3.823 0.000132 \*\*\*  
## electrodeC25 -1.20117 0.13886 -8.650 < 2e-16 \*\*\*  
## electrodeC31 -1.24878 0.13886 -8.993 < 2e-16 \*\*\*  
## electrodeC34 -0.41235 0.13886 -2.970 0.002985 \*\*   
## electrodeC38 -0.69703 0.13886 -5.020 5.21e-07 \*\*\*  
## electrodeC39 -1.82547 0.13886 -13.146 < 2e-16 \*\*\*  
## electrodeC44 -0.25448 0.13886 -1.833 0.066871 .   
## electrodeC45 -1.49549 0.13886 -10.770 < 2e-16 \*\*\*  
## electrodeC46 -2.21201 0.13886 -15.930 < 2e-16 \*\*\*  
## electrodeC51 -0.38987 0.13886 -2.808 0.004994 \*\*   
## electrodeC52 -1.09771 0.13886 -7.905 2.79e-15 \*\*\*  
## electrodeC53 -1.93640 0.13886 -13.945 < 2e-16 \*\*\*  
## electrodeC56 0.13324 0.13886 0.960 0.337283   
## electrodeC57 0.20819 0.13886 1.499 0.133810   
## electrodeC58 -1.74525 0.13886 -12.569 < 2e-16 \*\*\*  
## electrodeC59 -1.85191 0.13886 -13.337 < 2e-16 \*\*\*  
## electrodeC6 -0.16650 0.13886 -1.199 0.230504   
## electrodeC60 -1.93611 0.13886 -13.943 < 2e-16 \*\*\*  
## electrodeC7 -1.36212 0.13886 -9.809 < 2e-16 \*\*\*  
## conditionc1 0.16624 0.01362 12.209 < 2e-16 \*\*\*  
## conditionc2 0.01118 0.02358 0.474 0.635429   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.941 on 23260 degrees of freedom  
## Multiple R-squared: 0.6648, Adjusted R-squared: 0.664   
## F-statistic: 756.4 on 61 and 23260 DF, p-value: < 2.2e-16

# Anterior regions, Slow group:   
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window2[EEG.window2$location=='anterior'  
 & EEG.window2$RT.based\_Groups=='Slow',])  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window2[EEG.window2$location == "anterior" & EEG.window2$RT.based\_Groups ==   
## "Slow", ])  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -12.0602 -1.7802 -0.0467 1.6792 13.7893   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 3.12608 0.14249 21.939 < 2e-16 \*\*\*  
## time280 -0.56828 0.09380 -6.059 1.39e-09 \*\*\*  
## time288 -0.91671 0.09380 -9.773 < 2e-16 \*\*\*  
## time296 -1.33928 0.09380 -14.278 < 2e-16 \*\*\*  
## time304 -1.55625 0.09380 -16.591 < 2e-16 \*\*\*  
## time312 -1.90057 0.09380 -20.262 < 2e-16 \*\*\*  
## time320 -2.05415 0.09380 -21.900 < 2e-16 \*\*\*  
## time328 -2.25602 0.09380 -24.052 < 2e-16 \*\*\*  
## time336 -2.43745 0.09380 -25.986 < 2e-16 \*\*\*  
## time344 -2.37170 0.09380 -25.285 < 2e-16 \*\*\*  
## time352 -2.29042 0.09380 -24.419 < 2e-16 \*\*\*  
## time360 -2.43967 0.09380 -26.010 < 2e-16 \*\*\*  
## time368 -2.53523 0.09380 -27.029 < 2e-16 \*\*\*  
## participant11 1.30233 0.12476 10.438 < 2e-16 \*\*\*  
## participant14 -2.93089 0.12476 -23.492 < 2e-16 \*\*\*  
## participant15 -4.54777 0.12476 -36.451 < 2e-16 \*\*\*  
## participant16 -7.96780 0.12476 -63.863 < 2e-16 \*\*\*  
## participant19 0.38483 0.12476 3.085 0.002041 \*\*   
## participant2 -1.85075 0.12476 -14.834 < 2e-16 \*\*\*  
## participant21 -1.62101 0.12476 -12.993 < 2e-16 \*\*\*  
## participant22 -3.67708 0.12476 -29.472 < 2e-16 \*\*\*  
## participant23 -2.37559 0.12476 -19.041 < 2e-16 \*\*\*  
## participant24 -4.62525 0.12476 -37.072 < 2e-16 \*\*\*  
## participant29 0.67168 0.12476 5.384 7.37e-08 \*\*\*  
## participant34 1.99950 0.12476 16.026 < 2e-16 \*\*\*  
## participant35 -4.58701 0.12476 -36.766 < 2e-16 \*\*\*  
## participant37 -0.69722 0.12476 -5.588 2.32e-08 \*\*\*  
## participant39 -3.49830 0.12476 -28.039 < 2e-16 \*\*\*  
## participant4 -2.61274 0.12476 -20.942 < 2e-16 \*\*\*  
## participant41 2.55345 0.12476 20.466 < 2e-16 \*\*\*  
## participant42 -0.76456 0.12476 -6.128 9.04e-10 \*\*\*  
## participant45 -2.31320 0.12476 -18.541 < 2e-16 \*\*\*  
## participant5 0.67778 0.12476 5.433 5.61e-08 \*\*\*  
## participant6 -3.22621 0.12476 -25.859 < 2e-16 \*\*\*  
## participant9 -2.62352 0.12476 -21.028 < 2e-16 \*\*\*  
## electrodeC13 -0.77966 0.13265 -5.878 4.22e-09 \*\*\*  
## electrodeC14 -1.57882 0.13265 -11.902 < 2e-16 \*\*\*  
## electrodeC19 -0.41576 0.13265 -3.134 0.001725 \*\*   
## electrodeC2 -0.73174 0.13265 -5.516 3.50e-08 \*\*\*  
## electrodeC20 -0.89349 0.13265 -6.736 1.67e-11 \*\*\*  
## electrodeC21 -1.64224 0.13265 -12.380 < 2e-16 \*\*\*  
## electrodeC24 -0.60774 0.13265 -4.581 4.64e-06 \*\*\*  
## electrodeC25 -0.70777 0.13265 -5.336 9.61e-08 \*\*\*  
## electrodeC31 -1.47442 0.13265 -11.115 < 2e-16 \*\*\*  
## electrodeC34 -1.05408 0.13265 -7.946 2.01e-15 \*\*\*  
## electrodeC38 -0.46977 0.13265 -3.541 0.000399 \*\*\*  
## electrodeC39 -1.74756 0.13265 -13.174 < 2e-16 \*\*\*  
## electrodeC44 -0.43742 0.13265 -3.298 0.000977 \*\*\*  
## electrodeC45 -1.26763 0.13265 -9.556 < 2e-16 \*\*\*  
## electrodeC46 -1.97847 0.13265 -14.915 < 2e-16 \*\*\*  
## electrodeC51 -0.75815 0.13265 -5.715 1.11e-08 \*\*\*  
## electrodeC52 -1.11170 0.13265 -8.381 < 2e-16 \*\*\*  
## electrodeC53 -1.82940 0.13265 -13.791 < 2e-16 \*\*\*  
## electrodeC56 -0.50885 0.13265 -3.836 0.000125 \*\*\*  
## electrodeC57 -0.79952 0.13265 -6.027 1.69e-09 \*\*\*  
## electrodeC58 -1.94392 0.13265 -14.654 < 2e-16 \*\*\*  
## electrodeC59 -1.94266 0.13265 -14.645 < 2e-16 \*\*\*  
## electrodeC6 0.34428 0.13265 2.595 0.009455 \*\*   
## electrodeC60 -1.85166 0.13265 -13.959 < 2e-16 \*\*\*  
## electrodeC7 -1.46454 0.13265 -11.041 < 2e-16 \*\*\*  
## conditionc1 0.09944 0.01301 7.645 2.17e-14 \*\*\*  
## conditionc2 -0.06267 0.02253 -2.782 0.005412 \*\*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.809 on 23260 degrees of freedom  
## Multiple R-squared: 0.4728, Adjusted R-squared: 0.4714   
## F-statistic: 341.9 on 61 and 23260 DF, p-value: < 2.2e-16

# Posterior regions, Quick group:   
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window2[EEG.window2$location=='posterior'  
 & EEG.window2$RT.based\_Groups=='Quick',])  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window2[EEG.window2$location == "posterior" &   
## EEG.window2$RT.based\_Groups == "Quick", ])  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -17.2797 -1.9369 0.0435 1.9890 21.2005   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 3.446203 0.165975 20.763 < 2e-16 \*\*\*  
## time280 -0.004758 0.109258 -0.044 0.965266   
## time288 -0.260936 0.109258 -2.388 0.016937 \*   
## time296 -0.402172 0.109258 -3.681 0.000233 \*\*\*  
## time304 -0.507194 0.109258 -4.642 3.47e-06 \*\*\*  
## time312 -0.556644 0.109258 -5.095 3.52e-07 \*\*\*  
## time320 -0.626100 0.109258 -5.730 1.01e-08 \*\*\*  
## time328 -0.743451 0.109258 -6.805 1.04e-11 \*\*\*  
## time336 -0.898834 0.109258 -8.227 < 2e-16 \*\*\*  
## time344 -1.205537 0.109258 -11.034 < 2e-16 \*\*\*  
## time352 -1.523704 0.109258 -13.946 < 2e-16 \*\*\*  
## time360 -1.937867 0.109258 -17.737 < 2e-16 \*\*\*  
## time368 -2.462510 0.109258 -22.538 < 2e-16 \*\*\*  
## participant12 -0.972267 0.145327 -6.690 2.28e-11 \*\*\*  
## participant13 -0.796638 0.145327 -5.482 4.26e-08 \*\*\*  
## participant17 -1.114946 0.145327 -7.672 1.76e-14 \*\*\*  
## participant18 -2.958728 0.145327 -20.359 < 2e-16 \*\*\*  
## participant20 0.413252 0.145327 2.844 0.004465 \*\*   
## participant26 -3.471150 0.145327 -23.885 < 2e-16 \*\*\*  
## participant27 -2.242555 0.145327 -15.431 < 2e-16 \*\*\*  
## participant28 -3.456420 0.145327 -23.784 < 2e-16 \*\*\*  
## participant3 -1.672378 0.145327 -11.508 < 2e-16 \*\*\*  
## participant30 -2.614502 0.145327 -17.990 < 2e-16 \*\*\*  
## participant31 -3.881853 0.145327 -26.711 < 2e-16 \*\*\*  
## participant32 -1.159145 0.145327 -7.976 1.58e-15 \*\*\*  
## participant36 -2.557218 0.145327 -17.596 < 2e-16 \*\*\*  
## participant38 0.188327 0.145327 1.296 0.195027   
## participant40 -1.764845 0.145327 -12.144 < 2e-16 \*\*\*  
## participant44 -0.856632 0.145327 -5.895 3.81e-09 \*\*\*  
## participant46 -5.828229 0.145327 -40.104 < 2e-16 \*\*\*  
## participant47 -0.910485 0.145327 -6.265 3.79e-10 \*\*\*  
## participant48 -5.439543 0.145327 -37.430 < 2e-16 \*\*\*  
## participant49 -1.091491 0.145327 -7.511 6.10e-14 \*\*\*  
## participant50 -10.138082 0.145327 -69.760 < 2e-16 \*\*\*  
## participant8 -1.914933 0.145327 -13.177 < 2e-16 \*\*\*  
## electrodeC10 1.754638 0.154514 11.356 < 2e-16 \*\*\*  
## electrodeC15 3.293219 0.154514 21.313 < 2e-16 \*\*\*  
## electrodeC16 4.039162 0.154514 26.141 < 2e-16 \*\*\*  
## electrodeC17 0.916252 0.154514 5.930 3.07e-09 \*\*\*  
## electrodeC22 1.283397 0.154514 8.306 < 2e-16 \*\*\*  
## electrodeC23 1.964786 0.154514 12.716 < 2e-16 \*\*\*  
## electrodeC26 0.762175 0.154514 4.933 8.17e-07 \*\*\*  
## electrodeC27 1.663246 0.154514 10.764 < 2e-16 \*\*\*  
## electrodeC28 1.685538 0.154514 10.909 < 2e-16 \*\*\*  
## electrodeC29 0.323665 0.154514 2.095 0.036207 \*   
## electrodeC3 2.142099 0.154514 13.863 < 2e-16 \*\*\*  
## electrodeC33 0.067426 0.154514 0.436 0.662571   
## electrodeC35 2.191365 0.154514 14.182 < 2e-16 \*\*\*  
## electrodeC36 0.980452 0.154514 6.345 2.26e-10 \*\*\*  
## electrodeC4 1.027499 0.154514 6.650 3.00e-11 \*\*\*  
## electrodeC40 3.027833 0.154514 19.596 < 2e-16 \*\*\*  
## electrodeC41 2.956309 0.154514 19.133 < 2e-16 \*\*\*  
## electrodeC42 1.130932 0.154514 7.319 2.57e-13 \*\*\*  
## electrodeC47 2.610500 0.154514 16.895 < 2e-16 \*\*\*  
## electrodeC48 2.627074 0.154514 17.002 < 2e-16 \*\*\*  
## electrodeC49 0.311162 0.154514 2.014 0.044041 \*   
## electrodeC54 1.355713 0.154514 8.774 < 2e-16 \*\*\*  
## electrodeC55 1.290996 0.154514 8.355 < 2e-16 \*\*\*  
## electrodeC8 3.177504 0.154514 20.564 < 2e-16 \*\*\*  
## electrodeC9 3.258387 0.154514 21.088 < 2e-16 \*\*\*  
## conditionc1 0.195990 0.015151 12.935 < 2e-16 \*\*\*  
## conditionc2 -0.206820 0.026243 -7.881 3.39e-15 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 3.272 on 23260 degrees of freedom  
## Multiple R-squared: 0.3983, Adjusted R-squared: 0.3968   
## F-statistic: 252.5 on 61 and 23260 DF, p-value: < 2.2e-16

# Posterior regions, Slow group:   
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window2[EEG.window2$location=='posterior'  
 & EEG.window2$RT.based\_Groups=='Slow',])  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window2[EEG.window2$location == "posterior" &   
## EEG.window2$RT.based\_Groups == "Slow", ])  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -15.3728 -1.8382 -0.0029 1.8239 18.2409   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 3.48573 0.15601 22.343 < 2e-16 \*\*\*  
## time280 -0.24168 0.10270 -2.353 0.018616 \*   
## time288 -0.37108 0.10270 -3.613 0.000303 \*\*\*  
## time296 -0.77380 0.10270 -7.535 5.08e-14 \*\*\*  
## time304 -0.92085 0.10270 -8.966 < 2e-16 \*\*\*  
## time312 -1.09483 0.10270 -10.660 < 2e-16 \*\*\*  
## time320 -0.96734 0.10270 -9.419 < 2e-16 \*\*\*  
## time328 -1.15057 0.10270 -11.203 < 2e-16 \*\*\*  
## time336 -1.38306 0.10270 -13.467 < 2e-16 \*\*\*  
## time344 -1.55587 0.10270 -15.150 < 2e-16 \*\*\*  
## time352 -1.79595 0.10270 -17.487 < 2e-16 \*\*\*  
## time360 -2.10187 0.10270 -20.466 < 2e-16 \*\*\*  
## time368 -2.25052 0.10270 -21.914 < 2e-16 \*\*\*  
## participant11 -0.97716 0.13660 -7.153 8.72e-13 \*\*\*  
## participant14 -4.15627 0.13660 -30.426 < 2e-16 \*\*\*  
## participant15 -2.20245 0.13660 -16.123 < 2e-16 \*\*\*  
## participant16 0.91670 0.13660 6.711 1.98e-11 \*\*\*  
## participant19 -0.63141 0.13660 -4.622 3.82e-06 \*\*\*  
## participant2 -1.82572 0.13660 -13.365 < 2e-16 \*\*\*  
## participant21 -4.49776 0.13660 -32.926 < 2e-16 \*\*\*  
## participant22 -0.79892 0.13660 -5.848 5.03e-09 \*\*\*  
## participant23 -3.80055 0.13660 -27.822 < 2e-16 \*\*\*  
## participant24 -3.34157 0.13660 -24.462 < 2e-16 \*\*\*  
## participant29 -2.79408 0.13660 -20.454 < 2e-16 \*\*\*  
## participant34 0.91650 0.13660 6.709 2.00e-11 \*\*\*  
## participant35 -4.54916 0.13660 -33.302 < 2e-16 \*\*\*  
## participant37 -1.48463 0.13660 -10.868 < 2e-16 \*\*\*  
## participant39 -5.69441 0.13660 -41.686 < 2e-16 \*\*\*  
## participant4 -1.72613 0.13660 -12.636 < 2e-16 \*\*\*  
## participant41 2.49072 0.13660 18.233 < 2e-16 \*\*\*  
## participant42 -5.23744 0.13660 -38.341 < 2e-16 \*\*\*  
## participant45 -1.56079 0.13660 -11.426 < 2e-16 \*\*\*  
## participant5 -2.69454 0.13660 -19.725 < 2e-16 \*\*\*  
## participant6 -3.19756 0.13660 -23.408 < 2e-16 \*\*\*  
## participant9 -6.42158 0.13660 -47.009 < 2e-16 \*\*\*  
## electrodeC10 2.34259 0.14524 16.129 < 2e-16 \*\*\*  
## electrodeC15 3.40708 0.14524 23.458 < 2e-16 \*\*\*  
## electrodeC16 4.37508 0.14524 30.123 < 2e-16 \*\*\*  
## electrodeC17 1.65392 0.14524 11.388 < 2e-16 \*\*\*  
## electrodeC22 1.17545 0.14524 8.093 6.10e-16 \*\*\*  
## electrodeC23 1.73767 0.14524 11.964 < 2e-16 \*\*\*  
## electrodeC26 0.75158 0.14524 5.175 2.30e-07 \*\*\*  
## electrodeC27 2.04762 0.14524 14.098 < 2e-16 \*\*\*  
## electrodeC28 2.04780 0.14524 14.099 < 2e-16 \*\*\*  
## electrodeC29 0.27058 0.14524 1.863 0.062480 .   
## electrodeC3 2.09621 0.14524 14.433 < 2e-16 \*\*\*  
## electrodeC33 -0.01484 0.14524 -0.102 0.918638   
## electrodeC35 2.48902 0.14524 17.137 < 2e-16 \*\*\*  
## electrodeC36 1.40545 0.14524 9.677 < 2e-16 \*\*\*  
## electrodeC4 1.26232 0.14524 8.691 < 2e-16 \*\*\*  
## electrodeC40 3.60353 0.14524 24.811 < 2e-16 \*\*\*  
## electrodeC41 3.50024 0.14524 24.100 < 2e-16 \*\*\*  
## electrodeC42 2.00187 0.14524 13.783 < 2e-16 \*\*\*  
## electrodeC47 3.01753 0.14524 20.776 < 2e-16 \*\*\*  
## electrodeC48 3.37321 0.14524 23.225 < 2e-16 \*\*\*  
## electrodeC49 0.79467 0.14524 5.471 4.51e-08 \*\*\*  
## electrodeC54 0.97235 0.14524 6.695 2.21e-11 \*\*\*  
## electrodeC55 1.10729 0.14524 7.624 2.56e-14 \*\*\*  
## electrodeC8 3.49596 0.14524 24.070 < 2e-16 \*\*\*  
## electrodeC9 2.98207 0.14524 20.532 < 2e-16 \*\*\*  
## conditionc1 0.21128 0.01424 14.835 < 2e-16 \*\*\*  
## conditionc2 0.22853 0.02467 9.264 < 2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 3.076 on 23260 degrees of freedom  
## Multiple R-squared: 0.4211, Adjusted R-squared: 0.4196   
## F-statistic: 277.4 on 61 and 23260 DF, p-value: < 2.2e-16

# Summary window 2: The modality-switching effect is already consider-  
# able in this window. In all but one of the data subsets, contrast 1  
# is orders of magnitude larger than contrast 2.  
  
  
  
# WINDOW 3 (350-550 ms)  
summaryBy(microvolts ~ c(location, RT.based\_Groups, condition), EEG.window3)

## location RT.based\_Groups condition microvolts.mean  
## 1 anterior Quick visual2visual -2.4968054  
## 2 anterior Quick auditory2visual -2.5645234  
## 3 anterior Quick haptic2visual -3.0906523  
## 4 anterior Slow visual2visual -1.8366218  
## 5 anterior Slow auditory2visual -2.8902585  
## 6 anterior Slow haptic2visual -2.7759643  
## 7 posterior Quick visual2visual -0.1937060  
## 8 posterior Quick auditory2visual -0.8032672  
## 9 posterior Quick haptic2visual -0.7027541  
## 10 posterior Slow visual2visual 0.4895456  
## 11 posterior Slow auditory2visual -0.2760227  
## 12 posterior Slow haptic2visual -0.6192159

# First, setting in random effects structure  
m0 = lmer(microvolts ~ 1+ (1| participant), data=EEG.window3,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0) # Departing from random intercepts Participant.  
 # Will be adding & commenting one by one.  
  
m0.01 = lmer(microvolts ~ 1+ (1| participant)+ (1|time),  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.01)  
anova(m0, m0.01) # random intercepts Time: IN (no random slopes because

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m0: microvolts ~ 1 + (1 | participant)  
## m0.01: microvolts ~ 1 + (1 | participant) + (1 | time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0 3 976836 976866 -488415 976830   
## m0.01 4 974128 974168 -487060 974120 2710.3 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

# all time points belong to a coherent window already)  
  
m0.010 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant: time), data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.010)  
anova(m0.01, m0.010) # random intercepts Time per ppt: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m0.01: microvolts ~ 1 + (1 | participant) + (1 | time)  
## m0.010: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.01 4 974128 974168 -487060 974120   
## m0.010 5 962339 962390 -481165 962329 11791 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.01, m0.010)

## df AIC  
## m0.01 4 974128.5  
## m0.010 5 962339.9

m0.1 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant: time)+ (1| electrode),   
 data=EEG.window3,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.1)  
anova(m0.010, m0.1) # random intercepts Electrode: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m0.010: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time)  
## m0.1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1: (1 | electrode)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.010 5 962339 962390 -481165 962329   
## m0.1 6 933715 933775 -466851 933703 28627 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

m0.1b = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant: time)+ (1| electrode)   
 + (1|electrode: participant), data=EEG.window3,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.1, m0.1b) # random intercepts Electrode: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m0.1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1: (1 | electrode)  
## m0.1b: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1b: (1 | electrode) + (1 | electrode:participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.1 6 933715 933775 -466851 933703   
## m0.1b 7 834152 834222 -417069 834138 99565 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

m0.12 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)+ (1|electrode)  
 + (1|participant: time)+ (1|electrode: participant)+   
 (1| condition: participant), data=EEG.window3,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.1b, m0.12)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m0.1b: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1b: (1 | electrode) + (1 | electrode:participant)  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | electrode) +   
## m0.12: (1 | participant:time) + (1 | electrode:participant) + (1 |   
## m0.12: condition:participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.1b 7 834152 834222 -417069 834138   
## m0.12 8 792817 792897 -396400 792801 41337 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.1b, m0.12) # intercepts cond by participant: IN

## df AIC  
## m0.1b 7 834151.9  
## m0.12 8 792816.9

m0.121 = lmer(microvolts ~ 1+ (1|time)+ (1|participant:time)+   
 (1| electrode)+ (1|electrode: participant)+ (1+ condition|   
 participant), data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m0.121) # slopes condition by participant: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | electrode) +   
## m0.12: (1 | participant:time) + (1 | electrode:participant) + (1 |   
## m0.12: condition:participant)  
## m0.121: microvolts ~ 1 + (1 | time) + (1 | participant:time) + (1 | electrode) +   
## m0.121: (1 | electrode:participant) + (1 + condition | participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m0.12 8 792817 792897 -396400 792801   
## m0.121 12 792822 792943 -396399 792798 2.7802 4 0.5953

m1 = lmer(microvolts ~ 1+ (1|participant)+ (1|time) +(1|participant: time)   
 + (1| electrode)+ (1|electrode: participant)+ (1|condition:   
 participant)+ (1| RT.based\_Groups: time), data=EEG.window3,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m1)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | electrode) +   
## m0.12: (1 | participant:time) + (1 | electrode:participant) + (1 |   
## m0.12: condition:participant)  
## m1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m1: (1 | RT.based\_Groups:time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m0.12 8 792817 792897 -396400 792801   
## m1 9 792818 792909 -396400 792800 0.6748 1 0.4114

AIC(m0.12, m1) # intercepts RT.based\_Groups by time: out

## df AIC  
## m0.12 8 792816.9  
## m1 9 792818.2

m2.02 = lmer(microvolts ~ 1+ (1|participant)+ (1|time) +(1|participant:   
 time)+ (1| electrode) +(1|electrode: participant) +(1|condition:   
 participant)+ (1| electrode: participant: condition),  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m2.02)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | electrode) +   
## m0.12: (1 | participant:time) + (1 | electrode:participant) + (1 |   
## m0.12: condition:participant)  
## m2.02: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m2.02: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.02: (1 | electrode:participant:condition)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.12 8 792817 792897 -396400 792801   
## m2.02 9 754101 754192 -377042 754083 38717 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.12, m2.02) # int intercepts elec\*particp\*condit: IN

## df AIC  
## m0.12 8 792816.9  
## m2.02 9 754101.5

# Random effs structure set: m2.02. On to main effects:  
m2.1 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 +(1| electrode) +(1|electrode: participant) +(1|condition:   
 participant)+ (1| electrode: participant:   
 condition), data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m2.02, m2.1)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m2.02: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m2.02: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.02: (1 | electrode:participant:condition)  
## m2.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m2.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.1: (1 | electrode:participant:condition)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m2.02 9 754101 754192 -377042 754083   
## m2.1 32 754071 754395 -377004 754007 75.798 23 1.5e-07 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m2.02, m2.1) # ME time: IN

## df AIC  
## m2.02 9 754101.5  
## m2.1 32 754112.3

m3 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)+   
 (1|electrode) +(1|electrode: participant) +(1|condition:  
 participant)+ (1| electrode: participant:   
 condition)+ location, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m2.1, m3)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m2.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m2.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.1: (1 | electrode:participant:condition)  
## m3: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m2.1 32 754071 754395 -377004 754007   
## m3 33 754012 754346 -376973 753946 61.006 1 5.689e-15 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m2.1, m3) # ME location: IN

## df AIC  
## m2.1 32 754112.3  
## m3 33 754054.8

m3.1 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location + s\_Age\_months, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.1) # ME age: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.1: (1 | electrode:participant:condition) + location + s\_Age\_months  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3 33 754012 754346 -376973 753946   
## m3.1 34 754013 754356 -376972 753945 1.8354 1 0.1755

m3.4 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location + Lefthanded, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.4)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.4: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.4: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.4: (1 | electrode:participant:condition) + location + Lefthanded  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3 33 754012 754346 -376973 753946   
## m3.4 34 754014 754357 -376973 753946 0.4922 1 0.483

AIC(m3, m3.4) # ME handedness: out

## df AIC  
## m3 33 754054.8  
## m3.4 34 754054.8

m3.42 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location + Gender, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.42) # ME participant gender: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.42: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.42: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.42: (1 | electrode:participant:condition) + location + Gender  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3 33 754012 754346 -376973 753946   
## m3.42 34 754013 754356 -376972 753945 1.7402 1 0.1871

# Maximal null model set: m3  
  
# ...and finally the critical variables...  
  
# CONDITION  
m3.50 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)+   
 (1|electrode) +(1|electrode: participant) +(1|condition:  
 participant)+ (1| electrode: participant:   
 condition)+ location + condition, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3, m3.50) # ME cond: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3 33 754012 754346 -376973 753946   
## m3.50 35 754007 754360 -376968 753937 9.4735 2 0.008767 \*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

m3.5 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location+ condition+ location: condition,   
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.5) # int loc\*cond: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.5: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.5: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.5: (1 | electrode:participant:condition) + location + condition +   
## m3.5: location:condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 35 754007 754360 -376968 753937   
## m3.5 37 754008 754382 -376967 753934 2.7536 2 0.2524

m3.51 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location+ condition+ Lefthanded: condition,   
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.51) # int handedness\*cond: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.51: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.51: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.51: (1 | electrode:participant:condition) + location + condition +   
## m3.51: Lefthanded:condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 35 754007 754360 -376968 753937   
## m3.51 38 754012 754395 -376968 753936 1.2222 3 0.7477

# GROUP   
m3.7 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location+ condition + RT.based\_Groups,  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.7) # ME RT.based\_Groups: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.7: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.7: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.7: (1 | electrode:participant:condition) + location + condition +   
## m3.7: RT.based\_Groups  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 35 754007 754360 -376968 753937   
## m3.7 36 754009 754372 -376968 753937 0.3391 1 0.5604

m3.8 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location+ condition + RT.based\_Groups : location,  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.8) # int location \* RT.based\_Groups: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.8: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.8: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.8: (1 | electrode:participant:condition) + location + condition +   
## m3.8: RT.based\_Groups:location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 35 754007 754360 -376968 753937   
## m3.8 37 754009 754383 -376968 753935 1.7145 2 0.4243

AIC(m3.50, m3.8)

## df AIC  
## m3.50 35 754051.3  
## m3.8 37 754054.4

# Interactions w/ condition  
m3.851 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ location+   
 condition + condition : location, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.851) # int condition \* location: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.851: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.851: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.851: (1 | electrode:participant:condition) + location + condition +   
## m3.851: condition:location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 35 754007 754360 -376968 753937   
## m3.851 37 754008 754382 -376967 753934 2.7536 2 0.2524

AIC(m3.50, m3.851)

## df AIC  
## m3.50 35 754051.3  
## m3.851 37 754059.3

m3.86 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location+ condition + condition :  
 Lefthanded, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.86) # int condition \* handedness: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.86: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.86: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.86: (1 | electrode:participant:condition) + location + condition +   
## m3.86: condition:Lefthanded  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 35 754007 754360 -376968 753937   
## m3.86 38 754012 754395 -376968 753936 1.2222 3 0.7477

m3.87 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location+ condition + condition :   
 s\_Age\_months, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.87) # int condition \* age: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.87: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.87: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.87: (1 | electrode:participant:condition) + location + condition +   
## m3.87: condition:s\_Age\_months  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 35 754007 754360 -376968 753937   
## m3.87 38 754010 754394 -376967 753934 3.0516 3 0.3837

m3.88 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location+ condition + condition :   
 Gender, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.88) # int condition \* gender: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.88: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.88: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.88: (1 | electrode:participant:condition) + location + condition +   
## m3.88: condition:Gender  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 35 754007 754360 -376968 753937   
## m3.88 38 754011 754394 -376967 753935 2.1599 3 0.5399

# CONDITION \* GROUP  
m3.9 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location+ condition + condition :   
 RT.based\_Groups, data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.9) # int RT.based\_Groups \* condition: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window3  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + location + condition  
## m3.9: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.9: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.9: (1 | electrode:participant:condition) + location + condition +   
## m3.9: condition:RT.based\_Groups  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 35 754007 754360 -376968 753937   
## m3.9 38 754011 754395 -376968 753935 1.694 3 0.6383

AIC(m3.50, m3.9)

## df AIC  
## m3.50 35 754051.3  
## m3.9 38 754054.0

m3.91 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant:   
 condition)+ location+ condition + RT.based\_Groups :   
 location : condition,  
 data=EEG.window3,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))

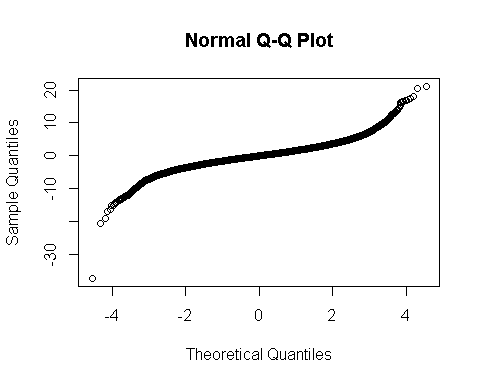
## fixed-effect model matrix is rank deficient so dropping 4 columns / coefficients

#!Rank deficient! # int RT.based\_Groups\*location\*condition: rank deficient.  
# This suggests the non-significance of this 3-way interaction in this  
# particular window, as evident from the fact that the model does per-  
# fectly form if including the 'RT.based\_Groups:condition' interaction. Of course  
# this cannot be included because it proved non-significant just above.  
  
# Conclusion window 3 overall. Model m3.50 chosen:  
summary(m3.50)

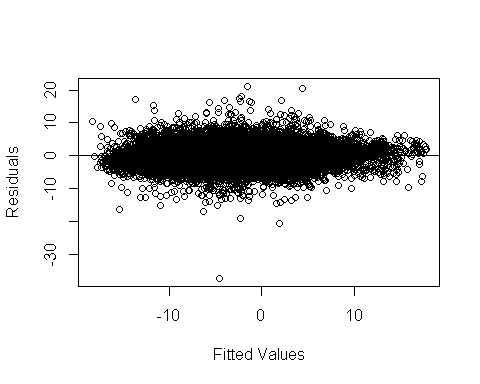
## Linear mixed model fit by REML ['lmerMod']  
## Formula: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## (1 | electrode:participant:condition) + location + condition  
## Data: EEG.window3  
## Control: lmerControl(optCtrl = list(maxfun = 1e+07))  
##   
## REML criterion at convergence: 753981.3  
##   
## Scaled residuals:   
## Min 1Q Median 3Q Max   
## -20.3804 -0.5753 -0.0042 0.5707 11.5588   
##   
## Random effects:  
## Groups Name Variance Std.Dev.  
## electrode:participant:condition (Intercept) 1.6801 1.2962   
## electrode:participant (Intercept) 4.4198 2.1023   
## participant:time (Intercept) 1.1757 1.0843   
## condition:participant (Intercept) 1.5939 1.2625   
## electrode (Intercept) 0.4695 0.6852   
## participant (Intercept) 2.9669 1.7225   
## Residual 3.3336 1.8258   
## Number of obs: 179400, groups:   
## electrode:participant:condition, 7176; electrode:participant, 2392; participant:time, 1150; condition:participant, 138; electrode, 52; participant, 46  
##   
## Fixed effects:  
## Estimate Std. Error t value  
## (Intercept) -1.1872 0.3846 -3.087  
## time360 -0.2534 0.2281 -1.111  
## time368 -0.4990 0.2281 -2.187  
## time376 -0.6964 0.2281 -3.053  
## time384 -0.8734 0.2281 -3.828  
## time392 -0.9144 0.2281 -4.008  
## time400 -0.9423 0.2281 -4.131  
## time408 -1.1062 0.2281 -4.849  
## time416 -1.3625 0.2281 -5.972  
## time424 -1.4122 0.2281 -6.190  
## time432 -1.3955 0.2281 -6.117  
## time440 -1.3993 0.2281 -6.133  
## time448 -1.4970 0.2281 -6.562  
## time456 -1.5749 0.2281 -6.903  
## time464 -1.5248 0.2281 -6.684  
## time472 -1.4823 0.2281 -6.498  
## time480 -1.4575 0.2281 -6.389  
## time488 -1.2567 0.2281 -5.508  
## time496 -0.9645 0.2281 -4.228  
## time504 -0.7622 0.2281 -3.341  
## time512 -0.6166 0.2281 -2.703  
## time520 -0.5974 0.2281 -2.619  
## time528 -0.5001 0.2281 -2.192  
## time536 -0.3979 0.2281 -1.744  
## time544 -0.2961 0.2281 -1.298  
## locationposterior 2.2582 0.2110 10.703  
## conditionauditory2visual -0.6241 0.2661 -2.345  
## conditionhaptic2visual -0.7877 0.2661 -2.960

##   
## Correlation matrix not shown by default, as p = 28 > 12.  
## Use print(x, correlation=TRUE) or  
## vcov(x) if you need it

# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(m3.50))



# Plot of Residuals vs. Fitted values:  
plot(fitted(m3.50),resid(m3.50),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



# Fit  
1-var(residuals(m3.50))/(var(model.response(model.frame(m3.50)))) # Omega^2

## [1] 0.81358

r.squaredGLMM(m3.50) # R2m: fixed effs. R2c: fixed + random effs

## R2m R2c   
## 0.09298872 0.80667077

RMSE.merMod(m3.50, scale = FALSE) # Root MSE

## [1] 1.785175

png(file="Fixef win 3.png", units="in", width=6.5, height=6, res=500)  
plotFEsim(FEsim(m3.50))  
dev.off()

## png   
## 2

# Freeing up workspace  
rm(list=setdiff(ls(), c("EEG", "EEG.window1", "EEG.window2",  
 "EEG.window3", "EEG.window4")))  
  
  
# Follow-up ANOVAs into condition in each RT.based\_Groups and location. Effects are  
# based on general window 3. See contrasts 1 and 2 at the bottom.  
# Contrast 1 = visual2visual - (haptic2visual + auditory2visual)  
# Contrast 2 = auditory2visual - haptic2visual  
  
# All window 3, no subsets  
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window3)  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window3)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -38.432 -1.974 0.021 2.020 26.783   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.734473 0.087611 8.383 < 2e-16 \*\*\*  
## time360 -0.253430 0.056318 -4.500 6.80e-06 \*\*\*  
## time368 -0.499013 0.056318 -8.861 < 2e-16 \*\*\*  
## time376 -0.696415 0.056318 -12.366 < 2e-16 \*\*\*  
## time384 -0.873372 0.056318 -15.508 < 2e-16 \*\*\*  
## time392 -0.914390 0.056318 -16.236 < 2e-16 \*\*\*  
## time400 -0.942348 0.056318 -16.733 < 2e-16 \*\*\*  
## time408 -1.106161 0.056318 -19.641 < 2e-16 \*\*\*  
## time416 -1.362466 0.056318 -24.192 < 2e-16 \*\*\*  
## time424 -1.412239 0.056318 -25.076 < 2e-16 \*\*\*  
## time432 -1.395541 0.056318 -24.780 < 2e-16 \*\*\*  
## time440 -1.399269 0.056318 -24.846 < 2e-16 \*\*\*  
## time448 -1.496954 0.056318 -26.580 < 2e-16 \*\*\*  
## time456 -1.574888 0.056318 -27.964 < 2e-16 \*\*\*  
## time464 -1.524803 0.056318 -27.075 < 2e-16 \*\*\*  
## time472 -1.482343 0.056318 -26.321 < 2e-16 \*\*\*  
## time480 -1.457490 0.056318 -25.880 < 2e-16 \*\*\*  
## time488 -1.256680 0.056318 -22.314 < 2e-16 \*\*\*  
## time496 -0.964520 0.056318 -17.126 < 2e-16 \*\*\*  
## time504 -0.762207 0.056318 -13.534 < 2e-16 \*\*\*  
## time512 -0.616577 0.056318 -10.948 < 2e-16 \*\*\*  
## time520 -0.597385 0.056318 -10.607 < 2e-16 \*\*\*  
## time528 -0.500097 0.056318 -8.880 < 2e-16 \*\*\*  
## time536 -0.397919 0.056318 -7.066 1.61e-12 \*\*\*  
## time544 -0.296123 0.056318 -5.258 1.46e-07 \*\*\*  
## participant10 -0.164563 0.076394 -2.154 0.031231 \*   
## participant11 -1.422794 0.076394 -18.624 < 2e-16 \*\*\*  
## participant12 -1.422794 0.076394 -18.624 < 2e-16 \*\*\*  
## participant13 -1.641719 0.076394 -21.490 < 2e-16 \*\*\*  
## participant14 0.739171 0.076394 9.676 < 2e-16 \*\*\*  
## participant15 -2.777780 0.076394 -36.361 < 2e-16 \*\*\*  
## participant16 -2.294006 0.076394 -30.029 < 2e-16 \*\*\*  
## participant17 -2.988814 0.076394 -39.124 < 2e-16 \*\*\*  
## participant18 -1.827974 0.076394 -23.928 < 2e-16 \*\*\*  
## participant19 1.396665 0.076394 18.282 < 2e-16 \*\*\*  
## participant2 -3.834709 0.076394 -50.197 < 2e-16 \*\*\*  
## participant20 0.697221 0.076394 9.127 < 2e-16 \*\*\*  
## participant21 -2.224472 0.076394 -29.119 < 2e-16 \*\*\*  
## participant22 -2.439163 0.076394 -31.929 < 2e-16 \*\*\*  
## participant23 -1.030200 0.076394 -13.485 < 2e-16 \*\*\*  
## participant24 -3.624244 0.076394 -47.442 < 2e-16 \*\*\*  
## participant26 -1.786992 0.076394 -23.392 < 2e-16 \*\*\*  
## participant27 -2.772337 0.076394 -36.290 < 2e-16 \*\*\*  
## participant28 -2.292919 0.076394 -30.015 < 2e-16 \*\*\*  
## participant29 -0.920258 0.076394 -12.046 < 2e-16 \*\*\*  
## participant3 -0.446090 0.076394 -5.839 5.25e-09 \*\*\*  
## participant30 -5.724369 0.076394 -74.932 < 2e-16 \*\*\*  
## participant31 -2.891492 0.076394 -37.850 < 2e-16 \*\*\*  
## participant32 -0.584960 0.076394 -7.657 1.91e-14 \*\*\*  
## participant34 1.013431 0.076394 13.266 < 2e-16 \*\*\*  
## participant35 -1.575436 0.076394 -20.623 < 2e-16 \*\*\*  
## participant36 0.262864 0.076394 3.441 0.000580 \*\*\*  
## participant37 -1.042643 0.076394 -13.648 < 2e-16 \*\*\*  
## participant38 1.655129 0.076394 21.666 < 2e-16 \*\*\*  
## participant39 -3.296610 0.076394 -43.153 < 2e-16 \*\*\*  
## participant4 -0.431297 0.076394 -5.646 1.65e-08 \*\*\*  
## participant40 -1.824533 0.076394 -23.883 < 2e-16 \*\*\*  
## participant41 -0.134368 0.076394 -1.759 0.078598 .   
## participant42 -1.290374 0.076394 -16.891 < 2e-16 \*\*\*  
## participant44 1.850340 0.076394 24.221 < 2e-16 \*\*\*  
## participant45 -2.999053 0.076394 -39.258 < 2e-16 \*\*\*  
## participant46 -3.795964 0.076394 -49.690 < 2e-16 \*\*\*  
## participant47 -3.747830 0.076394 -49.059 < 2e-16 \*\*\*  
## participant48 -3.684421 0.076394 -48.229 < 2e-16 \*\*\*  
## participant49 1.518570 0.076394 19.878 < 2e-16 \*\*\*  
## participant5 -0.443458 0.076394 -5.805 6.45e-09 \*\*\*  
## participant50 -6.217589 0.076394 -81.389 < 2e-16 \*\*\*  
## participant6 -2.519992 0.076394 -32.987 < 2e-16 \*\*\*  
## participant8 -4.544355 0.076394 -59.486 < 2e-16 \*\*\*  
## participant9 -3.775179 0.076394 -49.417 < 2e-16 \*\*\*  
## electrodeC10 1.318036 0.081223 16.227 < 2e-16 \*\*\*  
## electrodeC12 0.203675 0.081223 2.508 0.012156 \*   
## electrodeC13 -0.875350 0.081223 -10.777 < 2e-16 \*\*\*  
## electrodeC14 -1.560937 0.081223 -19.218 < 2e-16 \*\*\*  
## electrodeC15 2.066618 0.081223 25.444 < 2e-16 \*\*\*  
## electrodeC16 2.633683 0.081223 32.425 < 2e-16 \*\*\*  
## electrodeC17 1.699890 0.081223 20.929 < 2e-16 \*\*\*  
## electrodeC19 0.206567 0.081223 2.543 0.010985 \*   
## electrodeC2 -0.916484 0.081223 -11.284 < 2e-16 \*\*\*  
## electrodeC20 -0.794497 0.081223 -9.782 < 2e-16 \*\*\*  
## electrodeC21 -1.470430 0.081223 -18.104 < 2e-16 \*\*\*  
## electrodeC22 1.614183 0.081223 19.873 < 2e-16 \*\*\*  
## electrodeC23 2.121776 0.081223 26.123 < 2e-16 \*\*\*  
## electrodeC24 0.516441 0.081223 6.358 2.04e-10 \*\*\*  
## electrodeC25 -0.012774 0.081223 -0.157 0.875029   
## electrodeC26 1.417990 0.081223 17.458 < 2e-16 \*\*\*  
## electrodeC27 1.690684 0.081223 20.815 < 2e-16 \*\*\*  
## electrodeC28 1.386580 0.081223 17.071 < 2e-16 \*\*\*  
## electrodeC29 0.324840 0.081223 3.999 6.35e-05 \*\*\*  
## electrodeC3 1.252769 0.081223 15.424 < 2e-16 \*\*\*  
## electrodeC31 -1.293136 0.081223 -15.921 < 2e-16 \*\*\*  
## electrodeC33 0.155643 0.081223 1.916 0.055337 .   
## electrodeC34 -0.914874 0.081223 -11.264 < 2e-16 \*\*\*  
## electrodeC35 1.501318 0.081223 18.484 < 2e-16 \*\*\*  
## electrodeC36 0.899087 0.081223 11.069 < 2e-16 \*\*\*  
## electrodeC38 -0.607645 0.081223 -7.481 7.40e-14 \*\*\*  
## electrodeC39 -1.624308 0.081223 -19.998 < 2e-16 \*\*\*  
## electrodeC4 0.616750 0.081223 7.593 3.13e-14 \*\*\*  
## electrodeC40 2.121455 0.081223 26.119 < 2e-16 \*\*\*  
## electrodeC41 1.756394 0.081223 21.624 < 2e-16 \*\*\*  
## electrodeC42 1.483244 0.081223 18.261 < 2e-16 \*\*\*  
## electrodeC44 0.283941 0.081223 3.496 0.000473 \*\*\*  
## electrodeC45 -0.974228 0.081223 -11.994 < 2e-16 \*\*\*  
## electrodeC46 -1.689105 0.081223 -20.796 < 2e-16 \*\*\*  
## electrodeC47 1.703950 0.081223 20.979 < 2e-16 \*\*\*  
## electrodeC48 2.609527 0.081223 32.128 < 2e-16 \*\*\*  
## electrodeC49 1.944820 0.081223 23.944 < 2e-16 \*\*\*  
## electrodeC51 0.480946 0.081223 5.921 3.20e-09 \*\*\*  
## electrodeC52 -0.476103 0.081223 -5.862 4.59e-09 \*\*\*  
## electrodeC53 -1.361381 0.081223 -16.761 < 2e-16 \*\*\*  
## electrodeC54 1.572328 0.081223 19.358 < 2e-16 \*\*\*  
## electrodeC55 2.414147 0.081223 29.722 < 2e-16 \*\*\*  
## electrodeC56 0.948977 0.081223 11.684 < 2e-16 \*\*\*  
## electrodeC57 0.254027 0.081223 3.128 0.001763 \*\*   
## electrodeC58 -1.701401 0.081223 -20.947 < 2e-16 \*\*\*  
## electrodeC59 -1.563571 0.081223 -19.250 < 2e-16 \*\*\*  
## electrodeC6 -0.573118 0.081223 -7.056 1.72e-12 \*\*\*  
## electrodeC60 -1.478400 0.081223 -18.202 < 2e-16 \*\*\*  
## electrodeC7 -1.514143 0.081223 -18.642 < 2e-16 \*\*\*  
## electrodeC8 2.274712 0.081223 28.006 < 2e-16 \*\*\*  
## electrodeC9 1.626358 0.081223 20.023 < 2e-16 \*\*\*  
## conditionc1 0.235312 0.005632 41.783 < 2e-16 \*\*\*  
## conditionc2 0.081814 0.009755 8.387 < 2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 3.373 on 179277 degrees of freedom  
## Multiple R-squared: 0.3348, Adjusted R-squared: 0.3343   
## F-statistic: 739.4 on 122 and 179277 DF, p-value: < 2.2e-16

# Summary window 3: robust effect of condition, which doesn't interact   
# with location or RT.based\_Groups.  
  
  
  
  
# WINDOW 4 (500-750 ms)  
summaryBy(microvolts ~ c(location, RT.based\_Groups, condition), EEG.window4)

## location RT.based\_Groups condition microvolts.mean  
## 1 anterior Quick visual2visual -0.08009954  
## 2 anterior Quick auditory2visual -0.38921063  
## 3 anterior Quick haptic2visual -0.56717800  
## 4 anterior Slow visual2visual 0.32084222  
## 5 anterior Slow auditory2visual -0.46224964  
## 6 anterior Slow haptic2visual -0.74370959  
## 7 posterior Quick visual2visual -0.14138983  
## 8 posterior Quick auditory2visual -0.94209585  
## 9 posterior Quick haptic2visual -0.48267447  
## 10 posterior Slow visual2visual 0.09096922  
## 11 posterior Slow auditory2visual -0.76781783  
## 12 posterior Slow haptic2visual -1.23523733

# First, setting in random effects structure  
m0 = lmer(microvolts ~ 1+ (1| participant), data=EEG.window4,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0) # Departing from random intercepts Participant.  
 # Will be adding & commenting one by one.  
  
m0.01 = lmer(microvolts ~ 1+ (1| participant)+ (1|time),  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.01)  
anova(m0, m0.01) # random intercepts Time: IN (no random slopes because

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m0: microvolts ~ 1 + (1 | participant)  
## m0.01: microvolts ~ 1 + (1 | participant) + (1 | time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0 3 1178953 1178984 -589473 1178947   
## m0.01 4 1176993 1177035 -588493 1176985 1961.4 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

# all time points belong to a coherent window already)  
  
m0.010 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant: time), data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.010)  
anova(m0.01, m0.010) # random intercepts Time per ppt: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m0.01: microvolts ~ 1 + (1 | participant) + (1 | time)  
## m0.010: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.01 4 1176993 1177035 -588493 1176985   
## m0.010 5 1165087 1165138 -582538 1165077 11909 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.01, m0.010)

## df AIC  
## m0.01 4 1176994  
## m0.010 5 1165088

m0.1 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant: time)+ (1| electrode),  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
 #summary(m0.1)  
anova(m0.010, m0.1) # random intercepts Electrode: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m0.010: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time)  
## m0.1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1: (1 | electrode)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.010 5 1165087 1165138 -582538 1165077   
## m0.1 6 1158929 1158991 -579458 1158917 6160.1 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

m0.1b = lmer(microvolts ~ 1+ (1| participant)+ (1|time)  
 + (1|participant: time)+ (1| electrode)  
 + (1|electrode: participant), data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.1, m0.1b) # random intercepts Electrode: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m0.1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1: (1 | electrode)  
## m0.1b: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1b: (1 | electrode) + (1 | electrode:participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.1 6 1158929 1158991 -579458 1158917   
## m0.1b 7 1067791 1067863 -533888 1067777 91140 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

m0.12 = lmer(microvolts ~ 1+ (1| participant)+ (1|time)+ (1|electrode)  
 + (1|participant: time)+ (1|electrode: participant)+  
 (1| condition: participant), data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.1b, m0.12)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m0.1b: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m0.1b: (1 | electrode) + (1 | electrode:participant)  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | electrode) +   
## m0.12: (1 | participant:time) + (1 | electrode:participant) + (1 |   
## m0.12: condition:participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.1b 7 1067791 1067863 -533888 1067777   
## m0.12 8 1007663 1007746 -503824 1007647 60129 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.1b, m0.12) # intercepts cond by participant: IN

## df AIC  
## m0.1b 7 1067792  
## m0.12 8 1007664

m0.121 = lmer(microvolts ~ 1+ (1|time)+ (1|participant:time)+   
 (1| electrode)+ (1|electrode: participant)+ (1+ condition|   
 participant), data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m0.121) # slopes condition by participant: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | electrode) +   
## m0.12: (1 | participant:time) + (1 | electrode:participant) + (1 |   
## m0.12: condition:participant)  
## m0.121: microvolts ~ 1 + (1 | time) + (1 | participant:time) + (1 | electrode) +   
## m0.121: (1 | electrode:participant) + (1 + condition | participant)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m0.12 8 1007663 1007746 -503824 1007647   
## m0.121 12 1007665 1007788 -503820 1007641 6.7313 4 0.1508

m1 = lmer(microvolts ~ 1+ (1|participant)+ (1|time) +(1|participant: time)   
 + (1| electrode)+ (1|electrode: participant)+ (1|condition:   
 participant)+ (1| RT.based\_Groups: time), data=EEG.window4,   
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m1)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | electrode) +   
## m0.12: (1 | participant:time) + (1 | electrode:participant) + (1 |   
## m0.12: condition:participant)  
## m1: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m1: (1 | RT.based\_Groups:time)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m0.12 8 1007663 1007746 -503824 1007647   
## m1 9 1007665 1007758 -503824 1007647 0 1 0.9998

AIC(m0.12, m1) # intercepts RT.based\_Groups by time: out

## df AIC  
## m0.12 8 1007664  
## m1 9 1007666

m2.02 = lmer(microvolts ~ 1+ (1|participant)+ (1|time) +(1|participant:   
 time)+ (1| electrode) +(1|electrode: participant) +(1|condition:   
 participant)+ (1| electrode: participant: condition),   
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m0.12, m2.02)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m0.12: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | electrode) +   
## m0.12: (1 | participant:time) + (1 | electrode:participant) + (1 |   
## m0.12: condition:participant)  
## m2.02: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m2.02: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.02: (1 | electrode:participant:condition)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m0.12 8 1007663 1007746 -503824 1007647   
## m2.02 9 952160 952253 -476071 952142 55505 1 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m0.12, m2.02) # int intercepts elec\*particp\*condit: IN

## df AIC  
## m0.12 8 1007664.2  
## m2.02 9 952160.8

# Random effs structure set: m2.02. On to main effects:  
m2.1 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 +(1| electrode) +(1|electrode: participant) +(1|condition:   
 participant)+ (1| electrode: participant: condition),  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m2.02, m2.1)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m2.02: microvolts ~ 1 + (1 | participant) + (1 | time) + (1 | participant:time) +   
## m2.02: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.02: (1 | electrode:participant:condition)  
## m2.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m2.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.1: (1 | electrode:participant:condition)  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m2.02 9 952160 952253 -476071 952142   
## m2.1 38 952134 952526 -476029 952058 83.905 29 3.063e-07 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m2.02, m2.1) # ME time: IN

## df AIC  
## m2.02 9 952160.8  
## m2.1 38 952195.2

m3 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)+   
 (1|electrode) +(1|electrode: participant) +(1|condition:  
 participant)+ (1| electrode: participant: condition)+ location,  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m2.1, m3)

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m2.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m2.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.1: (1 | electrode:participant:condition)  
## m3: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3: (1 | electrode:participant:condition) + location  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m2.1 38 952134 952526 -476029 952058   
## m3 39 952133 952535 -476028 952055 2.8536 1 0.09117 .  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

AIC(m2.1, m3) # ME location: out

## df AIC  
## m2.1 38 952195.2  
## m3 39 952196.3

m3.1 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months,  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m2.1, m3.1) # ME age: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m2.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m2.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m2.1: (1 | electrode:participant:condition)  
## m3.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.1: (1 | electrode:participant:condition) + s\_Age\_months  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m2.1 38 952134 952526 -476029 952058   
## m3.1 39 952128 952530 -476025 952050 8.1579 1 0.004287 \*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

m3.4 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months   
 + Lefthanded, data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.1, m3.4) # ME handedness: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m3.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.1: (1 | electrode:participant:condition) + s\_Age\_months  
## m3.4: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.4: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.4: (1 | electrode:participant:condition) + s\_Age\_months + Lefthanded  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.1 39 952128 952530 -476025 952050   
## m3.4 40 952128 952541 -476024 952048 1.7838 1 0.1817

m3.42 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months+   
 Gender, data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.1, m3.42) # ME participant gender: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m3.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.1: (1 | electrode:participant:condition) + s\_Age\_months  
## m3.42: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.42: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.42: (1 | electrode:participant:condition) + s\_Age\_months + Gender  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.1 39 952128 952530 -476025 952050   
## m3.42 40 952129 952542 -476025 952049 0.4738 1 0.4912

# Maximal null model set: m3.1  
  
# ...and finally the critical variables...  
  
# CONDITION  
m3.50 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)+   
 (1|electrode) +(1|electrode: participant) +(1|condition:  
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months +   
 condition, data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.1, m3.50) # ME cond: IN

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m3.1: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.1: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.1: (1 | electrode:participant:condition) + s\_Age\_months  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + s\_Age\_months + condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)   
## m3.1 39 952128 952530 -476025 952050   
## m3.50 41 952124 952547 -476021 952042 7.5804 2 0.02259 \*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

m3.5 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months+   
 condition+ location: condition, data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
# int loc\*cond: not converging, suggesting lack of data for this test,   
# suggesting non-significant addition  
  
m3.51 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months+   
 condition+ Lefthanded: condition,   
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.51) # int handedness\*cond: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + s\_Age\_months + condition  
## m3.51: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.51: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.51: (1 | electrode:participant:condition) + s\_Age\_months + condition +   
## m3.51: Lefthanded:condition  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 41 952124 952547 -476021 952042   
## m3.51 44 952127 952581 -476020 952039 2.8243 3 0.4195

# GROUP   
m3.7 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months+   
 condition + RT.based\_Groups,  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.7) # ME RT.based\_Groups: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + s\_Age\_months + condition  
## m3.7: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.7: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.7: (1 | electrode:participant:condition) + s\_Age\_months + condition +   
## m3.7: RT.based\_Groups  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 41 952124 952547 -476021 952042   
## m3.7 42 952126 952559 -476021 952042 0.3148 1 0.5748

m3.8 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months+   
 condition + RT.based\_Groups: location,  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

#!Rank deficient! # int RT.based\_Groups\*location: rank deficient  
# As with m3.91 in Window 3, this suggests non-significant interaction.   
# The model does perfectly form if including main effect of RT.based\_Groups but  
# of course this cannot be granted to it, as RT.based\_Groups just proved non-sig.  
  
# Other interactions w/ condition  
m3.87 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months+   
 condition + condition: s\_Age\_months,  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.87) # int condition \* age: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + s\_Age\_months + condition  
## m3.87: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.87: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.87: (1 | electrode:participant:condition) + s\_Age\_months + condition +   
## m3.87: condition:s\_Age\_months  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 41 952124 952547 -476021 952042   
## m3.87 43 952126 952569 -476020 952040 2.5627 2 0.2777

m3.88 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months+   
 condition + condition: Gender,  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.88) # int condition \* gender: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + s\_Age\_months + condition  
## m3.88: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.88: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.88: (1 | electrode:participant:condition) + s\_Age\_months + condition +   
## m3.88: condition:Gender  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 41 952124 952547 -476021 952042   
## m3.88 44 952130 952584 -476021 952042 0.5426 3 0.9094

# CONDITION \* GROUP  
m3.9 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months+  
 condition + condition: RT.based\_Groups,  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))  
anova(m3.50, m3.9) # int RT.based\_Groups \* condition: out

## refitting model(s) with ML (instead of REML)

## Data: EEG.window4  
## Models:  
## m3.50: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.50: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.50: (1 | electrode:participant:condition) + s\_Age\_months + condition  
## m3.9: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## m3.9: (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## m3.9: (1 | electrode:participant:condition) + s\_Age\_months + condition +   
## m3.9: condition:RT.based\_Groups  
## Df AIC BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## m3.50 41 952124 952547 -476021 952042   
## m3.9 44 952128 952582 -476020 952040 1.9775 3 0.5771

m3.91 = lmer(microvolts ~ (1|participant)+ time+ (1|participant: time)   
 + (1|electrode) +(1|electrode: participant)+ (1|condition:   
 participant)+ (1| electrode: participant: condition)+ s\_Age\_months+   
 condition + RT.based\_Groups: location: condition,  
 data=EEG.window4,  
 control = lmerControl(optCtrl=list(maxfun=10000000)))

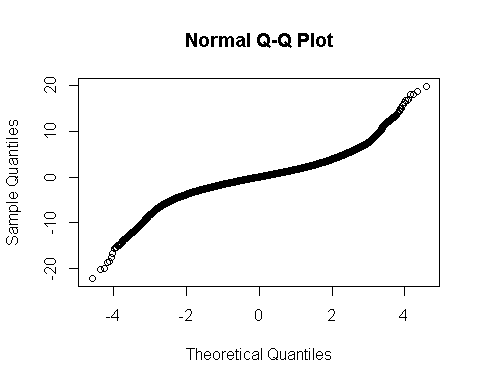
## fixed-effect model matrix is rank deficient so dropping 3 columns / coefficients

#!Rank deficient! # int RT.based\_Groups\*location\*condition: rank deficient  
# As previously, this deficiency suggests non-significant interaction.   
# Model does perfectly form if including 'RT.based\_Groups:condition' interaction.  
# Of course this cannot be granted to it, having just proven non-sig.  
  
# Conclusion window 4 overall. Model m3.50 chosen:  
summary(m3.50)

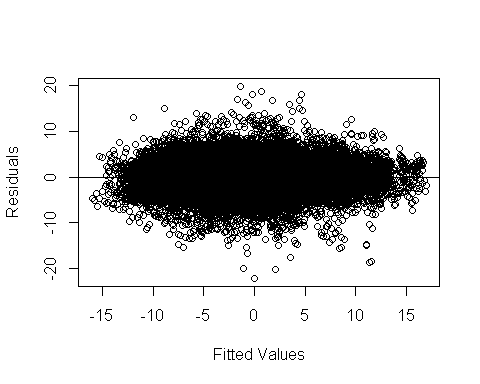
## Linear mixed model fit by REML ['lmerMod']  
## Formula: microvolts ~ (1 | participant) + time + (1 | participant:time) +   
## (1 | electrode) + (1 | electrode:participant) + (1 | condition:participant) +   
## (1 | electrode:participant:condition) + s\_Age\_months + condition  
## Data: EEG.window4  
## Control: lmerControl(optCtrl = list(maxfun = 1e+07))  
##   
## REML criterion at convergence: 952106  
##   
## Scaled residuals:   
## Min 1Q Median 3Q Max   
## -11.6063 -0.5589 0.0045 0.5563 10.3710   
##   
## Random effects:  
## Groups Name Variance Std.Dev.  
## electrode:participant:condition (Intercept) 2.0614 1.4357   
## electrode:participant (Intercept) 3.3205 1.8222   
## participant:time (Intercept) 0.8625 0.9287   
## condition:participant (Intercept) 2.2087 1.4862   
## electrode (Intercept) 0.2279 0.4773   
## participant (Intercept) 1.5565 1.2476   
## Residual 3.6860 1.9199   
## Number of obs: 222456, groups:   
## electrode:participant:condition, 7176; electrode:participant, 2392; participant:time, 1426; condition:participant, 138; electrode, 52; participant, 46  
##   
## Fixed effects:  
## Estimate Std. Error t value  
## (Intercept) -0.7934 0.3283 -2.417  
## time512 0.1456 0.1963 0.742  
## time520 0.1648 0.1963 0.840  
## time528 0.2621 0.1963 1.335  
## time536 0.3643 0.1963 1.856  
## time544 0.4661 0.1963 2.374  
## time552 0.7281 0.1963 3.709  
## time560 0.6939 0.1963 3.535  
## time568 0.8303 0.1963 4.230  
## time576 0.8852 0.1963 4.510  
## time584 0.8412 0.1963 4.285  
## time592 0.8933 0.1963 4.551  
## time600 0.8521 0.1963 4.341  
## time608 0.9385 0.1963 4.781  
## time616 0.8798 0.1963 4.482  
## time624 0.9063 0.1963 4.617  
## time632 0.9506 0.1963 4.843  
## time640 0.9185 0.1963 4.679  
## time648 1.0261 0.1963 5.227  
## time656 1.0291 0.1963 5.243  
## time664 0.9471 0.1963 4.825  
## time672 1.0186 0.1963 5.189  
## time680 1.0915 0.1963 5.560  
## time688 1.1231 0.1963 5.721  
## time696 1.2419 0.1963 6.327  
## time704 1.2622 0.1963 6.430  
## time712 1.2420 0.1963 6.327  
## time720 1.1733 0.1963 5.977  
## time728 1.0360 0.1963 5.278  
## time736 1.1174 0.1963 5.693  
## time744 1.0400 0.1963 5.298  
## s\_Age\_months 0.6678 0.2283 2.924  
## conditionauditory2visual -0.6879 0.3128 -2.199  
## conditionhaptic2visual -0.8048 0.3128 -2.573

##   
## Correlation matrix not shown by default, as p = 34 > 12.  
## Use print(x, correlation=TRUE) or  
## vcov(x) if you need it

# Residuals diagnostics:  
# Normal Q-Q plot of residuals:  
qqnorm(resid(m3.50))



# Plot of Residuals vs. Fitted values:  
plot(fitted(m3.50),resid(m3.50),xlab='Fitted Values', ylab='Residuals');   
abline(h=0)



# Fit  
1-var(residuals(m3.50))/(var(model.response(model.frame(m3.50)))) # Omega^2

## [1] 0.7543074

r.squaredGLMM(m3.50) # R2m: fixed effs. R2c: fixed + random effs

## R2m R2c   
## 0.04676131 0.74764987

RMSE.merMod(m3.50, scale = FALSE) # Root MSE

## [1] 1.883987

png(file="Fixef win 4.png", units="in", width=6, height=6, res=500)  
plotFEsim(FEsim(m3.50))  
dev.off()

## png   
## 2

# Freeing up workspace  
rm(list=setdiff(ls(), c("EEG", "EEG.window1", "EEG.window2",  
 "EEG.window3", "EEG.window4")))  
  
  
# Follow-up ANOVAs into condition in each RT.based\_Groups and location. Effects are  
# based on general window 1, except that age cannot be entered due to insufficient   
# variation. . See contrasts 1 and 2 at the bottom.  
# Contrast 1 = visual2visual - (haptic2visual + auditory2visual)  
# Contrast 2 = auditory2visual - haptic2visual  
  
# All window 4, no subsets  
fit = aov(microvolts ~ time+ participant+ electrode+ conditionc,  
 data=EEG.window4)  
summary.lm(fit)

##   
## Call:  
## aov(formula = microvolts ~ time + participant + electrode + conditionc,   
## data = EEG.window4)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -20.656 -1.989 0.022 1.993 24.592   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.462330 0.079842 5.791 7.02e-09 \*\*\*  
## time512 0.145630 0.055786 2.611 0.009041 \*\*   
## time520 0.164822 0.055786 2.955 0.003132 \*\*   
## time528 0.262110 0.055786 4.698 2.62e-06 \*\*\*  
## time536 0.364288 0.055786 6.530 6.59e-11 \*\*\*  
## time544 0.466084 0.055786 8.355 < 2e-16 \*\*\*  
## time552 0.728102 0.055786 13.052 < 2e-16 \*\*\*  
## time560 0.693903 0.055786 12.439 < 2e-16 \*\*\*  
## time568 0.830276 0.055786 14.883 < 2e-16 \*\*\*  
## time576 0.885229 0.055786 15.868 < 2e-16 \*\*\*  
## time584 0.841176 0.055786 15.079 < 2e-16 \*\*\*  
## time592 0.893325 0.055786 16.013 < 2e-16 \*\*\*  
## time600 0.852126 0.055786 15.275 < 2e-16 \*\*\*  
## time608 0.938495 0.055786 16.823 < 2e-16 \*\*\*  
## time616 0.879816 0.055786 15.771 < 2e-16 \*\*\*  
## time624 0.906272 0.055786 16.245 < 2e-16 \*\*\*  
## time632 0.950555 0.055786 17.039 < 2e-16 \*\*\*  
## time640 0.918521 0.055786 16.465 < 2e-16 \*\*\*  
## time648 1.026074 0.055786 18.393 < 2e-16 \*\*\*  
## time656 1.029119 0.055786 18.448 < 2e-16 \*\*\*  
## time664 0.947085 0.055786 16.977 < 2e-16 \*\*\*  
## time672 1.018610 0.055786 18.259 < 2e-16 \*\*\*  
## time680 1.091463 0.055786 19.565 < 2e-16 \*\*\*  
## time688 1.123052 0.055786 20.131 < 2e-16 \*\*\*  
## time696 1.241881 0.055786 22.261 < 2e-16 \*\*\*  
## time704 1.262236 0.055786 22.626 < 2e-16 \*\*\*  
## time712 1.241983 0.055786 22.263 < 2e-16 \*\*\*  
## time720 1.173284 0.055786 21.032 < 2e-16 \*\*\*  
## time728 1.035998 0.055786 18.571 < 2e-16 \*\*\*  
## time736 1.117445 0.055786 20.031 < 2e-16 \*\*\*  
## time744 1.040019 0.055786 18.643 < 2e-16 \*\*\*  
## participant10 -0.882997 0.067955 -12.994 < 2e-16 \*\*\*  
## participant11 -2.424830 0.067955 -35.683 < 2e-16 \*\*\*  
## participant12 -2.424830 0.067955 -35.683 < 2e-16 \*\*\*  
## participant13 -2.840687 0.067955 -41.802 < 2e-16 \*\*\*  
## participant14 1.332151 0.067955 19.603 < 2e-16 \*\*\*  
## participant15 -1.529259 0.067955 -22.504 < 2e-16 \*\*\*  
## participant16 -3.378966 0.067955 -49.723 < 2e-16 \*\*\*  
## participant17 -3.085280 0.067955 -45.402 < 2e-16 \*\*\*  
## participant18 -1.219915 0.067955 -17.952 < 2e-16 \*\*\*  
## participant19 0.575649 0.067955 8.471 < 2e-16 \*\*\*  
## participant2 -5.853588 0.067955 -86.139 < 2e-16 \*\*\*  
## participant20 -2.983127 0.067955 -43.898 < 2e-16 \*\*\*  
## participant21 -1.378592 0.067955 -20.287 < 2e-16 \*\*\*  
## participant22 -2.715434 0.067955 -39.959 < 2e-16 \*\*\*  
## participant23 0.266962 0.067955 3.928 8.55e-05 \*\*\*  
## participant24 -1.746721 0.067955 -25.704 < 2e-16 \*\*\*  
## participant26 -0.624942 0.067955 -9.196 < 2e-16 \*\*\*  
## participant27 -2.989150 0.067955 -43.987 < 2e-16 \*\*\*  
## participant28 -1.510893 0.067955 -22.234 < 2e-16 \*\*\*  
## participant29 -1.302906 0.067955 -19.173 < 2e-16 \*\*\*  
## participant3 -1.287224 0.067955 -18.942 < 2e-16 \*\*\*  
## participant30 -2.954235 0.067955 -43.473 < 2e-16 \*\*\*  
## participant31 -0.444577 0.067955 -6.542 6.08e-11 \*\*\*  
## participant32 -1.190630 0.067955 -17.521 < 2e-16 \*\*\*  
## participant34 0.019234 0.067955 0.283 0.777153   
## participant35 -1.798071 0.067955 -26.460 < 2e-16 \*\*\*  
## participant36 0.502169 0.067955 7.390 1.48e-13 \*\*\*  
## participant37 -0.397514 0.067955 -5.850 4.93e-09 \*\*\*  
## participant38 3.157405 0.067955 46.463 < 2e-16 \*\*\*  
## participant39 -2.832854 0.067955 -41.687 < 2e-16 \*\*\*  
## participant4 -0.589153 0.067955 -8.670 < 2e-16 \*\*\*  
## participant40 -2.110641 0.067955 -31.059 < 2e-16 \*\*\*  
## participant41 -1.730132 0.067955 -25.460 < 2e-16 \*\*\*  
## participant42 -0.766226 0.067955 -11.275 < 2e-16 \*\*\*  
## participant44 2.288338 0.067955 33.674 < 2e-16 \*\*\*  
## participant45 -2.877685 0.067955 -42.347 < 2e-16 \*\*\*  
## participant46 -3.553166 0.067955 -52.287 < 2e-16 \*\*\*  
## participant47 -3.513744 0.067955 -51.707 < 2e-16 \*\*\*  
## participant48 -1.293209 0.067955 -19.030 < 2e-16 \*\*\*  
## participant49 0.320279 0.067955 4.713 2.44e-06 \*\*\*  
## participant5 -2.082872 0.067955 -30.651 < 2e-16 \*\*\*  
## participant50 -2.601007 0.067955 -38.275 < 2e-16 \*\*\*  
## participant6 -2.605387 0.067955 -38.340 < 2e-16 \*\*\*  
## participant8 -3.846675 0.067955 -56.606 < 2e-16 \*\*\*  
## participant9 -2.018338 0.067955 -29.701 < 2e-16 \*\*\*  
## electrodeC10 -0.304850 0.072251 -4.219 2.45e-05 \*\*\*  
## electrodeC12 0.463410 0.072251 6.414 1.42e-10 \*\*\*  
## electrodeC13 -0.440040 0.072251 -6.090 1.13e-09 \*\*\*  
## electrodeC14 -0.800469 0.072251 -11.079 < 2e-16 \*\*\*  
## electrodeC15 -0.741627 0.072251 -10.265 < 2e-16 \*\*\*  
## electrodeC16 -0.979373 0.072251 -13.555 < 2e-16 \*\*\*  
## electrodeC17 -0.212223 0.072251 -2.937 0.003311 \*\*   
## electrodeC19 0.725232 0.072251 10.038 < 2e-16 \*\*\*  
## electrodeC2 -0.416555 0.072251 -5.765 8.16e-09 \*\*\*  
## electrodeC20 0.089194 0.072251 1.234 0.217021   
## electrodeC21 -0.111444 0.072251 -1.542 0.122967   
## electrodeC22 -0.873283 0.072251 -12.087 < 2e-16 \*\*\*  
## electrodeC23 -0.779232 0.072251 -10.785 < 2e-16 \*\*\*  
## electrodeC24 0.546825 0.072251 7.568 3.79e-14 \*\*\*  
## electrodeC25 0.606227 0.072251 8.391 < 2e-16 \*\*\*  
## electrodeC26 -0.791567 0.072251 -10.956 < 2e-16 \*\*\*  
## electrodeC27 -0.691531 0.072251 -9.571 < 2e-16 \*\*\*  
## electrodeC28 0.052038 0.072251 0.720 0.471380   
## electrodeC29 0.170752 0.072251 2.363 0.018114 \*   
## electrodeC3 -0.054242 0.072251 -0.751 0.452812   
## electrodeC31 -0.601736 0.072251 -8.328 < 2e-16 \*\*\*  
## electrodeC33 0.189753 0.072251 2.626 0.008633 \*\*   
## electrodeC34 -0.313531 0.072251 -4.339 1.43e-05 \*\*\*  
## electrodeC35 0.053694 0.072251 0.743 0.457389   
## electrodeC36 0.106008 0.072251 1.467 0.142321   
## electrodeC38 -0.231596 0.072251 -3.205 0.001349 \*\*   
## electrodeC39 -0.959057 0.072251 -13.274 < 2e-16 \*\*\*  
## electrodeC4 -0.148181 0.072251 -2.051 0.040278 \*   
## electrodeC40 -0.216010 0.072251 -2.990 0.002793 \*\*   
## electrodeC41 -0.616614 0.072251 -8.534 < 2e-16 \*\*\*  
## electrodeC42 -0.010278 0.072251 -0.142 0.886875   
## electrodeC44 0.625134 0.072251 8.652 < 2e-16 \*\*\*  
## electrodeC45 -0.304888 0.072251 -4.220 2.45e-05 \*\*\*  
## electrodeC46 -0.737765 0.072251 -10.211 < 2e-16 \*\*\*  
## electrodeC47 -1.118157 0.072251 -15.476 < 2e-16 \*\*\*  
## electrodeC48 -0.684245 0.072251 -9.470 < 2e-16 \*\*\*  
## electrodeC49 0.466571 0.072251 6.458 1.07e-10 \*\*\*  
## electrodeC51 1.119562 0.072251 15.495 < 2e-16 \*\*\*  
## electrodeC52 0.620880 0.072251 8.593 < 2e-16 \*\*\*  
## electrodeC53 0.017425 0.072251 0.241 0.809427   
## electrodeC54 -0.887029 0.072251 -12.277 < 2e-16 \*\*\*  
## electrodeC55 -0.268046 0.072251 -3.710 0.000207 \*\*\*  
## electrodeC56 0.909958 0.072251 12.594 < 2e-16 \*\*\*  
## electrodeC57 0.591680 0.072251 8.189 2.64e-16 \*\*\*  
## electrodeC58 -1.113163 0.072251 -15.407 < 2e-16 \*\*\*  
## electrodeC59 -0.727253 0.072251 -10.066 < 2e-16 \*\*\*  
## electrodeC6 -0.573586 0.072251 -7.939 2.05e-15 \*\*\*  
## electrodeC60 -0.150256 0.072251 -2.080 0.037561 \*   
## electrodeC7 -0.958956 0.072251 -13.272 < 2e-16 \*\*\*  
## electrodeC8 -0.057876 0.072251 -0.801 0.423111   
## electrodeC9 -0.474664 0.072251 -6.570 5.06e-11 \*\*\*  
## conditionc1 0.248784 0.005010 49.660 < 2e-16 \*\*\*  
## conditionc2 0.058428 0.008677 6.734 1.66e-11 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 3.342 on 222327 degrees of freedom  
## Multiple R-squared: 0.2275, Adjusted R-squared: 0.2271   
## F-statistic: 511.6 on 128 and 222327 DF, p-value: < 2.2e-16

# Summary window 4: like window 3, window 4 presents a robust effect of   
# condition, which doesn't interact with location or RT.based\_Groups.