

Install and load the NPL package:

<https://github.com/EricMenetre/NPL>

Install and load the lme4, lmerTest, emmeans and MuMIn packages

# Cheat Sheet Linear Mixed Models

## Step 1: investigate the normality of the different variables

```
exp_plots_LMM(data, data$DV,  
data$ID, data$class)
```

Perform other plots if needed

## Step 2: build an empty model (m0) with the minimum of random variables

```
M0 <- lmer(DV ~ 1 +  
(1|subject), data = data, REML  
= FALSE)
```

## Step 3: build several models adding always one fixed effect at a time

```
M1 <- lmer(DV ~ IV1 + (1|subject), data =  
data, REML = FALSE)  
M2 <- lmer(DV ~ IV1 + IV2 + (1|subject),  
data = data, REML = FALSE)  
Mn <- lmer(DV ~ IV1 + IV2 + IVn  
(1|subject), data = data, REML = FALSE)
```

Do not add the interactions at this step.  
REML should be set to FALSE, see step 5

## Step 6: add the interactions to the model

```
Mn <- lmer(DV ~ IV1 + IV2 + IVn  
+ IV1:IV2 + (1|subject)+  
(1|item), data = data, REML =  
FALSE)
```

REML must be set as FALSE since we compare  
fixed effects here

## Step 5: add the other eventual random effects

```
Mn <- lmer(DV ~ IV1 + IV2 + IVn  
(1|subject)+ (1|item), data = data, REML =  
TRUE)
```

Do not add the interactions at this step.  
To compare models based on their fixed effects,  
we need to set REML = FALSE. When comparing  
interactions, REML must be TRUE

## Step 4: for each model, check the postulates and estimate the marginal and conditional R<sup>2</sup>

```
summary(model)  
LMM_check(model)  
r.squaredGLMM(model)
```

All the plots should show normal distributions

## Step 6: compare the models to find the best one

- Systematically compare the models based on (information available in the summary):
  - the difference in deviance The AIC; BIC and cAIC (only the cAIC is available in the REML models)
  - The two R<sup>2</sup>
- Select the model with the **lowest** AIC; BIC or cAIC and the **highest** R<sup>2</sup>

## Step 7: get the main effects and the post-hocs

```
anova(model_opt)  
summary(model_opt)  
emmeans(model_opt,  
list(pairwise ~ IV | IV2),  
adjust = 'tukey')
```

### Dictionary:

- Fixed effects**: same as the independent variables in the ANOVA
- Random effects**: either random intercept or random slope → part of the variance explained by the fact that a certain subject belongs to a certain group, or that a certain RT belongs to a certain subject
- Marginal R<sup>2</sup>**: part of variance explained by the fixed effects
- Conditional R<sup>2</sup>**: part of variance explained by the fixed and the random effects
- REML**: adjustment method, either maximum likelihood (ML) or REML for restricted maximum likelihood.