

# Mixed effects analysis of Experiments 1 and 2

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NB Only rating scales are common to both studies

NB R treats the two conditions alphabetically (i.e., insects, flowers), so that all effects sizes are returned as negative despite being in line with the hypotheses. All are inverted when reported in the manuscript to make the reported results congruent with the wording of the hypothesis.

```
library(tidyverse)
library(psych)
library(BayesFactor)
library(afex)

# experiment 1
exp1_df <-
  read.csv("/Users/Ian/Dropbox/Work/Manuscripts/Hussey & De Houwer - the IAT as an analogical learning")
  select(participant,
         condition,
         block_order,
         ratings_pre,
         ratings_post,
         ratings_change_scores) %>% # select only necessary columns
  mutate(experiment = 1,
         unique_identifier = paste(experiment, participant, sep = "_"),
         ratings_pre_Z_scores = as.numeric(scale(ratings_pre, # convert ratings to z scores
                                                center = TRUE, # i.e., deduct rows from mean
                                                scale = TRUE)),
         ratings_post_Z_scores = as.numeric(scale(ratings_post, # convert ratings to z scores
                                                center = TRUE, # i.e., deduct rows from mean
                                                scale = TRUE)),
         ratings_change_Z_scores = as.numeric(scale(ratings_change_scores, # convert ratings to z scores
                                                center = TRUE, # i.e., deduct rows from mean
                                                scale = TRUE))) # i.e., divide by SD

# experiment 2
exp2_df <-
  read.csv("/Users/Ian/Dropbox/Work/Manuscripts/Hussey & De Houwer - the IAT as an analogical learning")
  select(participant,
         condition,
         IAT_block_order,
         ratings_pre,
         ratings_post,
         ratings_change_scores) %>% # select only necessary columns
  rename(block_order = IAT_block_order) %>%
```

```

mutate(experiment = 2,
       unique_identifier = paste(experiment, participant, sep = "_"),
       ratings_pre_Z_scores = as.numeric(scale(ratings_pre, # convert ratings to z scores
                                              center = TRUE, # i.e., deduct rows from mean
                                              scale = TRUE)),
       ratings_post_Z_scores = as.numeric(scale(ratings_post, # convert ratings to z scores
                                              center = TRUE, # i.e., deduct rows from mean
                                              scale = TRUE)),
       ratings_change_Z_scores = as.numeric(scale(ratings_change_scores, # convert ratings to z scores
                                              center = TRUE, # i.e., deduct rows from mean
                                              scale = TRUE))) # i.e., divide by SD

# combine data
combined_df <-
  full_join(exp1_df, exp2_df) %>%
  select(unique_identifier,
         experiment,
         condition,
         block_order,
         ratings_pre_Z_scores,
         ratings_post_Z_scores,
         ratings_change_Z_scores) %>%
  mutate(experiment = as.factor(experiment),
         condition = as.factor(condition),
         block_order = as.factor(block_order))

## Joining, by = c("participant", "condition", "block_order", "ratings_pre", "ratings_post", "ratings_change")

```

## Hypothesis tests

### Differences in ratings changes between conditions

Experiment entered as a random factor

#### Frequentist

```

model_1 <- afex::mixed(ratings_change_Z_scores ~ condition + (1 | experiment),
                      contrasts = TRUE,
                      data = combined_df,
                      type = 3, # sum of squares
                      method = "KR",
                      progress = TRUE,
                      return = "mixed")

## Contrasts set to contr.sum for the following variables: condition, experiment
## Fitting 2 (g)lmer() models:
## [...]
## Obtaining 1 p-values:
## [...]

summary(model_1)

```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: ratings_change_Z_scores ~ condition + (1 | experiment)
## Data: combined_df
##
## REML criterion at convergence: 424.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.4783 -0.5033 -0.0939  0.5581  3.0676
##
## Random effects:
## Groups      Name      Variance Std.Dev.
## experiment (Intercept) 8.967e-35 9.470e-18
## Residual          9.253e-01 9.619e-01
## Number of obs: 152, groups:  experiment, 2
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept) -0.007148   0.078049  -0.092
## condition1  -0.271642   0.078049  -3.480
##
## Correlation of Fixed Effects:
##              (Intr)
## condition1 0.026
print(model_1) # same as using anova() here
##      Effect      df F.scaling      F p.value
## 1 condition 1, 149.10      1.00 12.10 ***   .0007
```

## Bayes factors

```
anovaBF(ratings_change_Z_scores ~ condition + experiment,
        whichRandom = "experiment",
        data = combined_df,
        rscaleFixed = "medium",
        multicore = TRUE)

## Note: Progress bars and callbacks are suppressed when running multicore.
## Bayes factor analysis
## -----
## [1] condition + experiment : 39.68598 ±0.95%
##
## Against denominator:
## ratings_change_Z_scores ~ experiment
## ---
## Bayes factor type: BFlinearModel, JZS
```

## Exploratory tests

### Influence of block order on the effect

Experiment entered as a random factor

## Frequentist

```
model_2 <- afex::mixed(ratings_change_Z_scores ~ condition * block_order + (1 | experiment),
                      contrasts = TRUE,
                      data = combined_df,
                      type = 3, # sum of squares
                      method = "KR",
                      progress = TRUE,
                      return = "mixed")

## Contrasts set to contr.sum for the following variables: condition, block_order, experiment
## Fitting 4 (g)lmer() models:
## [...]
## Obtaining 3 p-values:
## [...]

summary(model_2)

## Linear mixed model fit by REML ['lmerMod']
## Formula:
## ratings_change_Z_scores ~ condition * block_order + (1 | experiment)
## Data: combined_df
##
## REML criterion at convergence: 430.5
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.4664 -0.5168 -0.0774  0.5452  3.0312
##
## Random effects:
##   Groups      Name      Variance Std.Dev.
##   experiment (Intercept) 9.083e-35 9.531e-18
##   Residual              9.372e-01 9.681e-01
## Number of obs: 152, groups:  experiment, 2
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)   -0.006946   0.078564  -0.088
## condition1    -0.271844   0.078564  -3.460
## block_order1   -0.006629   0.078564  -0.084
## condition1:block_order1 -0.022434   0.078564  -0.286
##
## Correlation of Fixed Effects:
##              (Intr) cndtn1 blk_1
## condition1    0.026
## block_ordr1   0.012 -0.012
## cndtn1:blk_1 -0.012  0.012  0.026

print(model_2) # same as using anova() here

##              Effect              df F.scaling      F p.value
## 1            condition 1, 147.10      1.00 11.96 ***  .0007
## 2            block_order 1, 147.02      1.00  0.01   .93
## 3 condition:block_order 1, 147.02      1.00  0.08   .78
```

## Bayes factors

```
anovaBF(ratings_change_Z_scores ~ condition * block_order + experiment,
        whichRandom = "experiment",
        data = combined_df,
        rscaleFixed = "medium",
        multicore = TRUE)

## Note: Progress bars and callbacks are suppressed when running multicore.

## Bayes factor analysis
## -----
## [1] condition + experiment : 37.85566 ±1.73%
## [2] block_order + experiment : 0.1635947 ±1.19%
## [3] condition + block_order + experiment : 6.465425 ±1.81%
## [4] condition + block_order + condition:block_order + experiment : 1.755916 ±1.84%
##
## Against denominator:
## ratings_change_Z_scores ~ experiment
## ---
## Bayes factor type: BFlinearModel, JZS
```