Mixed effects analysis of Experiments 1 and 2

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Contents

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 retured 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 t
  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 score
                                                    center = TRUE,  # i.e., deduct rows from mean
                                                    scale = TRUE)))  # i.e., devide by SD

# experiment 2
exp2_df <-
  read.csv("/Users/Ian/Dropbox/Work/Manuscripts/Hussey & De Houwer - the IAT as an analogical learning t
  select(participant,
         condition,
         block_order,
         ratings_pre,
         ratings_post,
         ratings_change_scores) %>%  # select only necessary columns
  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 score
                                                    center = TRUE,  # i.e., deduct rows from mean
                                                    scale = TRUE)))  # i.e., devide 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_cl
```

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 : 38.22776 ±1.53%
##
## 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 blck_1
## condition1   0.026
## block_ordr1  0.012 -0.012
## cndtn1:bl_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                                          : 38.48817  ±2.24%
## [2] block_order + experiment                                        : 0.1714507 ±2.9%
## [3] condition + block_order + experiment                            : 7.304458  ±8.72%
## [4] condition + block_order + condition:block_order + experiment : 1.703722  ±1.72%
##
## Against denominator:
##   ratings_change_Z_scores ~ experiment
## ---
## Bayes factor type: BFlinearModel, JZS
```