Feelings_initial

2025-04-13

```
feelings_initial <- load("feelings_initial.RData")
ls()
```

```
## [1] "dat"              "feelings_initial" "Iaro_wide"        "Ineg_wide"
## [5] "Ipos_wide"
```

```
summary(feelings_initial)
```

```
##    Length     Class      Mode
##         4 character character
```

```
str(dat)
```

```
## 'data.frame':    16380 obs. of  9 variables:
##  $ subj     : Factor w/ 156 levels "f001","f002",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ trial.num: int  1 2 3 4 5 6 7 8 9 10 ...
##  $ trial.val: Factor w/ 3 levels "neg","neu","pos": 3 1 1 3 3 2 2 1 1 3 ...
##  $ sex      : Factor w/ 3 levels "male","female",..: 2 2 2 2 2 2 2 2 2 2 ...
##  $ age      : int  19 19 19 19 19 19 19 19 19 19 ...
##  $ ethn     : Factor w/ 7 levels "Asian or Pacific Islander",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ Ineg     : num  1 4 2 1 1 1 1 3 5 1 ...
##  $ Ipos     : num  3.69 1 1 1 4 ...
##  $ Iaro     : num  2.86 3 2 2 3 ...
```

Descriptive statistics

```
summary(dat[, c("Ineg", "Ipos", "Iaro")])
```

```
##       Ineg            Ipos            Iaro
##  Min.   :1.000   Min.   :1.000   Min.   :1.000
##  1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000
##  Median :2.000   Median :2.000   Median :3.000
##  Mean   :3.075   Mean   :3.066   Mean   :3.265
##  3rd Qu.:5.000   3rd Qu.:5.000   3rd Qu.:5.000
##  Max.   :9.000   Max.   :9.000   Max.   :9.000
```

```
# identify NAs
colSums(is.na(dat))
```

```
##      subj trial.num trial.val       sex       age      ethn      Ineg      Ipos
##         0         0         0         0         0         0         0         0
##      Iaro
##         0
```

There are no NAs in the dataset.

```
# identify outliers using z-score

# Calculate Z-scores for Ineg, Ipos, and Iaro
dat$z_Ineg <- scale(dat$Ineg)
dat$z_Ipos <- scale(dat$Ipos)
dat$z_Iaro <- scale(dat$Iaro)

# Identify outliers (Z-score > 3 or < -3)
outliers_Ineg <- dat[abs(dat$z_Ineg) > 3, ]
outliers_Ineg
```

```
##  [1] subj      trial.num trial.val sex       age       ethn      Ineg
##  [8] Ipos      Iaro      z_Ineg    z_Ipos    z_Iaro
## <0 rows> (or 0-length row.names)
```

```
outliers_Ipos <- dat[abs(dat$z_Ipos) > 3, ]
outliers_Ipos
```

```
##  [1] subj      trial.num trial.val sex       age       ethn      Ineg
##  [8] Ipos      Iaro      z_Ineg    z_Ipos    z_Iaro
## <0 rows> (or 0-length row.names)
```

```
outliers_Iaro <- dat[abs(dat$z_Iaro) > 3, ]
outliers_Iaro
```

```
##  [1] subj      trial.num trial.val sex       age       ethn      Ineg
##  [8] Ipos      Iaro      z_Ineg    z_Ipos    z_Iaro
## <0 rows> (or 0-length row.names)
```

There are no outliers.

Mixed-effects model: analyze data with repeated measures

- Each participant has multiple trials, so the trials within a participant are likely correlated
- Data is nested
- Each participant may have their own baseline level of emotional responses
- fixed effects (trial.val, sex, age, ethn) explain the variation between individuals
- random effects (1|subj) explain the correlation of repeated measures within individuals

```r
library(lme4)
```

```
## Loading required package: Matrix
```

```r
# Mixed-effects model for predicting Ineg
model_ineg <- lmer(Ineg ~ trial.val + sex + age + ethn + (1|subj), data = dat)
summary(model_ineg)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: Ineg ~ trial.val + sex + age + ethn + (1 | subj)
##    Data: dat
##
## REML criterion at convergence: 58969.5
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.9915 -0.5714 -0.0487  0.5031  5.6660
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  subj     (Intercept) 0.5259   0.7252
##  Residual             2.0745   1.4403
## Number of obs: 16380, groups:  subj, 156
##
## Fixed effects:
##                                                    Estimate Std. Error
## (Intercept)                                        5.218934   0.443816
## trial.valneu                                      -4.076439   0.034381
## trial.valpos                                      -4.086175   0.024311
## sexfemale                                          0.317543   0.121858
## sexother                                          -0.031652   0.747300
## age                                                0.001809   0.021086
## ethnBlack/African American                        -0.060943   0.237892
## ethnLatino/Hispanic                               -0.317652   0.232008
## ethnOther                                          0.138570   0.290750
## ethnWhite/Caucasian                                0.070420   0.155354
## ethnAmerican Indian/Native American or Alaskan Native -0.692261   0.393608
## ethnDecline to state                              -0.275510   0.543413
##                                                    t value
## (Intercept)                                         11.759
## trial.valneu                                      -118.566
## trial.valpos                                      -168.079
## sexfemale                                            2.606
## sexother                                            -0.042
## age                                                  0.086
## ethnBlack/African American                          -0.256
## ethnLatino/Hispanic                                 -1.369
## ethnOther                                            0.477
## ethnWhite/Caucasian                                  0.453
## ethnAmerican Indian/Native American or Alaskan Native   -1.759
## ethnDecline to state                                -0.507
##
```

```
## Correlation of Fixed Effects:
##             (Intr) trl.vln trl.vlp sexfml sexthr age    etB/AA ethL/H ethnOt
## trial.valne -0.019
## trial.valps -0.027  0.354
## sexfemale   -0.197  0.000   0.000
## sexother    -0.070  0.000   0.000   0.084
## age         -0.941  0.000   0.000   0.021  0.059
## ethnBlck/AA -0.026  0.000   0.000   0.072 -0.002 -0.149
## ethnLtn/Hsp  0.065  0.000   0.000   0.072 -0.008 -0.250  0.334
## ethnOther   -0.081  0.000   0.000  -0.044 -0.006 -0.038  0.234  0.244
## ethnWht/Ccs -0.091  0.000   0.000   0.107 -0.062 -0.171  0.468  0.496  0.357
## ethAI/NAoAN -0.141  0.000   0.000   0.123  0.012  0.029  0.176  0.178  0.134
## ethnDclntst -0.067  0.000   0.000   0.144  0.010 -0.027  0.139  0.145  0.096
##             ethW/C eIAoAN
## trial.valne
## trial.valps
## sexfemale
## sexother
## age
## ethnBlck/AA
## ethnLtn/Hsp
## ethnOther
## ethnWht/Ccs
## ethAI/NAoAN  0.271
## ethnDclntst  0.211  0.092
```

- Random effects: each participant has a different baseline emotional response
  - `(1|subj)`: represents the random effect
    - each participant (subj) has a different baseline deviation (intercept).
    - This accounts for the correlation between multiple trial results from the same participant
- `REML score` (residual maximum likelihood estimate): assess the model fit
- Fixed Effects:
  - Intercept: Negative trial
  - `trial.valneu` (Neutral trial): Estimate = -4.08, t = -118.57, a very significant negative value.
    - Compared to the baseline (negative trial), the neutral trial significantly decreases negative emotions (Ineg)
  - `trial.valpos` (Positive trial): Estimate = -4.09, t = -168.08, also significant.
    - the positive trial also significantly decreases negative emotions compared to the negative trial
  - sexfemale: Estimate = 0.317543, t = 2.606.
    - Females have significantly higher negative emotional responses (Ineg) compared to males
  - The effects of age and ethnicity are small and not significant

```r
# Mixed-effects model for predicting Ipos
model_ipos <- lmer(Ipos ~ trial.val + sex + age + ethn + (1|subj), data = dat)
summary(model_ipos)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: Ipos ~ trial.val + sex + age + ethn + (1 | subj)
##    Data: dat
##
```

```
## REML criterion at convergence: 60034.7
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.8302 -0.5834 -0.0294  0.5335  5.4659
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  subj     (Intercept) 0.5687   0.7541
##  Residual             2.2138   1.4879
## Number of obs: 16380, groups:  subj, 156
##
## Fixed effects:
##                                                          Estimate Std. Error
## (Intercept)                                               0.71768    0.46141
## trial.valneu                                              0.33658    0.03552
## trial.valpos                                              4.03432    0.02511
## sexfemale                                                 0.20020    0.12669
## sexother                                                 -1.13135    0.77693
## age                                                       0.02213    0.02192
## ethnBlack/African American                                0.08731    0.24732
## ethnLatino/Hispanic                                      -0.33718    0.24121
## ethnOther                                                -0.01740    0.30228
## ethnWhite/Caucasian                                       0.13375    0.16151
## ethnAmerican Indian/Native American or Alaskan Native -0.93997    0.40921
## ethnDecline to state                                     -0.33289    0.56496
##                                                          t value
## (Intercept)                                                1.555
## trial.valneu                                               9.477
## trial.valpos                                             160.642
## sexfemale                                                  1.580
## sexother                                                  -1.456
## age                                                        1.010
## ethnBlack/African American                                 0.353
## ethnLatino/Hispanic                                       -1.398
## ethnOther                                                 -0.058
## ethnWhite/Caucasian                                        0.828
## ethnAmerican Indian/Native American or Alaskan Native  -2.297
## ethnDecline to state                                      -0.589
##
## Correlation of Fixed Effects:
##             (Intr) trl.vln trl.vlp sexfml sexthr age    etB/AA ethL/H ethnOt
## trial.valne -0.019
## trial.valps -0.027  0.354
## sexfemale   -0.197  0.000   0.000
## sexother    -0.070  0.000   0.000   0.084
## age         -0.941  0.000   0.000   0.021  0.059
## ethnBlck/AA -0.026  0.000   0.000   0.072 -0.002 -0.149
## ethnLtn/Hsp  0.065  0.000   0.000   0.072 -0.008 -0.250  0.334
## ethnOther   -0.081  0.000   0.000  -0.044 -0.006 -0.038  0.234  0.244
## ethnWht/Ccs -0.091  0.000   0.000   0.107 -0.062 -0.171  0.468  0.496  0.357
## ethAI/NAoAN -0.141  0.000   0.000   0.123  0.012  0.029  0.176  0.178  0.134
## ethnDclntst -0.067  0.000   0.000   0.144  0.010 -0.027  0.139  0.145  0.096
##             ethW/C eIAoAN
```

```
## trial.valne
## trial.valps
## sexfemale
## sexother
## age
## ethnBlck/AA
## ethnLtn/Hsp
## ethnOther
## ethnWht/Ccs
## ethAI/NAoAN  0.271
## ethnDclntst  0.211  0.092
```

- Intercept (negative trial): estimate = 0.72, t-value = 1.56. The effect of negative trial on positive emotions (Ipos) is small.
- `trial.valneu`: estimate = 0.34, t-value = 9.48. Compared to valneg, the neutral trial significantly increases positive emotions (Ipos).
- `trial.valpos`: estimate = 4.03, t-value = 160.64. Compared to valneg, the positive trial largely increases positive emotions (Ipos), and the effect is extremely significant.
- `sexfemale`: estimate = 0.20, t = 1.58. Females tend to have slightly higher positive emotional responses than males.
- `ethnAmerican Indian/Native American or Alaskan Native`: estimate = -0.94, t = -2.30. This ethnicity tends to have significantly lower positive emotional responses compared to the reference group.
- `trial.valneu` and `trial.valpos` have a correlation of 0.354, showing that the effects of neutral and positive trials are somewhat related.

```r
# Mixed-effects model for predicting Iaro
model_aro <- lmer(Iaro ~ trial.val + sex + age + ethn + (1|subj), data = dat)
summary(model_aro)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: Iaro ~ trial.val + sex + age + ethn + (1 | subj)
##    Data: dat
##
## REML criterion at convergence: 59841.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.4843 -0.6288 -0.1072  0.5760  4.8022
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  subj     (Intercept) 1.593    1.262
##  Residual             2.168    1.472
## Number of obs: 16380, groups:  subj, 156
##
## Fixed effects:
##                                                    Estimate Std. Error
## (Intercept)                                         2.92802    0.76311
## trial.valneu                                       -2.25913    0.03515
## trial.valpos                                       -0.30058    0.02485
## sexfemale                                           0.22642    0.20959
## sexother                                           -1.53358    1.28529
```

```
## age                                                    0.02904    0.03627
## ethnBlack/African American                             0.22313    0.40915
## ethnLatino/Hispanic                                    0.12385    0.39903
## ethnOther                                              0.52839    0.50007
## ethnWhite/Caucasian                                    0.06932    0.26720
## ethnAmerican Indian/Native American or Alaskan Native -0.85245    0.67697
## ethnDecline to state                                   0.07313    0.93462
##                                                       t value
## (Intercept)                                             3.837
## trial.valneu                                          -64.279
## trial.valpos                                          -12.095
## sexfemale                                               1.080
## sexother                                               -1.193
## age                                                     0.801
## ethnBlack/African American                              0.545
## ethnLatino/Hispanic                                     0.310
## ethnOther                                               1.057
## ethnWhite/Caucasian                                     0.259
## ethnAmerican Indian/Native American or Alaskan Native  -1.259
## ethnDecline to state                                    0.078
##
## Correlation of Fixed Effects:
##             (Intr) trl.vln trl.vlp sexfml sexthr age    etB/AA ethL/H ethnOt
## trial.valne -0.012
## trial.valps -0.016  0.354
## sexfemale   -0.197  0.000   0.000
## sexother    -0.070  0.000   0.000   0.084
## age         -0.942  0.000   0.000   0.021  0.059
## ethnBlck/AA -0.026  0.000   0.000   0.072 -0.002 -0.149
## ethnLtn/Hsp  0.065  0.000   0.000   0.072 -0.008 -0.250  0.334
## ethnOther   -0.081  0.000   0.000  -0.044 -0.006 -0.038  0.234  0.244
## ethnWht/Ccs -0.091  0.000   0.000   0.107 -0.062 -0.171  0.468  0.496  0.357
## ethAI/NAoAN -0.141  0.000   0.000   0.123  0.012  0.029  0.176  0.178  0.134
## ethnDclntst -0.067  0.000   0.000   0.144  0.010 -0.027  0.139  0.145  0.096
##             ethW/C eIAoAN
## trial.valne
## trial.valps
## sexfemale
## sexother
## age
## ethnBlck/AA
## ethnLtn/Hsp
## ethnOther
## ethnWht/Ccs
## ethAI/NAoAN  0.271
## ethnDclntst  0.211  0.092
```

- Intercept (negative trial): estimate = 2.93, t-value = 3.84. The effect of negative trial on arousal (Iaro) is moderate.
- `trial.valneu`: estimate -2.26, t-value = -64.28. Compared to `valneg`, the neutral trial significantly decreases arousal (Iaro), which can be expected.
- `trial.valpos`: estimate = -0.30, t-value = -12.10. Compared to `valneg`, the positive trial also significantly decreases arousal (Iaro), but the effect is small.
- Other fixed effects are not significant.

Autoregressive Modeling

Assign 1 overall inertia score for pos, neg, and aro for each participant:

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

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

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

```
library(purrr)
library(broom)

# Create a function to return inertia (lag-1 beta value)
get_inertia <- function(x) {
  # Create lagged data
  lag_x <- dplyr::lag(x)
  df <- data.frame(current = x, lagged = lag_x)
  df <- na.omit(df)

  # Linear regression: current ~ lagged
  model <- lm(current ~ lagged, data = df)
  coef(model)["lagged"]
}

# find inertia scores for the 3 emotions for each participant
overall_inertia <- dat %>%
  group_by(subj) %>%
  summarise(
    pos_inertia = get_inertia(Ipos),
    neg_inertia = get_inertia(Ineg),
    aro_inertia = get_inertia(Iaro)
  )
overall_inertia
```

```
## # A tibble: 156 x 4
##    subj  pos_inertia neg_inertia aro_inertia
##    <fct>       <dbl>       <dbl>       <dbl>
##  1 f001      -0.0956     -0.149     -0.139
##  2 f002       0.0187      0.0682     0.0974
##  3 f003      -0.0855     -0.143      0.0149
##  4 f004       0.0648     -0.0705     0.0150
##  5 f005      -0.0433     -0.0918    -0.0962
##  6 f006      -0.0750      0.160      0.175
##  7 f007       0.0834      0.0245     0.190
```

```
##  8 f008      -0.0125     -0.0254     0.00949
##  9 f009       0.0162      0.0865    -0.136
## 10 f010       0.164       0.110      0.0143
## # i 146 more rows
```

For each of the 3 emotional reactions (pos, neg, aro), assign 1 inertia score for each of the 3 trial type (pos, neg, neu)

```
library(tidyr)
```

```
##
## Attaching package: 'tidyr'

## The following objects are masked from 'package:Matrix':
##
##     expand, pack, unpack
```

```
# For each subj × trial.val × emotion
inertia_long <- dat %>%
  group_by(subj, trial.val) %>%
  summarise(
    pos_inertia = get_inertia(Ipos),
    neg_inertia = get_inertia(Ineg),
    aro_inertia = get_inertia(Iaro),
    .groups = "drop"
  )

# Reshape into wide format: 1 row per participant, 9 inertia scores
inertia_wide <- inertia_long %>%
  pivot_wider(
    names_from = trial.val,
    values_from = c(pos_inertia, neg_inertia, aro_inertia),
    names_glue = "{.value}_{trial.val}"
  )

inertia_wide
```

```
## # A tibble: 156 x 10
##    subj  pos_inertia_neg pos_inertia_neu pos_inertia_pos neg_inertia_neg
##    <fct>           <dbl>           <dbl>           <dbl>           <dbl>
##  1 f001          -0.0233         NA              0.0214         -0.203
##  2 f002          -0.0233         -0.115         -0.00418         0.376
##  3 f003           0.131          -0.0939        -0.127          -0.106
##  4 f004          -0.0732         -0.0111         0.196           0.0689
##  5 f005           0.223          -0.0769         0.0571          0.107
##  6 f006          -0.0883         -0.161          0.239           0.416
##  7 f007          -0.0233         -0.0888         0.0636          0.191
##  8 f008           0.0422         -0.247          0.0363         -0.174
##  9 f009          -0.0560          0.0590         0.0652          0.0603
## 10 f010          -0.0233          0.0577         0.199           0.220
## # i 146 more rows
## # i 5 more variables: neg_inertia_neu <dbl>, neg_inertia_pos <dbl>,
## #   aro_inertia_neg <dbl>, aro_inertia_neu <dbl>, aro_inertia_pos <dbl>
```

```r
# Find the reason of NAs

# Whether there's not enough data for each subj × trial.val group?

dat %>%
  group_by(subj, trial.val) %>%
  summarise(n = n()) %>%
  filter(n < 5)
```

```
## `summarise()` has grouped output by 'subj'. You can override using the
## `.groups` argument.
```

```
## # A tibble: 0 x 3
## # Groups:   subj [0]
## # i 3 variables: subj <fct>, trial.val <fct>, n <int>
```

```r
# Whether some emotion ratings for certain trial type are always the same?

dat %>%
  group_by(subj, trial.val) %>%
  summarise(
    Ineg_var = var(Ineg),
    Ipos_var = var(Ipos),
    Iaro_var = var(Iaro)
  ) %>%
  filter(Ineg_var == 0 | Ipos_var == 0 | Iaro_var == 0)
```

```
## `summarise()` has grouped output by 'subj'. You can override using the
## `.groups` argument.
```

```
## # A tibble: 106 x 5
## # Groups:   subj [80]
##    subj  trial.val Ineg_var Ipos_var Iaro_var
##    <fct> <fct>        <dbl>    <dbl>    <dbl>
##  1 f001  neu          0       0.267    0.352
##  2 f001  pos          0       1.61     1.08
##  3 f002  neu          0       1.26     1.35
##  4 f002  pos          0       1.51     1.14
##  5 f005  neu          0       0.267    0.0667
##  6 f007  neu          0       0.0663   0
##  7 f007  pos          0       0.786    0.382
##  8 f013  neu          0       0.0659   0
##  9 f019  neu          0.124   4.92     0
## 10 f020  neu          0       2.52     1.55
## # i 96 more rows
```

- The reason of NAs is not due to insufficient data for each subj × trial.val group
- NAs are also not likely to be caused by zero-variance of some emotion inertia ratings, since NAs from inertia_wide are more than the number of Var = 0.

```r
# Merge all inertia scores (by subj)
inertia_all <- overall_inertia %>%
  left_join(inertia_wide, by = "subj")
inertia_all
```

```
## # A tibble: 156 x 13
##    subj  pos_inertia neg_inertia aro_inertia pos_inertia_neg pos_inertia_neu
##    <fct>       <dbl>       <dbl>       <dbl>           <dbl>           <dbl>
##  1 f001      -0.0956     -0.149     -0.139           -0.0233         NA
##  2 f002       0.0187      0.0682     0.0974          -0.0233         -0.115
##  3 f003      -0.0855     -0.143      0.0149           0.131          -0.0939
##  4 f004       0.0648     -0.0705     0.0150          -0.0732         -0.0111
##  5 f005      -0.0433     -0.0918    -0.0962           0.223          -0.0769
##  6 f006      -0.0750      0.160      0.175           -0.0883         -0.161
##  7 f007       0.0834      0.0245     0.190           -0.0233         -0.0888
##  8 f008      -0.0125     -0.0254     0.00949          0.0422         -0.247
##  9 f009       0.0162      0.0865    -0.136           -0.0560          0.0590
## 10 f010       0.164       0.110      0.0143          -0.0233          0.0577
## # i 146 more rows
## # i 7 more variables: pos_inertia_pos <dbl>, neg_inertia_neg <dbl>,
## #   neg_inertia_neu <dbl>, neg_inertia_pos <dbl>, aro_inertia_neg <dbl>,
## #   aro_inertia_neu <dbl>, aro_inertia_pos <dbl>
```

```r
library(ggplot2)
library(dplyr)
library(tidyr)
library(e1071)   # for skewness
library(psych)   # for describe()
```

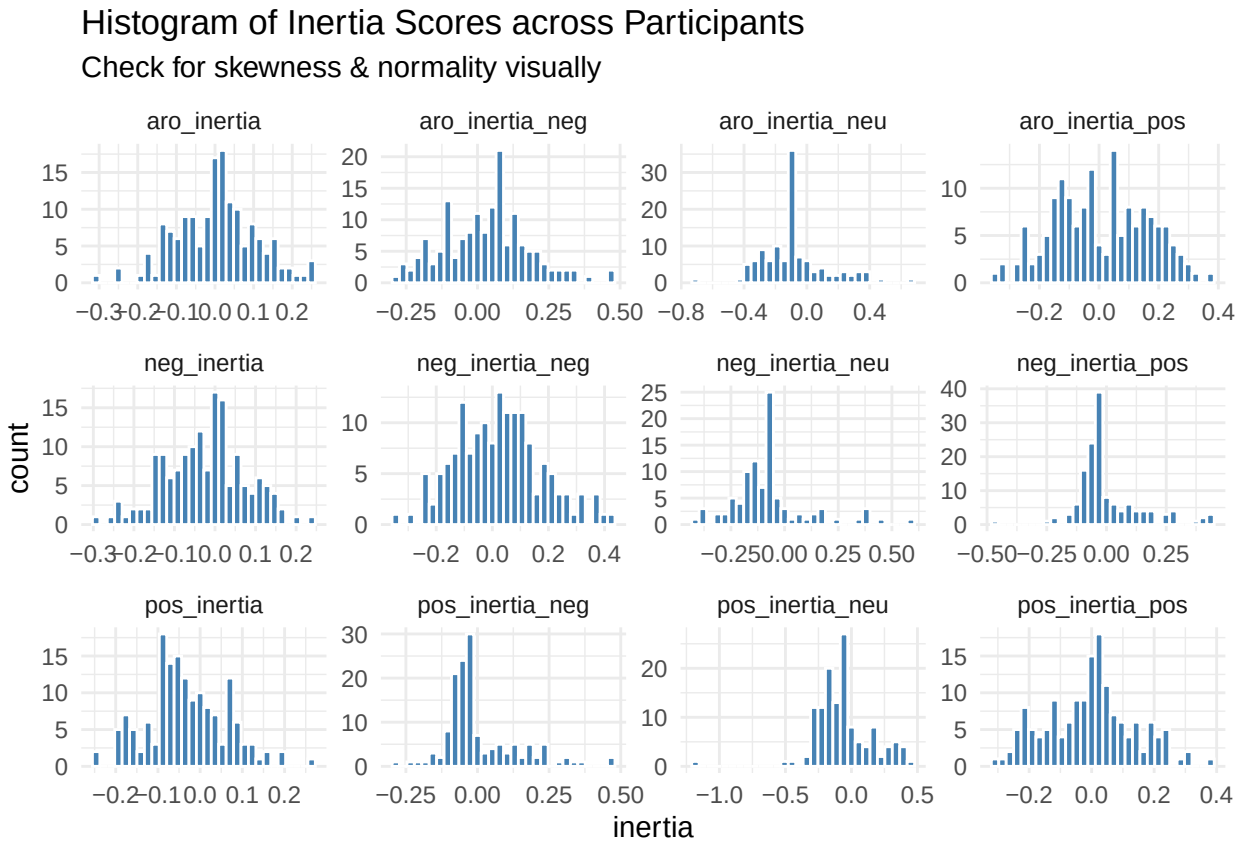
```
##
## Attaching package: 'psych'
```

```
## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha
```

```r
# Convert to inertia_long format
inertia_long <- inertia_all %>%
  pivot_longer(-subj, names_to = "inertia_type", values_to = "inertia")

# Distribution & Skewness
inertia_long %>%
  group_by(inertia_type) %>%
  mutate(
    skew = skewness(inertia, na.rm = TRUE),
    normality_p = shapiro.test(inertia)$p.value
  ) %>%
  ggplot(aes(x = inertia)) +
  geom_histogram(bins = 30, fill = "steelblue", color = "white") +
  facet_wrap(~ inertia_type, scales = "free") +
  theme_minimal() +
  labs(title = "Histogram of Inertia Scores across Participants",
       subtitle = "Check for skewness & normality visually")
```

```
## Warning: Removed 159 rows containing non-finite outside the scale range
## (`stat_bin()`).
```




```
# describe_stats for all 3 + 9 = 12 types of inertia
describe_stats <- inertia_long %>%
  group_by(inertia_type) %>%
  summarise(
    n = sum(!is.na(inertia)),
    sd = sd(inertia, na.rm = TRUE),
    Q1 = quantile(inertia, 0.25, na.rm = TRUE),
    Q3 = quantile(inertia, 0.75, na.rm = TRUE),
    skewness = skewness(inertia, na.rm = TRUE),
    normality_p = shapiro.test(inertia)$p.value
  )
describe_stats
```

```
## # A tibble: 12 x 7
##    inertia_type        n     sd      Q1       Q3 skewness normality_p
##    <chr>           <int>  <dbl>   <dbl>    <dbl>    <dbl>       <dbl>
##  1 aro_inertia       156 0.103  -0.0630  0.0666   -0.0809    6.10e- 1
##  2 aro_inertia_neg   156 0.150  -0.0772  0.124     0.230     1.39e- 1
##  3 aro_inertia_neu   117 0.208  -0.182  -0.00947   0.715     3.86e- 5
##  4 aro_inertia_pos   154 0.157  -0.117   0.134     0.0368    1.11e- 1
##  5 neg_inertia       156 0.0998 -0.0890  0.0316   -0.120     8.17e- 1
##  6 neg_inertia_neg   156 0.151  -0.0928  0.117     0.253     4.16e- 1
```

```
##  7 neg_inertia_neu    95 0.177  -0.166  -0.0635    1.30      1.30e- 7
##  8 neg_inertia_pos   141 0.139  -0.0694  0.0458    1.08      6.69e-10
##  9 pos_inertia       156 0.0927 -0.0889  0.0276    0.290     2.67e- 1
## 10 pos_inertia_neg   140 0.129  -0.0691  0.0479    1.27      2.32e- 9
## 11 pos_inertia_neu   130 0.216  -0.167   0.0242   -0.399     8.44e- 8
## 12 pos_inertia_pos   156 0.141  -0.119   0.0684    0.0816    1.17e- 1
```

Inertia scores that are not normal:

- neg_inertia_pos: normality_p = 6.689087e-10; skewness = 1.07982750
  - Under positive stimuli, negative emotion inertia is right-skewed: a few individuals have unusually persistent negative emotions
- pos_inertia_neg: normality_p = 2.318693e-09; skewness = 1.27067898
  - Under negative stimuli, positive emotion inertia is strongly right-skewed: most people have low inertia in positive feelings, with a few showing strong inertia
- pos_inertia_neu: normality_p = 8.436415e-08; skewness = -0.39896752
  - For neutral stimuli, positive emotion inertia is slightly left-skewed
- neg_inertia_neu: normality_p = 1.296106e-07; skewness = 1.29575508
  - For neutral stimuli, negative emotion inertia is strongly right-skewed
- aro_inertia_neu: normality_p = 3.859573e-05; skewness = 0.71497318
  - For neutral stimuli, arousal inertia is right-skewed

```r
# Transform the skewed inertia types to normal
library(bestNormalize)

skewed_vars <- c(
  "neg_inertia_pos", "pos_inertia_neg", "pos_inertia_neu",
  "neg_inertia_neu", "aro_inertia_neu"
)

inertia_long_normalized <- inertia_long %>%
  group_by(inertia_type) %>%
  mutate(
    inertia_trans = if_else(
      inertia_type %in% skewed_vars,
      orderNorm(inertia)$x.t,  # transform only these
      inertia  # leave others unchanged
    )
  )
```

```
## Warning: There were 6 warnings in `mutate()`.
## The first warning was:
## i In argument: `inertia_trans = if_else(...)`.
## i In group 3: `inertia_type = "aro_inertia_neu"`.
## Caused by warning in `orderNorm()`:
## ! Ties in data, Normal distribution not guaranteed
## i Run `dplyr::last_dplyr_warnings()` to see the 5 remaining warnings.
```

```
inertia_long_normalized
```

```
## # A tibble: 1,872 x 4
## # Groups:   inertia_type [12]
##    subj  inertia_type    inertia inertia_trans
##    <fct> <chr>             <dbl>         <dbl>
##  1 f001  pos_inertia     -0.0956       -0.0956
##  2 f001  neg_inertia     -0.149        -0.149
##  3 f001  aro_inertia     -0.139        -0.139
##  4 f001  pos_inertia_neg -0.0233        0.244
##  5 f001  pos_inertia_neu NA            NA
##  6 f001  pos_inertia_pos  0.0214        0.0214
##  7 f001  neg_inertia_neg -0.203        -0.203
##  8 f001  neg_inertia_neu NA            NA
##  9 f001  neg_inertia_pos NA            NA
## 10 f001  aro_inertia_neg -0.187        -0.187
## # i 1,862 more rows
```

```
# Find mean value of each of the 12 inertia types

inertia_means <- inertia_long_normalized %>%
  group_by(inertia_type) %>%
  summarise(
    mean_inertia = mean(inertia_trans, na.rm = TRUE),
    sd_inertia = sd(inertia_trans, na.rm = TRUE),
    n = sum(!is.na(inertia_trans))
  ) %>%
  arrange(desc(abs(mean_inertia)))

inertia_means
```

```
## # A tibble: 12 x 4
##    inertia_type     mean_inertia sd_inertia     n
##    <chr>                   <dbl>      <dbl> <int>
##  1 pos_inertia     -0.0324           0.0927   156
##  2 aro_inertia_neg  0.0308           0.150    156
##  3 neg_inertia     -0.0244           0.0998   156
##  4 neg_inertia_neg  0.0242           0.151    156
##  5 aro_inertia_pos  0.00693          0.157    154
##  6 pos_inertia_pos -0.00589          0.141    156
##  7 aro_inertia      0.00482          0.103    156
##  8 neg_inertia_neu -0.0000523        0.998     95
##  9 aro_inertia_neu -0.0000440        0.998    117
## 10 pos_inertia_neg -0.0000328        0.999    140
## 11 neg_inertia_pos -0.00000932       0.999    141
## 12 pos_inertia_neu  0.0000000373     0.999    130
```

- aro_inertia_neu: Extremely high SD (0.998) — suggests arousal inertia under neutral stimuli varies greatly across individuals
- neg_inertia (mean = -0.024): Negative emotion inertia is slightly negative, meaning negative emotion is not likely to last

- neg_inertia_pos: Negative near-zero mean (-9.32e-06) but very high variance (sd = 0.999);
  - Negative emotion is likely to bounce back after positive stimuli, but the effect is extremely small
  - There's huge individual differences
- pos_inertia_neg: Negative near-zero mean (-3.28e-05) but very high variance (sd = 0.999);
  - Positive emotion is likely to bounce back after negative stimuli, but the effect is also small
  - There's huge individual differences
- pos_inertia (mean = -0.032): negative mean — indicates that positive emotions tend to drop off quickly
- aro_inertia_neg (mean = 0.031): clear positive inertia — arousal tends to linger more after negative stimuli
- neg_inertia_neg (mean = 0.024): negative emotions tend to persist more after negative trials
- **neg_inertia (mean = -0.024) vs. pos_inertia (mean = -0.032)**:
  - **neg_inertia is bigger than pos_inertia, meaning that negative emotions tend to last longer**
  - Positive emotions bounce back faster than negative emotions
- **neg_inertia_pos (mean = -9.32e-06) vs. pos_inertia_neg (-3.28e-05)**:
  - **Emotions tend to reset quickly when the stimulus is the opposite, meaning that people are likely to be affected by opposite stimuli**
  - **Positive emotions may dissipate faster in response to negative stimuli than negative emotions do in response to positive ones (positive emotion is more likely to be affected by negative stimuli)**