RI-CLPM

Contents

1 Cross-lag paths (how one emotion affect another at the next time point) & Inertia

```r
load("feelings_initial.RData")
library(lavaan)
```

```
## This is lavaan 0.6-19
## lavaan is FREE software! Please report any bugs.
```

```r
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
```

```r
library(tidyr)

clpm_data <- dat %>%
  arrange(subj, trial.num) %>%
  group_by(subj) %>%
  mutate(
    Ipos_lag1 = lag(Ipos),
    Ineg_lag1 = lag(Ineg),
    Iaro_lag1 = lag(Iaro)
  ) %>%
  filter(!is.na(Ipos_lag1))

model_clpm <- '
  # Autoregressive (inertia) paths
  Ipos ~ a1 * Ipos_lag1
  Ineg ~ a2 * Ineg_lag1
  Iaro ~ a3 * Iaro_lag1

  # Cross-lagged paths
  Ipos ~ b1 * Ineg_lag1 + b2 * Iaro_lag1
  Ineg ~ c1 * Ipos_lag1 + c2 * Iaro_lag1
  Iaro ~ d1 * Ipos_lag1 + d2 * Ineg_lag1
'

fit_clpm <- sem(model_clpm, data = clpm_data)
summary(fit_clpm, standardized = TRUE, fit.measures = TRUE)
```

```
## lavaan 0.6-19 ended normally after 30 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        15
##
##   Number of observations                         16224
##
## Model Test User Model:
##
##   Test statistic                                 0.000
##   Degrees of freedom                                 0
##
## Model Test Baseline Model:
##
##   Test statistic                             17555.797
##   Degrees of freedom                                12
##   P-value                                        0.000
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    1.000
##   Tucker-Lewis Index (TLI)                       1.000
##
## Loglikelihood and Information Criteria:
##
```

```
##   Loglikelihood user model (H0)           -102945.652
##   Loglikelihood unrestricted model (H1)   -102945.652
##
##   Akaike (AIC)                             205921.305
##   Bayesian (BIC)                           206036.718
##   Sample-size adjusted Bayesian (SABIC)    205989.049
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                         0.000
##   90 Percent confidence interval - lower        0.000
##   90 Percent confidence interval - upper        0.000
##   P-value H_0: RMSEA <= 0.050                      NA
##   P-value H_0: RMSEA >= 0.080                      NA
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                          0.000
##
## Parameter Estimates:
##
##   Standard errors                            Standard
##   Information                                Expected
##   Information saturated (h1) model         Structured
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1 (a1)    0.137    0.011   12.869    0.000    0.137    0.137
##   Ineg ~
##     Ineg_lag1 (a2)    0.143    0.011   12.894    0.000    0.143    0.143
##   Iaro ~
##     Iaro_lag1 (a3)    0.414    0.009   43.903    0.000    0.414    0.414
##   Ipos ~
##     Ineg_lag1 (b1)    0.165    0.011   14.920    0.000    0.165    0.166
##     Iaro_lag1 (b2)    0.010    0.012    0.795    0.427    0.010    0.008
##   Ineg ~
##     Ipos_lag1 (c1)    0.173    0.011   16.158    0.000    0.173    0.172
##     Iaro_lag1 (c2)   -0.008    0.013   -0.650    0.516   -0.008   -0.007
##   Iaro ~
##     Ipos_lag1 (d1)   -0.043    0.008   -5.289    0.000   -0.043   -0.053
##     Ineg_lag1 (d2)   -0.063    0.008   -7.507    0.000   -0.063   -0.078
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -3.425    0.058  -59.271    0.000   -3.425   -0.526
##    .Iaro              1.218    0.040   30.743    0.000    1.218    0.249
##  .Ineg ~~
##    .Iaro              1.886    0.041   45.562    0.000    1.886    0.383
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              6.482    0.072   90.067    0.000    6.482    0.974
```

```
##    .Ineg              6.549    0.073   90.067    0.000    6.549    0.975
##    .Iaro              3.700    0.041   90.067    0.000    3.700    0.860
```

1.1 Difference in paths by sex

```r
# Group by sex

fit_clpm_sex <- sem(model_clpm,
                    data = clpm_data,
                    group = "sex")
```

```
## Warning: lavaan->lavParTable():
##    using a single label per parameter in a multiple group setting implies
##    imposing equality constraints across all the groups; If this is not
##    intended, either remove the label(s), or use a vector of labels (one for
##    each group); See the Multiple groups section in the man page of
##    model.syntax.
```

```r
summary(fit_clpm_sex, standardized = TRUE, fit.measures = TRUE)
```

```
## lavaan 0.6-19 ended normally after 161 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        54
##   Number of equality constraints                    18
##
##   Number of observations per group:
##     female                                        8632
##     other                                          104
##     male                                          7488
##
## Model Test User Model:
##
##   Test statistic                                70.669
##   Degrees of freedom                                18
##   P-value (Chi-square)                           0.000
##   Test statistic for each group:
##     female                                      19.632
##     other                                       30.323
##     male                                        20.714
##
## Model Test Baseline Model:
##
##   Test statistic                             17419.660
##   Degrees of freedom                                36
##   P-value                                        0.000
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.997
```

```
##   Tucker-Lewis Index (TLI)                       0.994
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)            -102756.204
##   Loglikelihood unrestricted model (H1)    -102720.870
##
##   Akaike (AIC)                              205584.409
##   Bayesian (BIC)                            205861.402
##   Sample-size adjusted Bayesian (SABIC)     205746.996
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.023
##   90 Percent confidence interval - lower         0.018
##   90 Percent confidence interval - upper         0.029
##   P-value H_0: RMSEA <= 0.050                    1.000
##   P-value H_0: RMSEA >= 0.080                    0.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.011
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
##
## Group 1 [female]:
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1 (a1)    0.136    0.011   12.796    0.000    0.136    0.136
##   Ineg ~
##     Ineg_lag1 (a2)    0.137    0.011   12.379    0.000    0.137    0.137
##   Iaro ~
##     Iaro_lag1 (a3)    0.408    0.009   43.375    0.000    0.408    0.413
##   Ipos ~
##     Ineg_lag1 (b1)    0.163    0.011   14.827    0.000    0.163    0.164
##     Iaro_lag1 (b2)    0.005    0.012    0.385    0.700    0.005    0.004
##   Ineg ~
##     Ipos_lag1 (c1)    0.167    0.011   15.630    0.000    0.167    0.166
##     Iaro_lag1 (c2)   -0.009    0.012   -0.705    0.481   -0.009   -0.007
##   Iaro ~
##     Ipos_lag1 (d1)   -0.045    0.008   -5.657    0.000   -0.045   -0.058
##     Ineg_lag1 (d2)   -0.065    0.008   -7.826    0.000   -0.065   -0.083
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -3.913    0.087  -44.726    0.000   -3.913   -0.549
```

```
##    .Iaro              1.264    0.058   21.802    0.000    1.264    0.241
##  .Ineg ~~
##    .Iaro              2.077    0.061   34.120    0.000    2.077    0.395
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              2.204    0.057   38.710    0.000    2.204    0.818
##    .Ineg              2.299    0.057   40.163    0.000    2.299    0.850
##    .Iaro              2.366    0.043   55.253    0.000    2.366    1.118
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              7.090    0.108   65.696    0.000    7.090    0.977
##    .Ineg              7.158    0.109   65.696    0.000    7.158    0.978
##    .Iaro              3.866    0.059   65.696    0.000    3.866    0.863
##
##
## Group 2 [other]:
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1 (a1)    0.136    0.011   12.796    0.000    0.136    0.132
##   Ineg ~
##     Ineg_lag1 (a2)    0.137    0.011   12.379    0.000    0.137    0.134
##   Iaro ~
##     Iaro_lag1 (a3)    0.408    0.009   43.375    0.000    0.408    0.356
##   Ipos ~
##     Ineg_lag1 (b1)    0.163    0.011   14.827    0.000    0.163    0.213
##     Iaro_lag1 (b2)    0.005    0.012    0.385    0.700    0.005    0.004
##   Ineg ~
##     Ipos_lag1 (c1)    0.167    0.011   15.630    0.000    0.167    0.121
##     Iaro_lag1 (c2)   -0.009    0.012   -0.705    0.481   -0.009   -0.005
##   Iaro ~
##     Ipos_lag1 (d1)   -0.045    0.008   -5.657    0.000   -0.045   -0.048
##     Ineg_lag1 (d2)   -0.065    0.008   -7.826    0.000   -0.065   -0.093
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -1.115    0.287   -3.881    0.000   -1.115   -0.412
##    .Iaro             -0.095    0.175   -0.541    0.589   -0.095   -0.053
##  .Ineg ~~
##    .Iaro              1.072    0.258    4.149    0.000    1.072    0.445
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              1.176    0.144    8.159    0.000    1.176    0.815
##    .Ineg              2.231    0.192   11.631    0.000    2.231    1.155
##    .Iaro              1.197    0.127    9.441    0.000    1.197    0.900
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              2.003    0.278    7.211    0.000    2.003    0.962
```

```
##    .Ineg              3.667    0.508    7.211    0.000    3.667    0.983
##    .Iaro              1.581    0.219    7.211    0.000    1.581    0.894
##
##
## Group 3 [male]:
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1 (a1)    0.136    0.011   12.796    0.000    0.136    0.136
##   Ineg ~
##     Ineg_lag1 (a2)    0.137    0.011   12.379    0.000    0.137    0.137
##   Iaro ~
##     Iaro_lag1 (a3)    0.408    0.009   43.375    0.000    0.408    0.402
##   Ipos ~
##     Ineg_lag1 (b1)    0.163    0.011   14.827    0.000    0.163    0.163
##     Iaro_lag1 (b2)    0.005    0.012    0.385    0.700    0.005    0.004
##   Ineg ~
##     Ipos_lag1 (c1)    0.167    0.011   15.630    0.000    0.167    0.166
##     Iaro_lag1 (c2)   -0.009    0.012   -0.705    0.481   -0.009   -0.007
##   Iaro ~
##     Ipos_lag1 (d1)   -0.045    0.008   -5.657    0.000   -0.045   -0.055
##     Ineg_lag1 (d2)   -0.065    0.008   -7.826    0.000   -0.065   -0.079
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -2.915    0.075  -38.669    0.000   -2.915   -0.500
##    .Iaro              1.155    0.054   21.448    0.000    1.155    0.256
##  .Ineg ~~
##    .Iaro              1.651    0.056   29.644    0.000    1.651    0.365
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              2.062    0.053   39.082    0.000    2.062    0.844
##    .Ineg              2.033    0.053   38.352    0.000    2.033    0.830
##    .Iaro              2.178    0.040   54.163    0.000    2.178    1.083
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              5.821    0.095   61.188    0.000    5.821    0.975
##    .Ineg              5.849    0.096   61.188    0.000    5.849    0.976
##    .Iaro              3.504    0.057   61.188    0.000    3.504    0.867
```

```
# Check for significant difference between men and women

model_clpm_free <- '
  # Inertia paths
  Ipos ~ c(a1f, a1m, a1o)*Ipos_lag1
  Ineg ~ c(a2f, a2m, a2o)*Ineg_lag1
  Iaro ~ c(a3f, a3m, a3o)*Iaro_lag1

  # Cross-lag
  Ipos ~ c(b1f, b1m, b1o)*Ineg_lag1 + c(b2f, b2m, b2o)*Iaro_lag1
```

```r
  Ineg ~ c(c1f, c1m, c1o)*Ipos_lag1 + c(c2f, c2m, c2o)*Iaro_lag1
  Iaro ~ c(d1f, d1m, d1o)*Ipos_lag1 + c(d2f, d2m, d2o)*Ineg_lag1
'


fit_free <- sem(model_clpm_free, data = clpm_data, group = "sex")

# Whether there's significant difference between sex in at least one path
anova(fit_clpm_sex, fit_free)
```

```
##
## Chi-Squared Difference Test
##
##              Df    AIC    BIC  Chisq Chisq diff    RMSEA Df diff Pr(>Chisq)
## fit_free      0 205550 205965  0.000
## fit_clpm_sex 18 205584 205861 70.669     70.669 0.023261      18  3.482e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Check which paths are significantly different

lavTestScore(fit_clpm_sex)
```

```
## $test
##
## total score test:
##
##    test     X2 df p.value
## 1 score 68.394 18       0
##
## $uni
##
## univariate score tests:
##
##     lhs op   rhs     X2 df p.value
## 1   .p1. == .p28.  0.493  1   0.483
## 2   .p1. == .p55.  3.462  1   0.063
## 3   .p2. == .p29.  3.167  1   0.075
## 4   .p2. == .p56.  1.512  1   0.219
## 5   .p3. == .p30. 10.313  1   0.001
## 6   .p3. == .p57. 17.559  1   0.000
## 7   .p4. == .p31.  3.800  1   0.051
## 8   .p4. == .p58.  1.048  1   0.306
## 9   .p5. == .p32.  0.254  1   0.614
## 10 .p5. == .p59.  0.120  1   0.729
## 11 .p6. == .p33.  1.387  1   0.239
## 12 .p6. == .p60.  1.372  1   0.241
## 13 .p7. == .p34.  0.082  1   0.775
## 14 .p7. == .p61.  0.722  1   0.396
## 15 .p8. == .p35.  0.353  1   0.552
## 16 .p8. == .p62.  3.460  1   0.063
## 17 .p9. == .p36.  0.131  1   0.717
## 18 .p9. == .p63.  2.193  1   0.139
```

```r
# Understand which paths are them

pe <- parameterEstimates(fit_clpm_sex, standardized = TRUE)
pe[c(3, 30, 57), c("lhs", "op", "rhs", "group", "est", "std.all")]
```

```
##     lhs op       rhs group   est std.all
## 3  Iaro  ~ Iaro_lag1     1 0.408   0.413
## 30 Iaro  ~ Iaro_lag1     2 0.408   0.356
## 57 Iaro  ~ Iaro_lag1     3 0.408   0.402
```

- females (0.413) and males (0.402) are significantly different in arousal inertia ($p < 0.001$)
- females (0.413) and other (0.356) are also significantly different in arousal inertia ($p = 0.001$)

1.2 Difference in paths by ethnicity

```r
model_clpm_nolabel <- '
  Ipos ~ Ipos_lag1 + Ineg_lag1 + Iaro_lag1
  Ineg ~ Ineg_lag1 + Ipos_lag1 + Iaro_lag1
  Iaro ~ Iaro_lag1 + Ipos_lag1 + Ineg_lag1
'

fit_multigroup_free <- sem(model_clpm_nolabel, data = clpm_data, group = "ethn")
summary(fit_multigroup_free, standardized = TRUE)
```

```
## lavaan 0.6-19 ended normally after 343 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                       126
##
##   Number of observations per group:
##     Asian or Pacific Islander                                 3536
##     Black/African American                                    1456
##     Latino/Hispanic                                           1664
##     White/Caucasian                                           8112
##     Other                                                      832
##     American Indian/Native American or Alaskan Native          416
##     Decline to state                                           208
##
## Model Test User Model:
##
##   Test statistic                                 0.000
##   Degrees of freedom                                 0
##   Test statistic for each group:
##     Asian or Pacific Islander                    0.000
##     Black/African American                       0.000
##     Latino/Hispanic                              0.000
##     White/Caucasian                              0.000
##     Other                                        0.000
##     American Indian/Native American or Alaskan Native    0.000
```

```
##     Decline to state                          0.000
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
##
## Group 1 [Asian or Pacific Islander]:
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1         0.095    0.023    4.173    0.000    0.095    0.095
##     Ineg_lag1         0.109    0.023    4.730    0.000    0.109    0.112
##     Iaro_lag1         0.028    0.026    1.088    0.277    0.028    0.023
##   Ineg ~
##     Ineg_lag1         0.143    0.023    6.096    0.000    0.143    0.143
##     Ipos_lag1         0.172    0.023    7.438    0.000    0.172    0.168
##     Iaro_lag1         0.021    0.026    0.800    0.424    0.021    0.017
##   Iaro ~
##     Iaro_lag1         0.428    0.020   21.743    0.000    0.428    0.427
##     Ipos_lag1        -0.037    0.017   -2.163    0.031   -0.037   -0.046
##     Ineg_lag1        -0.062    0.017   -3.552    0.000   -0.062   -0.078
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -3.417    0.123  -27.687    0.000   -3.417   -0.526
##    .Iaro              1.187    0.084   14.189    0.000    1.187    0.246
##  .Ineg ~~
##    .Iaro              1.771    0.088   20.117    0.000    1.771    0.360
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              2.334    0.110   21.223    0.000    2.334    0.918
##    .Ineg              2.090    0.112   18.646    0.000    2.090    0.801
##    .Iaro              2.134    0.083   25.587    0.000    2.134    1.026
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              6.371    0.152   42.048    0.000    6.371    0.986
##    .Ineg              6.619    0.157   42.048    0.000    6.619    0.972
##    .Iaro              3.665    0.087   42.048    0.000    3.665    0.847
##
##
## Group 2 [Black/African American]:
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1         0.187    0.037    5.103    0.000    0.187    0.187
##     Ineg_lag1         0.192    0.039    4.939    0.000    0.192    0.191
```

```
##     Iaro_lag1        -0.107    0.043   -2.519    0.012   -0.107   -0.085
##   Ineg ~
##     Ineg_lag1         0.126    0.039    3.276    0.001    0.126    0.126
##     Ipos_lag1         0.148    0.036    4.077    0.000    0.148    0.149
##     Iaro_lag1         0.047    0.042    1.116    0.264    0.047    0.038
##   Iaro ~
##     Iaro_lag1         0.384    0.032   11.904    0.000    0.384    0.383
##     Ipos_lag1        -0.063    0.028   -2.256    0.024   -0.063   -0.079
##     Ineg_lag1        -0.070    0.029   -2.373    0.018   -0.070   -0.087
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -3.878    0.208  -18.626    0.000   -3.878   -0.559
##    .Iaro              1.324    0.143    9.241    0.000    1.324    0.250
##  .Ineg ~~
##    .Iaro              1.987    0.147   13.488    0.000    1.987    0.378
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              2.358    0.179   13.156    0.000    2.358    0.882
##    .Ineg              2.015    0.178   11.343    0.000    2.015    0.759
##    .Iaro              2.529    0.136   18.606    0.000    2.529    1.187
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              6.995    0.259   26.981    0.000    6.995    0.979
##    .Ineg              6.873    0.255   26.981    0.000    6.873    0.974
##    .Iaro              4.024    0.149   26.981    0.000    4.024    0.887
##
##
## Group 3 [Latino/Hispanic]:
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1         0.075    0.037    2.005    0.045    0.075    0.075
##     Ineg_lag1         0.103    0.038    2.718    0.007    0.103    0.103
##     Iaro_lag1         0.194    0.040    4.903    0.000    0.194    0.189
##   Ineg ~
##     Ineg_lag1         0.135    0.038    3.516    0.000    0.135    0.135
##     Ipos_lag1         0.182    0.038    4.795    0.000    0.182    0.182
##     Iaro_lag1         0.041    0.040    1.034    0.301    0.041    0.040
##   Iaro ~
##     Iaro_lag1         0.484    0.035   13.933    0.000    0.484    0.483
##     Ipos_lag1         0.034    0.033    1.032    0.302    0.034    0.035
##     Ineg_lag1         0.004    0.033    0.120    0.905    0.004    0.004
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -2.914    0.168  -17.385    0.000   -2.914   -0.471
##    .Iaro              1.895    0.139   13.610    0.000    1.895    0.354
##  .Ineg ~~
```

```
##    .Iaro              2.274    0.144   15.761    0.000    2.274    0.419
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              1.608    0.134   12.015    0.000    1.608    0.626
##    .Ineg              1.754    0.136   12.923    0.000    1.754    0.684
##    .Iaro              1.631    0.117   13.885    0.000    1.631    0.651
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              6.101    0.212   28.844    0.000    6.101    0.925
##    .Ineg              6.273    0.217   28.844    0.000    6.273    0.955
##    .Iaro              4.699    0.163   28.844    0.000    4.699    0.749
##
##
## Group 4 [White/Caucasian]:
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1         0.133    0.015    8.914    0.000    0.133    0.133
##     Ineg_lag1         0.179    0.016   11.465    0.000    0.179    0.177
##     Iaro_lag1        -0.014    0.018   -0.784    0.433   -0.014   -0.011
##   Ineg ~
##     Ineg_lag1         0.122    0.015    7.871    0.000    0.122    0.122
##     Ipos_lag1         0.152    0.015   10.276    0.000    0.152    0.154
##     Iaro_lag1        -0.046    0.018   -2.528    0.011   -0.046   -0.034
##   Iaro ~
##     Iaro_lag1         0.396    0.013   30.688    0.000    0.396    0.396
##     Ipos_lag1        -0.078    0.011   -7.339    0.000   -0.078   -0.104
##     Ineg_lag1        -0.090    0.011   -8.122    0.000   -0.090   -0.119
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -3.668    0.085  -42.934    0.000   -3.668   -0.542
##    .Iaro              1.130    0.055   20.450    0.000    1.130    0.233
##  .Ineg ~~
##    .Iaro              1.761    0.057   30.889    0.000    1.761    0.365
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              2.241    0.077   29.102    0.000    2.241    0.849
##    .Ineg              2.435    0.077   31.791    0.000    2.435    0.932
##    .Iaro              2.493    0.055   45.420    0.000    2.493    1.260
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              6.800    0.107   63.687    0.000    6.800    0.977
##    .Ineg              6.728    0.106   63.687    0.000    6.728    0.985
##    .Iaro              3.457    0.054   63.687    0.000    3.457    0.882
##
##
## Group 5 [Other]:
```

```
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1         0.086    0.050    1.721    0.085    0.086    0.086
##     Ineg_lag1         0.083    0.055    1.511    0.131    0.083    0.089
##     Iaro_lag1         0.094    0.062    1.530    0.126    0.094    0.078
##   Ineg ~
##     Ineg_lag1         0.223    0.058    3.812    0.000    0.223    0.222
##     Ipos_lag1         0.241    0.053    4.534    0.000    0.241    0.225
##     Iaro_lag1        -0.013    0.065   -0.204    0.838   -0.013   -0.010
##   Iaro ~
##     Iaro_lag1         0.225    0.049    4.595    0.000    0.225    0.225
##     Ipos_lag1         0.112    0.040    2.802    0.005    0.112    0.135
##     Ineg_lag1         0.072    0.044    1.647    0.099    0.072    0.093
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -3.165    0.221  -14.296    0.000   -3.165   -0.571
##    .Iaro              0.464    0.145    3.190    0.001    0.464    0.111
##  .Ineg ~~
##    .Iaro              2.278    0.172   13.219    0.000    2.278    0.516
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              2.175    0.229    9.483    0.000    2.175    0.940
##    .Ineg              1.885    0.243    7.755    0.000    1.885    0.760
##    .Iaro              2.331    0.183   12.760    0.000    2.331    1.216
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              5.233    0.257   20.396    0.000    5.233    0.977
##    .Ineg              5.879    0.288   20.396    0.000    5.879    0.955
##    .Iaro              3.320    0.163   20.396    0.000    3.320    0.904
##
##
## Group 6 [American Indian/Native American or Alaskan Native]:
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1         0.068    0.065    1.045    0.296    0.068    0.068
##     Ineg_lag1         0.089    0.061    1.456    0.145    0.089    0.112
##     Iaro_lag1        -0.131    0.072   -1.816    0.069   -0.131   -0.130
##   Ineg ~
##     Ineg_lag1         0.214    0.077    2.796    0.005    0.214    0.212
##     Ipos_lag1         0.177    0.081    2.178    0.029    0.177    0.140
##     Iaro_lag1        -0.013    0.090   -0.144    0.886   -0.013   -0.010
##   Iaro ~
##     Iaro_lag1         0.008    0.072    0.108    0.914    0.008    0.008
##     Ipos_lag1         0.125    0.065    1.919    0.055    0.125    0.124
##     Ineg_lag1         0.127    0.061    2.084    0.037    0.127    0.159
##
```

```
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -1.208    0.152   -7.928    0.000   -1.208   -0.422
##    .Iaro              0.473    0.114    4.134    0.000    0.473    0.207
##  .Ineg ~~
##    .Iaro              1.578    0.160    9.840    0.000    1.578    0.551
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              1.975    0.189   10.472    0.000    1.975    1.302
##    .Ineg              1.486    0.236    6.288    0.000    1.486    0.770
##    .Iaro              1.681    0.189    8.904    0.000    1.681    1.097
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              2.284    0.158   14.422    0.000    2.284    0.992
##    .Ineg              3.587    0.249   14.422    0.000    3.587    0.963
##    .Iaro              2.287    0.159   14.422    0.000    2.287    0.974
##
##
## Group 7 [Decline to state]:
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos ~
##     Ipos_lag1         0.050    0.100    0.507    0.612    0.050    0.050
##     Ineg_lag1         0.051    0.111    0.460    0.645    0.051    0.050
##     Iaro_lag1         0.123    0.114    1.075    0.282    0.123    0.116
##   Ineg ~
##     Ineg_lag1         0.143    0.108    1.322    0.186    0.143    0.144
##     Ipos_lag1         0.196    0.098    2.010    0.044    0.196    0.199
##     Iaro_lag1        -0.006    0.112   -0.049    0.961   -0.006   -0.005
##   Iaro ~
##     Iaro_lag1         0.286    0.105    2.725    0.006    0.286    0.286
##     Ipos_lag1         0.027    0.091    0.300    0.764    0.027    0.029
##     Ineg_lag1        -0.030    0.102   -0.300    0.764   -0.030   -0.032
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .Ipos ~~
##    .Ineg             -1.966    0.363   -5.410    0.000   -1.966   -0.405
##    .Iaro              1.453    0.331    4.391    0.000    1.453    0.320
##  .Ineg ~~
##    .Iaro              2.285    0.347    6.577    0.000    2.285    0.512
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos              1.949    0.360    5.413    0.000    1.949    0.864
##    .Ineg              1.784    0.353    5.050    0.000    1.784    0.801
##    .Iaro              2.242    0.330    6.784    0.000    2.242    1.052
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
```

```
##    .Ipos              4.953    0.486   10.198    0.000    4.953    0.973
##    .Ineg              4.766    0.467   10.198    0.000    4.766    0.962
##    .Iaro              4.173    0.409   10.198    0.000    4.173    0.919
```

- Asian or Pacific Islander:
  - strong arousal inertia (β = .43, p < .001).
  - Both prior positive (β = –.05, p = .031) and negative emotion (β = –.08, p < .001) significantly reduced subsequent arousal
- Black/African American:
  - Strongest Ipos inertia (β = .187) among all groups (p < .001)
  - Arousal -> Positive emotion path is negative and significant (β=-.085, p = .012), suggesting arousal suppresses positivity here
- Latino/Hispanic:
  - Uniquely positive effect from prior arousal to later positive emotion (β = .189, p < .001).
  - Had the strongest Iaro inertia (β = .483, p < .001).
- White/Caucasian:
  - Negative cross-effects from both Ipos to Iaro (β = -.104, p < .001) and Ineg to Iaro (β = -.119, p < .001), showing a strong regulatory suppression of arousal by both emotion valences.
  - Effects tend to be more stable across emotional domains.
- American Indian/Native American or Alaskan Native:
  - The highest negative emotion inertia (β = .21, p = .005)
  - The only group where prior negative emotion significantly increased arousal (β = .16, p = .037)

1.3 Difference in paths by age

```r
library(dplyr)
library(broom)

# cross-lagged paths to analyze
paths <- list(
  Ipos_on_Ineg = c("Ipos", "Ineg_lag1"),
  Ipos_on_Aro = c("Ipos", "Iaro_lag1"),
  Ineg_on_Ipos = c("Ineg", "Ipos_lag1"),
  Ineg_on_Aro = c("Ineg", "Iaro_lag1"),
  Iaro_on_Ipos = c("Iaro", "Ipos_lag1"),
  Iaro_on_Ineg = c("Iaro", "Ineg_lag1")
)

results <- data.frame(path = character(), r = numeric(), p = numeric())

# run regression for each path + correlation with age
for (path_name in names(paths)) {
  lhs <- paths[[path_name]][1]
  rhs <- paths[[path_name]][2]

  # model each participant
  path_df <- clpm_data %>%
```

```
    group_by(subj) %>%
    filter(!is.na(.data[[lhs]]), !is.na(.data[[rhs]])) %>%
    do(tidy(lm(as.formula(paste(lhs, "~", rhs)), data = .))) %>%
    filter(term == rhs) %>%
    rename(estimate = estimate) %>%
    left_join(select(dat, subj, age), by = "subj")

  # find correlation with age
  cor_result <- cor.test(path_df$estimate, path_df$age)

  results <- rbind(results, data.frame(
    path = path_name,
    r = cor_result$estimate,
    p = cor_result$p.value
  ))
}

print(results)
```

```
##               path            r             p
## cor  Ipos_on_Ineg  0.124382721  1.763779e-57
## cor1  Ipos_on_Aro  0.202148879 1.272849e-150
## cor2 Ineg_on_Ipos -0.029140986  1.914050e-04
## cor3  Ineg_on_Aro -0.215376975 3.457817e-171
## cor4 Iaro_on_Ipos  0.009095577  2.444131e-01
## cor5 Iaro_on_Ineg -0.037882643  1.236128e-06
```

- Ipos_on_Ineg: As age increases, negative emotion exerts a stronger influence on subsequent positive emotion ($r = 0.124$, $p < .001$)
- Ipos_on_Aro: Higher arousal increasingly boosts next-step positive emotion with greater age ($r = 0.202$, $p < .001$)
- Ineg_on_Aro: Higher arousal is linked with lower next-step negative emotion, especially as age increases ($r = -0.215$, $p < .001$)
- Iaro_on_Ineg: With age, the influence of negative emotion on subsequent arousal slightly decreases ($r = -0.038$, $p < .001$)

2 RI-CLPM (Random-Intercept)–Causality

```
# ---------------------------------------------------------------------------
# EXAMPLE 1: RI-CLPM FOR THREE TIME POINTS (t=1,2,3)
# We use the original `dat` (not filtered `clpm_data`) to ensure time 1 is included.
# ---------------------------------------------------------------------------

# 1) Reshape the data to wide format for trials 1-3
wide3 <- dat %>%
  # Keep only trials 1, 2, and 3
  filter(trial.num %in% 1:3) %>%
  # Select subject ID plus the three emotion measures with their trial index
  select(subj, trial.num, Ipos, Ineg, Iaro) %>%
  # Pivot wide: one row per subject, columns Ipos_t1, Ipos_t2, Ipos_t3, etc.
```

```r
  pivot_wider(
    id_cols      = subj,
    names_from   = trial.num,
    names_prefix = "t",
    values_from  = c(Ipos, Ineg, Iaro)
  )

# Check that wide3 contains the expected columns:
colnames(wide3)
```

```
##  [1] "subj"    "Ipos_t1" "Ipos_t2" "Ipos_t3" "Ineg_t1" "Ineg_t2" "Ineg_t3"
##  [8] "Iaro_t1" "Iaro_t2" "Iaro_t3"
```

```r
# Expected: subj, Ipos_t1, Ipos_t2, Ipos_t3, Ineg_t1, ..., Iaro_t3
```

```r
# 2) Define the RI-CLPM model syntax
library(lavaan)
model_riclpm_3 <- '

  # 2.1 Random intercept (trait) latent factors:
  #     Each RI factor loads with coefficient = 1 on its observed indicators
  #     to capture stable between-person differences across t1-t3.
  RIpos =~ 1*Ipos_t1 + 1*Ipos_t2 + 1*Ipos_t3
  RIneg =~ 1*Ineg_t1 + 1*Ineg_t2 + 1*Ineg_t3
  RIaro =~ 1*Iaro_t1 + 1*Iaro_t2 + 1*Iaro_t3

  # 2.2 De-mean observed variables (fix intercepts to zero):
  #     Ensures residuals reflect within-person deviations from each person's mean.
  Ipos_t1 ~ 0*1
  Ipos_t2 ~ 0*1
  Ipos_t3 ~ 0*1
  Ineg_t1 ~ 0*1
  Ineg_t2 ~ 0*1
  Ineg_t3 ~ 0*1
  Iaro_t1 ~ 0*1
  Iaro_t2 ~ 0*1
  Iaro_t3 ~ 0*1

  # 2.3 Constrain residuals and RIs to be uncorrelated:
  #     Isolates within-person (state) variance from between-person (trait) variance.

  Ipos_t1 ~~ 0*RIpos
  Ipos_t2 ~~ 0*RIpos
  Ipos_t3 ~~ 0*RIpos
  Ineg_t1 ~~ 0*RIneg
  Ineg_t2 ~~ 0*RIneg
  Ineg_t3 ~~ 0*RIneg
  Iaro_t1 ~~ 0*RIaro
  Iaro_t2 ~~ 0*RIaro
  Iaro_t3 ~~ 0*RIaro

  # 2.4 Within-person lagged effects (on the residual/state level):
  #     Autoregressive ("inertia") and cross-lagged paths for t2 and t3.
```

```r
  #   At time 2:
  Ipos_t2 ~ a1*Ipos_t1 + b1*Ineg_t1 + b2*Iaro_t1
  Ineg_t2 ~ a2*Ineg_t1 + c1*Ipos_t1 + c2*Iaro_t1
  Iaro_t2 ~ a3*Iaro_t1 + d1*Ipos_t1 + d2*Ineg_t1

  #   At time 3:
  Ipos_t3 ~ a1*Ipos_t2 + b1*Ineg_t2 + b2*Iaro_t2
  Ineg_t3 ~ a2*Ineg_t2 + c1*Ipos_t2 + c2*Iaro_t2
  Iaro_t3 ~ a3*Iaro_t2 + d1*Ipos_t2 + d2*Ineg_t2
'

# 3) Fit the RI-CLPM with MLR estimator (robust ML)
fit_riclpm_3 <- sem(
  model     = model_riclpm_3,
  data      = wide3,
  estimator = "MLR"
)
```

```
## Warning: lavaan->lav_object_post_check():
##    covariance matrix of latent variables is not positive definite ; use
##    lavInspect(fit, "cov.lv") to investigate.
```

```r
# 4) Summarize results with standardized estimates and fit indices
summary(fit_riclpm_3, standardized = TRUE, fit.measures = TRUE)
```

```
## lavaan 0.6-19 ended normally after 99 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        33
##   Number of equality constraints                     9
##
##   Number of observations                           156
##
## Model Test User Model:
##                                               Standard      Scaled
##   Test Statistic                               472.096     450.676
##   Degrees of freedom                                30          30
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.048
##     Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                               481.779     390.692
##   Degrees of freedom                                36          36
##   P-value                                        0.000       0.000
##   Scaling correction factor                                  1.233
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.008       0.000
##   Tucker-Lewis Index (TLI)                      -0.190      -0.423
```

```
##
##   Robust Comparative Fit Index (CFI)                         0.000
##   Robust Tucker-Lewis Index (TLI)                           -0.209
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)             -3163.339   -3163.339
##   Scaling correction factor                                 0.892
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)     -2927.291   -2927.291
##   Scaling correction factor                                 1.127
##       for the MLR correction
##
##   Akaike (AIC)                               6374.678    6374.678
##   Bayesian (BIC)                             6447.875    6447.875
##   Sample-size adjusted Bayesian (SABIC)      6371.907    6371.907
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                         0.307       0.300
##   90 Percent confidence interval - lower        0.283       0.276
##   90 Percent confidence interval - upper        0.332       0.324
##   P-value H_0: RMSEA <= 0.050                   0.000       0.000
##   P-value H_0: RMSEA >= 0.080                   1.000       1.000
##
##   Robust RMSEA                                              0.307
##   90 Percent confidence interval - lower                    0.282
##   90 Percent confidence interval - upper                    0.332
##   P-value H_0: Robust RMSEA <= 0.050                        0.000
##   P-value H_0: Robust RMSEA >= 0.080                        1.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                          1.752       1.752
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   RIpos =~
##     Ipos_t1           1.000                               2.958    0.782
##     Ipos_t2           1.000                               2.958    0.753
##     Ipos_t3           1.000                               2.958    0.737
##   RIneg =~
##     Ineg_t1           1.000                               2.337    0.670
##     Ineg_t2           1.000                               2.337    0.623
##     Ineg_t3           1.000                               2.337    0.599
##   RIaro =~
##     Iaro_t1           1.000                               3.778    0.945
##     Iaro_t2           1.000                               3.778    1.017
```

```
##     Iaro_t3           1.000                               3.778    0.952
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos_t2 ~
##     Ipos_t1   (a1)    0.359    0.110    3.279    0.001    0.359    0.346
##     Ineg_t1   (b1)    0.661    0.099    6.678    0.000    0.661    0.586
##     Iaro_t1   (b2)   -0.752    0.154   -4.890    0.000   -0.752   -0.765
##   Ineg_t2 ~
##     Ineg_t1   (a2)    0.717    0.133    5.377    0.000    0.717    0.666
##     Ipos_t1   (c1)    0.782    0.082    9.591    0.000    0.782    0.789
##     Iaro_t1   (c2)   -1.079    0.127   -8.494    0.000   -1.079   -1.150
##   Iaro_t2 ~
##     Iaro_t1   (a3)   -0.003    0.094   -0.033    0.974   -0.003   -0.003
##     Ipos_t1   (d1)   -0.020    0.061   -0.325    0.745   -0.020   -0.020
##     Ineg_t1   (d2)   -0.093    0.063   -1.462    0.144   -0.093   -0.087
##   Ipos_t3 ~
##     Ipos_t2   (a1)    0.359    0.110    3.279    0.001    0.359    0.351
##     Ineg_t2   (b1)    0.661    0.099    6.678    0.000    0.661    0.617
##     Iaro_t2   (b2)   -0.752    0.154   -4.890    0.000   -0.752   -0.696
##   Ineg_t3 ~
##     Ineg_t2   (a2)    0.717    0.133    5.377    0.000    0.717    0.690
##     Ipos_t2   (c1)    0.782    0.082    9.591    0.000    0.782    0.787
##     Iaro_t2   (c2)   -1.079    0.127   -8.494    0.000   -1.079   -1.028
##   Iaro_t3 ~
##     Iaro_t2   (a3)   -0.003    0.094   -0.033    0.974   -0.003   -0.003
##     Ipos_t2   (d1)   -0.020    0.061   -0.325    0.745   -0.020   -0.020
##     Ineg_t2   (d2)   -0.093    0.063   -1.462    0.144   -0.093   -0.088
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   RIpos ~~
##    .Ipos_t1           0.000                               0.000    0.000
##    .Ipos_t2           0.000                               0.000    0.000
##    .Ipos_t3           0.000                               0.000    0.000
##   RIneg ~~
##    .Ineg_t1           0.000                               0.000    0.000
##    .Ineg_t2           0.000                               0.000    0.000
##    .Ineg_t3           0.000                               0.000    0.000
##   RIaro ~~
##    .Iaro_t1           0.000                               0.000    0.000
##    .Iaro_t2           0.000                               0.000    0.000
##    .Iaro_t3           0.000                               0.000    0.000
##   RIpos ~~
##     RIneg             6.133    0.569   10.780    0.000    0.887    0.887
##     RIaro            11.413    1.092   10.452    0.000    1.021    1.021
##   RIneg ~~
##     RIaro            10.081    1.107    9.108    0.000    1.142    1.142
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos_t1           0.000                               0.000    0.000
##    .Ipos_t2           0.000                               0.000    0.000
##    .Ipos_t3           0.000                               0.000    0.000
```

```
##    .Ineg_t1          0.000                               0.000    0.000
##    .Ineg_t2          0.000                               0.000    0.000
##    .Ineg_t3          0.000                               0.000    0.000
##    .Iaro_t1          0.000                               0.000    0.000
##    .Iaro_t2          0.000                               0.000    0.000
##    .Iaro_t3          0.000                               0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos_t1          5.569    0.749    7.435    0.000    5.569    0.389
##    .Ipos_t2          6.531    0.856    7.631    0.000    6.531    0.423
##    .Ipos_t3          7.555    1.060    7.128    0.000    7.555    0.469
##    .Ineg_t1          6.692    0.899    7.445    0.000    6.692    0.551
##    .Ineg_t2          7.315    0.890    8.221    0.000    7.315    0.520
##    .Ineg_t3         10.772    1.537    7.007    0.000   10.772    0.708
##    .Iaro_t1          1.712    0.231    7.412    0.000    1.712    0.107
##    .Iaro_t2          1.803    0.239    7.542    0.000    1.803    0.131
##    .Iaro_t3          3.862    0.513    7.522    0.000    3.862    0.245
##     RIpos            8.750    1.386    6.315    0.000    1.000    1.000
##     RIneg            5.461    1.353    4.038    0.000    1.000    1.000
##     RIaro           14.270    1.378   10.357    0.000    1.000    1.000
```

```
# ---------------------------------------------------------------------------------
# EXAMPLE 2: BLOCK-BASED RI-CLPM (AVERAGE EVERY 10 TRIALS → 11 BLOCKS)
# Aggregates high-frequency data to improve model identification.
# ---------------------------------------------------------------------------------

# 1) Create block variable (1-11) and compute block-wise averages per subject

block_size <- 10
clpm_block <- dat %>%
  # Assign each trial to a block index (e.g., trial 1-10 → block 1, etc.)
  mutate(block = ceiling(trial.num / block_size)) %>%
  # Group by subject and block
  group_by(subj, block) %>%
  # Compute mean Ipos, Ineg, Iaro within each block
  summarise(
    Ipos = mean(Ipos),
    Ineg = mean(Ineg),
    Iaro = mean(Iaro),
    .groups = "drop"
  )

# 2) Pivot the block-level data to wide format: Ipos_b1, Ipos_b2, ..., Iaro_b11
wide_blk <- clpm_block %>%
  pivot_wider(
    id_cols      = subj,
    names_from   = block,
    names_prefix = "b",
    values_from  = c(Ipos, Ineg, Iaro)
  )

# 3) Dynamically build the RI-CLPM syntax for 11 blocks
```

```r
# Identify block indices and variable names
waves <- sort(unique(clpm_block$block))  # 1:11
vars  <- c("Ipos","Ineg","Iaro")
vc    <- sub("^I", "", vars)             # Clean names: "pos","neg","aro"

# 3.1 Trait factors: each RI loads equally (1*) on all blocks
trait <- sapply(seq_along(vars), function(i){
  paste0("RI", vc[i], " =~ ",
         paste0("1*", vars[i], "_b", waves, collapse=" + "))
})

# 3.2 De-mean by fixing intercepts of all observed block scores to zero
ints <- unlist(lapply(vars, function(v){
  paste0(v, "_b", waves, " ~ 0*1")
}))

# 3.3 Constrain residuals of observed blocks to be uncorrelated with their RI
nocov <- unlist(lapply(vc, function(x){
  paste0("I", x, "_b", waves, " ~~ 0*RI", x)
}))

# 3.4 Specify within-person lagged regression paths for blocks 2-11
lags <- unlist(lapply(waves[-1], function(w){
  w0 <- w-1
  c(
    sprintf("Ipos_b%d ~ a1*Ipos_b%d + b1*Ineg_b%d + b2*Iaro_b%d", w, w0, w0, w0),
    sprintf("Ineg_b%d ~ a2*Ineg_b%d + c1*Ipos_b%d + c2*Iaro_b%d", w, w0, w0, w0),
    sprintf("Iaro_b%d ~ a3*Iaro_b%d + d1*Ipos_b%d + d2*Ineg_b%d", w, w0, w0, w0)
  )
}))

# 3.5 Combine all parts-each line separated by a newline-for lavaan
model_blk_riclpm <- paste(c(trait, ints, nocov, lags), collapse="\n")

# 4) Fit the block-based RI-CLPM
fit_blk_riclpm <- sem(
  model     = model_blk_riclpm,
  data      = wide_blk,
  estimator = "MLR"
)

# 5) Output summary with standardized estimates and fit indices
summary(fit_blk_riclpm, standardized=TRUE, fit.measures=TRUE)
```

```
## lavaan 0.6-19 ended normally after 77 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                       129
##   Number of equality constraints                    81
##
##   Number of observations                           156
##
```

```
## Model Test User Model:
##                                               Standard      Scaled
##   Test Statistic                              2309.705    2096.792
##   Degrees of freedom                               546         546
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.102
##     Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                              6881.327    6031.157
##   Degrees of freedom                               528         528
##   P-value                                        0.000       0.000
##   Scaling correction factor                                  1.141
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.722       0.718
##   Tucker-Lewis Index (TLI)                       0.732       0.727
##
##   Robust Comparative Fit Index (CFI)                         0.728
##   Robust Tucker-Lewis Index (TLI)                            0.737
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -5585.941   -5585.941
##   Scaling correction factor                                  0.497
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)      -4431.089   -4431.089
##   Scaling correction factor                                  1.121
##       for the MLR correction
##
##   Akaike (AIC)                               11267.882   11267.882
##   Bayesian (BIC)                             11414.275   11414.275
##   Sample-size adjusted Bayesian (SABIC)      11262.340   11262.340
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.144       0.135
##   90 Percent confidence interval - lower         0.138       0.129
##   90 Percent confidence interval - upper         0.150       0.141
##   P-value H_0: RMSEA <= 0.050                    0.000       0.000
##   P-value H_0: RMSEA >= 0.080                    1.000       1.000
##
##   Robust RMSEA                                               0.142
##   90 Percent confidence interval - lower                     0.135
##   90 Percent confidence interval - upper                     0.148
##   P-value H_0: Robust RMSEA <= 0.050                         0.000
##   P-value H_0: Robust RMSEA >= 0.080                         1.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           7.949       7.949
##
```

```
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   RIpos =~
##     Ipos_b1           1.000                               3.170    0.983
##     Ipos_b2           1.000                               3.170    0.994
##     Ipos_b3           1.000                               3.170    0.990
##     Ipos_b4           1.000                               3.170    0.981
##     Ipos_b5           1.000                               3.170    0.977
##     Ipos_b6           1.000                               3.170    0.985
##     Ipos_b7           1.000                               3.170    0.985
##     Ipos_b8           1.000                               3.170    0.977
##     Ipos_b9           1.000                               3.170    0.990
##     Ipos_b10          1.000                               3.170    0.983
##     Ipos_b11          1.000                               3.170    0.969
##   RIneg =~
##     Ineg_b1           1.000                               3.071    0.980
##     Ineg_b2           1.000                               3.071    0.943
##     Ineg_b3           1.000                               3.071    0.958
##     Ineg_b4           1.000                               3.071    0.946
##     Ineg_b5           1.000                               3.071    0.947
##     Ineg_b6           1.000                               3.071    0.949
##     Ineg_b7           1.000                               3.071    0.950
##     Ineg_b8           1.000                               3.071    0.947
##     Ineg_b9           1.000                               3.071    0.952
##     Ineg_b10          1.000                               3.071    0.945
##     Ineg_b11          1.000                               3.071    0.926
##   RIaro =~
##     Iaro_b1           1.000                               3.570    0.989
##     Iaro_b2           1.000                               3.570    1.008
##     Iaro_b3           1.000                               3.570    1.011
##     Iaro_b4           1.000                               3.570    1.015
##     Iaro_b5           1.000                               3.570    1.014
##     Iaro_b6           1.000                               3.570    1.014
##     Iaro_b7           1.000                               3.570    1.012
##     Iaro_b8           1.000                               3.570    1.012
##     Iaro_b9           1.000                               3.570    1.011
##     Iaro_b10          1.000                               3.570    1.010
##     Iaro_b11          1.000                               3.570    1.001
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   Ipos_b2 ~
##     Ipos_b1   (a1)   -0.104    0.028   -3.664    0.000   -0.104   -0.105
##     Ineg_b1   (b1)    0.239    0.028    8.662    0.000    0.239    0.235
##     Iaro_b1   (b2)   -0.131    0.036   -3.617    0.000   -0.131   -0.148
##   Ineg_b2 ~
##     Ineg_b1   (a2)   -0.112    0.027   -4.068    0.000   -0.112   -0.107
##     Ipos_b1   (c1)    0.252    0.023   11.154    0.000    0.252    0.250
```

```
##     Iaro_b1   (c2)   -0.099    0.033   -3.031    0.002   -0.099   -0.110
##   Iaro_b2 ~
##     Iaro_b1   (a3)    0.145    0.043    3.363    0.001    0.145    0.148
##     Ipos_b1   (d1)   -0.062    0.026   -2.383    0.017   -0.062   -0.056
##     Ineg_b1   (d2)   -0.132    0.032   -4.130    0.000   -0.132   -0.117
##   Ipos_b3 ~
##     Ipos_b2   (a1)   -0.104    0.028   -3.664    0.000   -0.104   -0.103
##     Ineg_b2   (b1)    0.239    0.028    8.662    0.000    0.239    0.243
##     Iaro_b2   (b2)   -0.131    0.036   -3.617    0.000   -0.131   -0.145
##   Ineg_b3 ~
##     Ineg_b2   (a2)   -0.112    0.027   -4.068    0.000   -0.112   -0.113
##     Ipos_b2   (c1)    0.252    0.023   11.154    0.000    0.252    0.251
##     Iaro_b2   (c2)   -0.099    0.033   -3.031    0.002   -0.099   -0.110
##   Iaro_b3 ~
##     Iaro_b2   (a3)    0.145    0.043    3.363    0.001    0.145    0.146
##     Ipos_b2   (d1)   -0.062    0.026   -2.383    0.017   -0.062   -0.056
##     Ineg_b2   (d2)   -0.132    0.032   -4.130    0.000   -0.132   -0.122
##   Ipos_b4 ~
##     Ipos_b3   (a1)   -0.104    0.028   -3.664    0.000   -0.104   -0.103
##     Ineg_b3   (b1)    0.239    0.028    8.662    0.000    0.239    0.237
##     Iaro_b3   (b2)   -0.131    0.036   -3.617    0.000   -0.131   -0.143
##   Ineg_b4 ~
##     Ineg_b3   (a2)   -0.112    0.027   -4.068    0.000   -0.112   -0.110
##     Ipos_b3   (c1)    0.252    0.023   11.154    0.000    0.252    0.249
##     Iaro_b3   (c2)   -0.099    0.033   -3.031    0.002   -0.099   -0.108
##   Iaro_b4 ~
##     Iaro_b3   (a3)    0.145    0.043    3.363    0.001    0.145    0.146
##     Ipos_b3   (d1)   -0.062    0.026   -2.383    0.017   -0.062   -0.056
##     Ineg_b3   (d2)   -0.132    0.032   -4.130    0.000   -0.132   -0.120
##   Ipos_b5 ~
##     Ipos_b4   (a1)   -0.104    0.028   -3.664    0.000   -0.104   -0.103
##     Ineg_b4   (b1)    0.239    0.028    8.662    0.000    0.239    0.239
##     Iaro_b4   (b2)   -0.131    0.036   -3.617    0.000   -0.131   -0.142
##   Ineg_b5 ~
##     Ineg_b4   (a2)   -0.112    0.027   -4.068    0.000   -0.112   -0.112
##     Ipos_b4   (c1)    0.252    0.023   11.154    0.000    0.252    0.251
##     Iaro_b4   (c2)   -0.099    0.033   -3.031    0.002   -0.099   -0.108
##   Iaro_b5 ~
##     Iaro_b4   (a3)    0.145    0.043    3.363    0.001    0.145    0.145
##     Ipos_b4   (d1)   -0.062    0.026   -2.383    0.017   -0.062   -0.057
##     Ineg_b4   (d2)   -0.132    0.032   -4.130    0.000   -0.132   -0.122
##   Ipos_b6 ~
##     Ipos_b5   (a1)   -0.104    0.028   -3.664    0.000   -0.104   -0.105
##     Ineg_b5   (b1)    0.239    0.028    8.662    0.000    0.239    0.241
##     Iaro_b5   (b2)   -0.131    0.036   -3.617    0.000   -0.131   -0.143
##   Ineg_b6 ~
##     Ineg_b5   (a2)   -0.112    0.027   -4.068    0.000   -0.112   -0.112
##     Ipos_b5   (c1)    0.252    0.023   11.154    0.000    0.252    0.253
##     Iaro_b5   (c2)   -0.099    0.033   -3.031    0.002   -0.099   -0.108
##   Iaro_b6 ~
##     Iaro_b5   (a3)    0.145    0.043    3.363    0.001    0.145    0.145
##     Ipos_b5   (d1)   -0.062    0.026   -2.383    0.017   -0.062   -0.057
##     Ineg_b5   (d2)   -0.132    0.032   -4.130    0.000   -0.132   -0.121
##   Ipos_b7 ~
```

```
##     Ipos_b6   (a1)  -0.104   0.028  -3.664   0.000  -0.104  -0.104
##     Ineg_b6   (b1)   0.239   0.028   8.662   0.000   0.239   0.240
##     Iaro_b6   (b2)  -0.131   0.036  -3.617   0.000  -0.131  -0.143
##   Ineg_b7 ~
##     Ineg_b6   (a2)  -0.112   0.027  -4.068   0.000  -0.112  -0.112
##     Ipos_b6   (c1)   0.252   0.023  11.154   0.000   0.252   0.251
##     Iaro_b6   (c2)  -0.099   0.033  -3.031   0.002  -0.099  -0.108
##   Iaro_b7 ~
##     Iaro_b6   (a3)   0.145   0.043   3.363   0.001   0.145   0.145
##     Ipos_b6   (d1)  -0.062   0.026  -2.383   0.017  -0.062  -0.057
##     Ineg_b6   (d2)  -0.132   0.032  -4.130   0.000  -0.132  -0.121
##   Ipos_b8 ~
##     Ipos_b7   (a1)  -0.104   0.028  -3.664   0.000  -0.104  -0.103
##     Ineg_b7   (b1)   0.239   0.028   8.662   0.000   0.239   0.238
##     Iaro_b7   (b2)  -0.131   0.036  -3.617   0.000  -0.131  -0.142
##   Ineg_b8 ~
##     Ineg_b7   (a2)  -0.112   0.027  -4.068   0.000  -0.112  -0.111
##     Ipos_b7   (c1)   0.252   0.023  11.154   0.000   0.252   0.250
##     Iaro_b7   (c2)  -0.099   0.033  -3.031   0.002  -0.099  -0.108
##   Iaro_b8 ~
##     Iaro_b7   (a3)   0.145   0.043   3.363   0.001   0.145   0.145
##     Ipos_b7   (d1)  -0.062   0.026  -2.383   0.017  -0.062  -0.057
##     Ineg_b7   (d2)  -0.132   0.032  -4.130   0.000  -0.132  -0.121
##   Ipos_b9 ~
##     Ipos_b8   (a1)  -0.104   0.028  -3.664   0.000  -0.104  -0.105
##     Ineg_b8   (b1)   0.239   0.028   8.662   0.000   0.239   0.242
##     Iaro_b8   (b2)  -0.131   0.036  -3.617   0.000  -0.131  -0.144
##   Ineg_b9 ~
##     Ineg_b8   (a2)  -0.112   0.027  -4.068   0.000  -0.112  -0.112
##     Ipos_b8   (c1)   0.252   0.023  11.154   0.000   0.252   0.254
##     Iaro_b8   (c2)  -0.099   0.033  -3.031   0.002  -0.099  -0.109
##   Iaro_b9 ~
##     Iaro_b8   (a3)   0.145   0.043   3.363   0.001   0.145   0.145
##     Ipos_b8   (d1)  -0.062   0.026  -2.383   0.017  -0.062  -0.057
##     Ineg_b8   (d2)  -0.132   0.032  -4.130   0.000  -0.132  -0.121
##   Ipos_b10 ~
##     Ipos_b9   (a1)  -0.104   0.028  -3.664   0.000  -0.104  -0.103
##     Ineg_b9   (b1)   0.239   0.028   8.662   0.000   0.239   0.239
##     Iaro_b9   (b2)  -0.131   0.036  -3.617   0.000  -0.131  -0.143
##   Ineg_b10 ~
##     Ineg_b9   (a2)  -0.112   0.027  -4.068   0.000  -0.112  -0.111
##     Ipos_b9   (c1)   0.252   0.023  11.154   0.000   0.252   0.248
##     Iaro_b9   (c2)  -0.099   0.033  -3.031   0.002  -0.099  -0.108
##   Iaro_b10 ~
##     Iaro_b9   (a3)   0.145   0.043   3.363   0.001   0.145   0.145
##     Ipos_b9   (d1)  -0.062   0.026  -2.383   0.017  -0.062  -0.056
##     Ineg_b9   (d2)  -0.132   0.032  -4.130   0.000  -0.132  -0.120
##   Ipos_b11 ~
##     Ipos_b10  (a1)  -0.104   0.028  -3.664   0.000  -0.104  -0.102
##     Ineg_b10  (b1)   0.239   0.028   8.662   0.000   0.239   0.238
##     Iaro_b10  (b2)  -0.131   0.036  -3.617   0.000  -0.131  -0.142
##   Ineg_b11 ~
##     Ineg_b10  (a2)  -0.112   0.027  -4.068   0.000  -0.112  -0.109
##     Ipos_b10  (c1)   0.252   0.023  11.154   0.000   0.252   0.245
```

```
##     Iaro_b10  (c2)   -0.099    0.033   -3.031    0.002   -0.099   -0.106
##   Iaro_b11 ~
##     Iaro_b10  (a3)    0.145    0.043    3.363    0.001    0.145    0.144
##     Ipos_b10  (d1)   -0.062    0.026   -2.383    0.017   -0.062   -0.056
##     Ineg_b10  (d2)   -0.132    0.032   -4.130    0.000   -0.132   -0.120
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   RIpos ~~
##    .Ipos_b1           0.000                               0.000    0.000
##    .Ipos_b2           0.000                               0.000    0.000
##    .Ipos_b3           0.000                               0.000    0.000
##    .Ipos_b4           0.000                               0.000    0.000
##    .Ipos_b5           0.000                               0.000    0.000
##    .Ipos_b6           0.000                               0.000    0.000
##    .Ipos_b7           0.000                               0.000    0.000
##    .Ipos_b8           0.000                               0.000    0.000
##    .Ipos_b9           0.000                               0.000    0.000
##    .Ipos_b10          0.000                               0.000    0.000
##    .Ipos_b11          0.000                               0.000    0.000
##   RIneg ~~
##    .Ineg_b1           0.000                               0.000    0.000
##    .Ineg_b2           0.000                               0.000    0.000
##    .Ineg_b3           0.000                               0.000    0.000
##    .Ineg_b4           0.000                               0.000    0.000
##    .Ineg_b5           0.000                               0.000    0.000
##    .Ineg_b6           0.000                               0.000    0.000
##    .Ineg_b7           0.000                               0.000    0.000
##    .Ineg_b8           0.000                               0.000    0.000
##    .Ineg_b9           0.000                               0.000    0.000
##    .Ineg_b10          0.000                               0.000    0.000
##    .Ineg_b11          0.000                               0.000    0.000
##   RIaro ~~
##    .Iaro_b1           0.000                               0.000    0.000
##    .Iaro_b2           0.000                               0.000    0.000
##    .Iaro_b3           0.000                               0.000    0.000
##    .Iaro_b4           0.000                               0.000    0.000
##    .Iaro_b5           0.000                               0.000    0.000
##    .Iaro_b6           0.000                               0.000    0.000
##    .Iaro_b7           0.000                               0.000    0.000
##    .Iaro_b8           0.000                               0.000    0.000
##    .Iaro_b9           0.000                               0.000    0.000
##    .Iaro_b10          0.000                               0.000    0.000
##    .Iaro_b11          0.000                               0.000    0.000
##   RIpos ~~
##     RIneg             9.583    0.394   24.352    0.000    0.984    0.984
##     RIaro            11.043    0.561   19.671    0.000    0.976    0.976
##   RIneg ~~
##     RIaro            10.689    0.524   20.391    0.000    0.975    0.975
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos_b1           0.000                               0.000    0.000
##    .Ipos_b2           0.000                               0.000    0.000
```

```
##    .Ipos_b3          0.000                               0.000    0.000
##    .Ipos_b4          0.000                               0.000    0.000
##    .Ipos_b5          0.000                               0.000    0.000
##    .Ipos_b6          0.000                               0.000    0.000
##    .Ipos_b7          0.000                               0.000    0.000
##    .Ipos_b8          0.000                               0.000    0.000
##    .Ipos_b9          0.000                               0.000    0.000
##    .Ipos_b10         0.000                               0.000    0.000
##    .Ipos_b11         0.000                               0.000    0.000
##    .Ineg_b1          0.000                               0.000    0.000
##    .Ineg_b2          0.000                               0.000    0.000
##    .Ineg_b3          0.000                               0.000    0.000
##    .Ineg_b4          0.000                               0.000    0.000
##    .Ineg_b5          0.000                               0.000    0.000
##    .Ineg_b6          0.000                               0.000    0.000
##    .Ineg_b7          0.000                               0.000    0.000
##    .Ineg_b8          0.000                               0.000    0.000
##    .Ineg_b9          0.000                               0.000    0.000
##    .Ineg_b10         0.000                               0.000    0.000
##    .Ineg_b11         0.000                               0.000    0.000
##    .Iaro_b1          0.000                               0.000    0.000
##    .Iaro_b2          0.000                               0.000    0.000
##    .Iaro_b3          0.000                               0.000    0.000
##    .Iaro_b4          0.000                               0.000    0.000
##    .Iaro_b5          0.000                               0.000    0.000
##    .Iaro_b6          0.000                               0.000    0.000
##    .Iaro_b7          0.000                               0.000    0.000
##    .Iaro_b8          0.000                               0.000    0.000
##    .Iaro_b9          0.000                               0.000    0.000
##    .Iaro_b10         0.000                               0.000    0.000
##    .Iaro_b11         0.000                               0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Ipos_b1          0.359    0.049    7.391    0.000    0.359    0.034
##    .Ipos_b2          0.473    0.060    7.897    0.000    0.473    0.046
##    .Ipos_b3          0.257    0.043    5.993    0.000    0.257    0.025
##    .Ipos_b4          0.489    0.072    6.789    0.000    0.489    0.047
##    .Ipos_b5          0.545    0.066    8.250    0.000    0.545    0.052
##    .Ipos_b6          0.375    0.065    5.810    0.000    0.375    0.036
##    .Ipos_b7          0.381    0.055    6.904    0.000    0.381    0.037
##    .Ipos_b8          0.549    0.065    8.492    0.000    0.549    0.052
##    .Ipos_b9          0.253    0.035    7.231    0.000    0.253    0.025
##    .Ipos_b10         0.412    0.060    6.823    0.000    0.412    0.040
##    .Ipos_b11         0.706    0.109    6.487    0.000    0.706    0.066
##    .Ineg_b1          0.394    0.060    6.536    0.000    0.394    0.040
##    .Ineg_b2          0.510    0.074    6.933    0.000    0.510    0.048
##    .Ineg_b3          0.255    0.034    7.613    0.000    0.255    0.025
##    .Ineg_b4          0.446    0.055    8.170    0.000    0.446    0.042
##    .Ineg_b5          0.432    0.057    7.581    0.000    0.432    0.041
##    .Ineg_b6          0.365    0.061    5.939    0.000    0.365    0.035
##    .Ineg_b7          0.359    0.053    6.840    0.000    0.359    0.034
##    .Ineg_b8          0.422    0.058    7.311    0.000    0.422    0.040
##    .Ineg_b9          0.293    0.041    7.152    0.000    0.293    0.028
```

```
##    .Ineg_b10          0.477    0.066    7.175    0.000    0.477    0.045
##    .Ineg_b11          0.900    0.119    7.589    0.000    0.900    0.082
##    .Iaro_b1           0.294    0.043    6.909    0.000    0.294    0.023
##    .Iaro_b2           0.239    0.031    7.733    0.000    0.239    0.019
##    .Iaro_b3           0.273    0.050    5.511    0.000    0.273    0.022
##    .Iaro_b4           0.192    0.032    6.016    0.000    0.192    0.016
##    .Iaro_b5           0.241    0.038    6.361    0.000    0.241    0.019
##    .Iaro_b6           0.239    0.033    7.146    0.000    0.239    0.019
##    .Iaro_b7           0.280    0.056    4.955    0.000    0.280    0.022
##    .Iaro_b8           0.285    0.044    6.534    0.000    0.285    0.023
##    .Iaro_b9           0.300    0.050    6.018    0.000    0.300    0.024
##    .Iaro_b10          0.330    0.055    5.978    0.000    0.330    0.026
##    .Iaro_b11          0.544    0.077    7.058    0.000    0.544    0.043
##     RIpos            10.051    0.527   19.067    0.000    1.000    1.000
##     RIneg             9.433    0.453   20.820    0.000    1.000    1.000
##     RIaro            12.744    0.790   16.126    0.000    1.000    1.000
```

2.1 Three-Timepoint RI-CLPM

Model Fit
- CFI = 0.008, TLI = –0.19, RMSEA = 0.307, SRMR = 1.752 (poor overall fit)
- RIs nearly collinear (non–positive-definite latent covariances)

Trait Variance
- RIpos Var = 8.75, RIneg Var = 5.46, RIaro Var = 14.27 (all $p < .001$)

Within-Person Autoregression
- **Positive affect** ($a_1 = 0.359$, $p = .001$) and **negative affect** ($a_2 = 0.717$, $p < .001$) show significant carry-over
- **Arousal** ($a_3 = –0.003$, $p = .974$) no persistence

Cross-Lagged Effects
- **Negative → Positive** ($b_1 = 0.661$, $p < .001$)
- **Positive → Negative** ($c_1 = 0.782$, $p < .001$)
- **Arousal → Positive** ($b_2 = –0.752$, $p < .001$) and **Arousal → Negative** ($c_2 = –1.079$, $p < .001$) - **Valence → Arousal** non-significant

---

2.2 Block-Based RI-CLPM (11 Blocks)

Model Fit
- CFI = 0.722, TLI = 0.732, RMSEA = 0.144, SRMR = 7.95 (exploratory)

Within-Person Autoregression
- **Positive affect** mean-reversion ($a_1 = –0.104$, $p < .001$)
- **Negative affect** mean-reversion ($a_2 = –0.112$, $p < .001$)
- **Arousal** persistence ($a_3 = 0.145$, $p = .001$)

Cross-Lagged Effects
- **Negative → Positive** ($b_1 = 0.239$, $p < .001$)
- **Positive → Negative** ($c_1 = 0.252$, $p < .001$)
- **Arousal → Positive** ($b_2 = –0.131$, $p < .001$) and **Arousal → Negative** ($c_2 = –0.099$, $p = .002$) - **Positive → Arousal** ($d_1 = –0.062$, $p = .017$) and **Negative → Arousal** ($d_2 = –0.132$, $p < .001$)

2.3 Causal Implications

After removing trait variance and using strict lagged ordering, significant cross-lag paths represent **within-person causal dynamics**:

- A spike in negative affect leads to a subsequent rise in positive affect.
- A spike in positive affect leads to a subsequent rise in negative affect.
- Elevated arousal suppresses both positive and negative affect on the next occasion.

  Note: Poor overall fit means these patterns should be interpreted as preliminary insights, pending model refinement and robustness checks.

3 trial.val -> inertia

Whether stimulus type affects the intensity of inertia?