Cognitive change before old age predicts cognitive change during old age

Contents

1. Setup

```
if (!require("pacman")) install.packages("pacman")

pacman::p_load(dplyr, ggplot2, grDevices, haven, knitr, lavaan, Matrix, matrixStats, psych)

# Disambiguate functions
select <- dplyr::select
summarise <- dplyr::summarise
filter <- dplyr::filter
rescale <- psych::rescale

#
options(max.print = 10000, width = 60)
```

---

2. Data

2.1 Original data

Note: Vector labels were not handled well by some of the functions used to compute descriptive statistics. For ease of analysis, labels were removed using *mutate_if(data, is.labelled, zap_labels)*

```
data <-
read_sav("Data/LBC1936_FedericaConte_LifeTimeCogChangeAndCogReserveAsPredictorsOfDecline_5wavesMerged.sav")



data = data[, c("lbc36no", "sex",
        "fathclass_w1", "fatheduc_w1", "hmsonum_w1", "yrsedu_w1",
        "agedays_SMS", "agedays_w1", "agedays_w2", "agedays_w3", "agedays_w4", "agedays_w5",
        "mht1947", "mht_w1",
        "matreas_w1", "matreas_w2", "matreas_w3", "matreas_w4", "matreas_w5",
        "blkdes_w1", "blkdes_w2", "blkdes_w3", "blkdes_w4", "blkdes_w5",
        "spanf_w1", "spanf_w2", "spanf_w3", "spanf_w4", "spanf_w5",
        "spanb_w1", "spanb_w2", "spanb_w3", "spanb_w4", "spanb_w5",
        "vpatotal_w1", "vpatotal_w2", "vpatotal_w3", "vpatotal_w4", "vpa_total_w5",
        "lmtotal_w1", "lmtotal_w2", "lmtotal_w3", "lmtotal_w4", "lmtotal_w5",
        "digback_w1", "digback_w2", "digback_w3", "digback_w4", "digback_w5",
        "digsym_w1", "digsym_w2", "digsym_w3", "digsym_w4", "digsym_w5",
        "symsear_w1", "symsear_w2", "symsear_w3", "symsear_w4", "symsear_w5",
        "crtmean_w1", "crtmean_w2", "crtmean_w3", "crtmean_w4", "crtmean_w5",
        "ittotal_w1", "ittotal_w2", "ittotal_w3", "ittotal_w4", "ittotal_w5",
        "nart_w1"
        )]


# Remove vector labels

data <- mutate_if(data, is.labelled, zap_labels)



# Recode missing

data[data == -999] <- NA

data[data == -777] <- NA

data[data == 999] <- NA
```

2.2 Outliers

Participants for whom age-11 MHT scores in childhood were not available (n = 63) or whose scores deviated more than 3.5 SD from the sample mean (n = 6) were excluded from analyses involving cognitive change between the ages of 11 and 70.

A new variable called **mht1947_o** encodes age-11 MHT scores for all included participants, whereas missing or outlying scores are encoded as NA.

```
# Define a mht1947 variable without outliers

data2 <- mutate(data, mht1947_o = case_when(abs(mht1947 - mean(mht1947,
```

```
  na.rm = T)) <= 3.5 * SD(mht1947, na.rm = T) ~ mht1947))
```

2.3 New variables

wave: last wave reached by the participant
spantot: sum score of spatial span forward + spatial span backward
agedays_w1c: age in days at the time of testing, centered (for "age-adjusted" supplementary models)
gnd: sex, centered (to test moderation effects/interaction)
delta²: Cognitive change from age 11 to 70, raw difference
res²: Cognitive change from age 11 to 70, regression-based
elc²: "early" life cognitive change - from age 11 to peak (i.e., NART)
mlc²: "mid" life cognitive change - from peak (i.e., NART) to age 70
delgnd², resgnd², elcgnd² & **mlcgnd²**: cognitive change x sex interaction terms

² suffixes:
A = adjusted for age differences at age 11
AA = adjusted for age differences at age 11 and in every testing wave (for "age-adjusted" supplementary models)

Age adjustment procedure:
Regression-based change: residuals of (age-adjusted) MHT-70 regressed on age-adjusted MHT-11
Raw difference change: raw difference regressed on age in childhood (and at wave 1)
11-NART change: residuals of NART regressed on age-adjusted MHT-11
NART - 70 change: residuals of raw MHT-70 regressed on raw NART_w1

```
# Wave reached
data2 <- mutate(
 data2,
 wave = case_when(!is.na(agedays_w5) ~ "w5",
                  !is.na(agedays_w4) ~ "w4",
                  !is.na(agedays_w3) ~ "w3",
                  !is.na(agedays_w2) ~ "w2",
                  !is.na(agedays_w1) ~ "w1",
                  TRUE ~ "1947"
 ))

data2$wave <- as.factor(data2$wave)

# Cognitive variables
data2 <- mutate(
 data2,
 # spatial span tot
 spantot_w1 = spanf_w1 + spanb_w1,
 spantot_w2 = spanf_w2 + spanb_w2,
 spantot_w3 = spanf_w3 + spanb_w3,
 spantot_w4 = spanf_w4 + spanb_w4,
 spantot_w5 = spanf_w5 + spanb_w5,
```

```
# age in days at time of testing - centered
agedays_w1C = scale(agedays_w1, center = T, scale = F),
agedays_w2C = scale(agedays_w2, center = T, scale = F),
agedays_w3C = scale(agedays_w3, center = T, scale = F),
agedays_w4C = scale(agedays_w4, center = T, scale = F),
agedays_w5C = scale(agedays_w5, center = T, scale = F),

# predictors
gnd = scale(sex, center = T, scale = F),
delta_w1 = mht_w1 - mht1947_o,
delta_w1A = residuals(lm(delta_w1 ~ agedays_SMS, na.action= na.exclude, data = data2)),
delta_w1AA = residuals(lm(
 delta_w1 ~ agedays_SMS+agedays_w1, na.action= na.exclude, data= data2)),
mht1947A = residuals(lm(
 mht1947_o ~ agedays_SMS, na.action= na.exclude, data= data2)),
mht_w1A = residuals(lm(
 mht_w1 ~ agedays_w1, na.action = na.exclude, data = data2)),
res_w1 = residuals(lm(
 mht_w1 ~ mht1947_o, na.action = na.exclude, data = data2)),
res_w1A = residuals(lm(
 mht_w1 ~ mht1947A, na.action = na.exclude, data = data2)),

res_w1AA = residuals(lm(
 mht_w1A ~ mht1947A, na.action = na.exclude, data = data2)),

delgnd = delta_w1 * gnd,
delgndA = delta_w1A * gnd,
delgndAA = delta_w1AA * gnd,
resgnd = res_w1 * gnd,
resgndA = res_w1A * gnd,
resgndAA = res_w1AA * gnd,

# new predictors
nart_w1A = residuals(lm(
 nart_w1 ~ agedays_w1, na.action = na.exclude, data = data2)),

elcA = residuals(lm(
 nart_w1 ~ mht1947A, na.action = na.exclude, data = data2)),

mlc = residuals(lm(
 mht_w1 ~ nart_w1, na.action = na.exclude, data = data2)),

elcgndA = elcA * gnd,
mlcgnd = mlc * gnd,
)
```

2.4 Data for models

Note that some of the cognitive test scores are scaled so that all test variances are within a similar range. This is to aid model convergence.

NB. 4-choice reaction time (**crtmean**) has also been reverse-scored so that a higher score corresponds to a better performance, to match all the other test results.

```
dset_mod <- mutate(data2,
                   blkdes_w1 = blkdes_w1/2,
                   blkdes_w2 = blkdes_w2/2,
                   blkdes_w3 = blkdes_w3/2,
                   blkdes_w4 = blkdes_w4/2,
                   blkdes_w5 = blkdes_w5/2,
                   lmtotal_w1 = lmtotal_w1/3,
                   lmtotal_w2 = lmtotal_w2/3,
                   lmtotal_w3 = lmtotal_w3/3,
                    lmtotal_w4 = lmtotal_w4/3,
                   lmtotal_w5 = lmtotal_w5/3,
                   digback_w1 = 3 *digback_w1,
                   digback_w2 = 3 * digback_w2,
                   digback_w3 = 3 *digback_w3,
                   digback_w4 = 3 * digback_w4,
                    digback_w5 = 3 *digback_w5,
                   digsym_w1 = digsym_w1/2,
                   digsym_w2 = digsym_w2/2,
                   digsym_w3 = digsym_w3/2,
                   digsym_w4 = digsym_w4/2,
                   digsym_w5 = digsym_w5/2,
                   ittotal_w1 = ittotal_w1/2,
                   ittotal_w2 = ittotal_w2/2,
                   ittotal_w3 = ittotal_w3/2,
                   ittotal_w4 = ittotal_w4/2,
                   ittotal_w5 = ittotal_w5/2,
                   crtmean_w1 = -50 * crtmean_w1,
                   crtmean_w2 = -50 * crtmean_w2,
                   crtmean_w3 = -50 * crtmean_w3,
                   crtmean_w4 = -50 * crtmean_w4,
                   crtmean_w5 = -50 *crtmean_w5
                   )
```

2.5 Time between waves (in years):

```
age_w1.1 <- colMeans(data2[data2$wave == "w5", "agedays_w1"],   na.rm = T)
age_w2.1 <- colMeans(data2[data2$wave == "w5", "agedays_w2"],   na.rm = T)
age_w3.1 <- colMeans(data2[data2$wave == "w5", "agedays_w3"],   na.rm = T)
age_w4.1 <- colMeans(data2[data2$wave == "w5", "agedays_w4"],   na.rm = T)
age_w5.1 <- colMeans(data2[data2$wave == "w5", "agedays_w5"],   na.rm = T)
```

w1 : w2 = 2.98

w1 : w3 = 6.74

w1 : w4 = 9.82

w1 : w5 = 12.54

---

3. Deriving measures of cognitive change

Notes:

- The latent growth curves model definitions are re-employed as "modules" of the more complex bifactor and individual domain models. See comments to the "Bifactor measurement model" code
- In the bifactor model, we standardized the latent variable for scale setting
- In the individual domain models, we used the marker variable method for scale setting (see supplementary analysis)
- To aid convergence in regression models, we fixed factor loadings, intercepts, and low-level covariances obtained from the measurement models, whereas regression coefficients and residual factor variances were freely estimated
- Some of the test slopes' residual variances were near zero and estimated as negative. To avoid these out of bounds estimates, residual variances that were estimated as negative are fixed to zero in the model.
- The Lavaan function *fitmeasures(fit, c("cfi", "tli", "RMSEA", "SRMR"))* was used to extract model fit indices

3.1 Task latent growth curves

```
# Visuospatial
pgmodel1 <- "
Imatreas =~ 1*matreas_w1 + 1*matreas_w2 + 1*matreas_w3 + 1*matreas_w4 + 1*matreas_w5
Smatreas =~ 0*matreas_w1 + 2.98*matreas_w2 + 6.75*matreas_w3 + 9.82*matreas_w4 + 12.54*matreas_w5
"
fit1 <- growth(pgmodel1, dset_mod, missing = "ml.x")

pgmodel2 <- "
Iblkdes =~ 1*blkdes_w1 + 1*blkdes_w2 + 1*blkdes_w3 + 1*blkdes_w4 + 1*blkdes_w5
Sblkdes=~ 0*blkdes_w1 + 2.98*blkdes_w2 + 6.75*blkdes_w3 + 9.82*blkdes_w4 + 12.54*blkdes_w5
"
fit2 <- growth(pgmodel2, dset_mod, missing = "ml.x")

pgmodel3 <- "
Ispantot =~ 1*spantot_w1 + 1*spantot_w2 + 1*spantot_w3 + 1*spantot_w4 + 1*spantot_w5
Sspantot=~ 0*spantot_w1 + 2.98*spantot_w2 + 6.75*spantot_w3 + 9.82*spantot_w4 + 12.54*spantot_w5
"
```

```
fit3 <- growth(pgmodel3, dset_mod, missing = "ml.x")

# Verbal memory
pgmodel7 <- "
Ivpatotal =~ 1*vpatotal_w1 + 1*vpatotal_w2 + 1*vpatotal_w3 + 1*vpatotal_w4 + 1*vpa_total_w5
Svpatotal =~ 0*vpatotal_w1 + 2.98*vpatotal_w2 + 6.75*vpatotal_w3 + 9.82*vpatotal_w4 +
12.54*vpa_total_w5
"
fit7 <- growth(pgmodel7, dset_mod, missing = "ml.x")

pgmodel8 <- "
Ilmtotal =~ 1*lmtotal_w1 + 1*lmtotal_w2 + 1*lmtotal_w3 + 1*lmtotal_w4 + 1*lmtotal_w5
Slmtotal =~ 0*lmtotal_w1 + 2.98*lmtotal_w2 + 6.75*lmtotal_w3 + 9.82*lmtotal_w4 + 12.54*lmtotal_w5
"
fit8 <- growth(pgmodel8, dset_mod, missing = "ml.x")

pgmodel9 <- "
Idigback =~ 1*digback_w1 + 1*digback_w2 + 1*digback_w3 + 1*digback_w4 + 1*digback_w5
Sdigback =~ 0*digback_w1 + 2.98*digback_w2 + 6.75*digback_w3 + 9.82*digback_w4 + 12.54*digback_w5
"
fit9 <- growth(pgmodel9, dset_mod, missing = "ml.x")

# Processing speed
pgmodel10 <- "
Isymsear =~ 1*symsear_w1 + 1*symsear_w2 + 1*symsear_w3 + 1*symsear_w4 + 1*symsear_w5
Ssymsear =~ 0*symsear_w1 + 2.98*symsear_w2 + 6.75*symsear_w3 + 9.82*symsear_w4 + 12.54*symsear_w5
"
fit10 <- growth(pgmodel10, dset_mod, missing = "ml.x")

pgmodel11 <- "
Idigsym =~ 1*digsym_w1 + 1*digsym_w2 + 1*digsym_w3 + 1*digsym_w4 + 1*digsym_w5
Sdigsym =~ 0*digsym_w1 + 2.98*digsym_w2 + 6.75*digsym_w3 + 9.82*digsym_w4 + 12.54*digsym_w5
"
fit11 <- growth(pgmodel11, dset_mod, missing = "ml.x")

pgmodel12 <- "
Ittotal =~ 1*ittotal_w1 + 1*ittotal_w2 + 1*ittotal_w3 + 1*ittotal_w4 + 1*ittotal_w5
Sittotal =~ 0*ittotal_w1 + 2.98*ittotal_w2 + 6.75*ittotal_w3 + 9.82*ittotal_w4 + 12.54*ittotal_w5
"
fit12 <- growth(pgmodel12, dset_mod, missing = "ml.x")

pgmodel13 <- "
Icrtmean =~ 1*crtmean_w1 + 1*crtmean_w2 + 1*crtmean_w3 + 1*crtmean_w4 + 1*crtmean_w5
Scrtmean =~ 0*crtmean_w1 + 2.98*crtmean_w2 + 6.75*crtmean_w3 + 9.82*crtmean_w4 +
12.54*crtmean_w5
"
fit13 <- growth(pgmodel13, dset_mod, missing = "ml.x")
```

3.2 Bifactor measurement model

```
bif_NC <- '
# Intercepts
IG =~ NA*Imatreas + Iblkdes + Ispantot + Ivpatotal + Ilmtotal + Idigback + Isymsear + Idigsym + Iittotal + Icrtmean
Ivis =~ NA*Imatreas + Iblkdes + Ispantot
Imem =~ NA*Ivpatotal + Ilmtotal + Idigback
Ispeed =~ NA*Isymsear + Idigsym + Iittotal + Icrtmean

# Slopes
SG =~ NA*Smatreas + Sblkdes + Sspantot + Svpatotal + Slmtotal + Sdigback + Ssymsear + Sdigsym + Sittotal + Scrtmean
Svis =~ NA*Smatreas + Sblkdes + Sspantot
Smem =~ NA*Svpatotal + Slmtotal + Sdigback
Sspeed =~ NA*Ssymsear + Sdigsym + Sittotal + Scrtmean

# Orthogonal factors
IG ~~ 0*Ivis
IG ~~ 0*Imem
IG ~~ 0*Ispeed

SG ~~ 0*Svis
SG ~~ 0*Smem
SG ~~ 0*Sspeed

#lv as scaling reference: var=1, int=0
IG ~~ 1*IG
Ivis ~~ 1*Ivis
Imem ~~ 1*Imem
Ispeed ~~ 1*Ispeed
SG ~~ 1*SG
Svis ~~ 1*Svis
Smem ~~ 1*Smem
Sspeed ~~ 1*Sspeed

IG ~ 0*1
Ivis ~ 0*1
Imem ~ 0*1
Ispeed ~ 0*1
SG ~ 0*1
Svis ~ 0*1
Smem ~ 0*1
Sspeed ~ 0*1

# covariances
IG ~~ SG
Ivis ~~ Svis
Imem ~~ Smem
Ispeed ~~ Sspeed
```

```
'


bif_NC_task_cov <- '
Imatreas ~~ Smatreas
Ilmtotal ~~ Slmtotal
Idigback ~~ Sdigback
Idigsym ~~ Sdigsym
Iittotal ~~ Sittotal

vpatotal_w2 ~~ lmtotal_w2
'


var_bif_NC<- '
# negative variances fixed at 0
Iblkdes ~~ 0*Iblkdes
Sblkdes ~~ 0*Sblkdes
Sspantot ~~ 0*Sspantot
Svpatotal ~~ 0*Svpatotal
Ssymsear ~~ 0*Ssymsear
Scrtmean  ~~ 0*Scrtmean
'


fitBifNC <- lavaan(
  model = c(
    pgmodel1, pgmodel2, pgmodel3, pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11, pgmodel12,
pgmodel13, #task growth curves
    bif_NC, bif_NC_task_cov, var_bif_NC), #higher-order paths
  data = dset_mod,
  missing = "ml.x",
  meanstructure = T,
  int.ov.free = F, int.lv.free = T,
  auto.fix.first = T, auto.fix.single = T,
  auto.var = T, auto.cov.lv.x = F,auto.cov.y = T,
  auto.efa = T, auto.th = T, auto.delta = T)
```

3.2.1 Bifactor measurement model - fixed parameters

Parameters were extracted using the lavaan function *partable(fit)* and rounding to 5 significant figures

```
bif_NC_fx <- '
# Intercepts
IG =~ 3.22117*Imatreas + 3.35180*Iblkdes + 1.63358*Ispantot + 3.63190*Ivpatotal +
2.69092*Ilmtotal + 3.49043*Idigback + 4.26303*Isymsear + 3.62410*Idigsym +
2.39926*Iittotal + 2.15864*Icrtmean
Ivis =~ 1.03213*Imatreas + 2.99962*Iblkdes + 0.10452*Ispantot
Imem =~ 5.32985*Ivpatotal + 3.20082*Ilmtotal + 1.07717*Idigback
Ispeed =~ 2.32133*Isymsear + 3.48882*Idigsym + 1.24496*Iittotal + 1.88752*Icrtmean

# Slopes
```

```
SG =~ 0.13128*Smatreas + 0.14082*Sblkdes + 0.06629*Sspantot + 0.39570*Svpatotal +
0.33320*Slmtotal + 0.11145*Sdigback + 0.29210*Ssymsear + 0.30545*Sdigsym +
0.28762*Sittotal + 0.30121*Scrtmean
Svis =~ -0.00992*Smatreas + -0.12415*Sblkdes + -0.02019*Sspantot
Smem =~ 0.47940*Svpatotal + 0.28272*Slmtotal + 0.05782*Sdigback
Sspeed =~ 0.10067*Ssymsear + 0.04327*Sdigsym + 0.07518*Sittotal + -
0.11115*Scrtmean

# Orthogonal factors
IG ~~ 0*Ivis
IG ~~ 0*Imem
IG ~~ 0*Ispeed

SG ~~ 0*Svis
SG ~~ 0*Smem
SG ~~ 0*Sspeed

#lv as scaling reference: var=1. int=0
IG ~~ 1*IG
Ivis ~~ 1*Ivis
Imem ~~ 1*Imem
Ispeed ~~ 1*Ispeed
SG ~~ 1*SG
Svis ~~ 1*Svis
Smem ~~ 1*Smem
Sspeed ~~ 1*Sspeed

IG ~ 0*1
Ivis ~ 0*1
Imem ~ 0*1
Ispeed ~ 0*1
SG ~ 0*1
Svis ~ 0*1
Smem ~ 0*1
Sspeed ~ 0*1

Imatreas ~ 13.43359*1
Smatreas ~ -0.15882*1
Iblkdes ~ 17.05193*1
Sblkdes ~ -0.26405*1
Ispantot ~ 14.81883*1
Sspantot ~ -0.11024*1
Ivpatotal ~ 26.45673*1
Svpatotal ~ -0.24767*1
Ilmtotal ~ 24.23269*1
Slmtotal ~ -0.12454*1
Idigback ~ 23.51142*1
Sdigback ~ -0.21074*1
Isymsear ~ 25.07959*1
Ssymsear ~ -0.36990*1
Idigsym ~ 28.68297*1
```

```
Sdigsym ~ -0.45679*1
Iittotal ~ 56.19184*1
Sittotal ~ -0.38499*1
Icrtmean ~ -31.88813*1
Scrtmean ~ -0.44324*1

# covariances
IG ~~ SG
Ivis ~~ Svis
Imem ~~ Smem
Ispeed ~~ Sspeed
'


bif_NC_task_cov_fx <- '
Imatreas ~~ -0.06642*Smatreas
Ilmtotal ~~ 0.03307*Slmtotal
Idigback ~~ -0.08441*Sdigback
Idigsym ~~ -0.21260*Sdigsym
Iittotal ~~ 0.00097*Sittotal

vpatotal_w2 ~~ 6.75331*lmtotal_w2
'
```

 # var_bif_NC || residual variances fixed at 0 (see measurement model)

3.3 Individual domain models (for supplementary analyses)

```
# Visuospatial
dom_visL_fx <- "
#domain parameters
Ivis =~ 1*Iblkdes + 0.93216*Imatreas + 0.38954*Ispantot
Svis =~ 1*Sblkdes + 0.81490*Smatreas + 0.49017*Sspantot

Iblkdes ~ 0*1
Sblkdes ~ 0*1
Imatreas ~ -2.46520*1
Smatreas ~ 0.06075*1
Ispantot ~ 8.17392*1
Sspantot ~ 0.02196*1
Ivis ~ 17.04436*1
Svis ~ -0.24698*1

#negative lv variances at 0
Sspantot ~~ 0*Sspantot

# covariances between parameters (not the fixed ones)
Imatreas ~~ 0.00051*Smatreas
Iblkdes ~~ -0.06360*Sblkdes
Ivis ~~ Svis
"
```

```
# Memory
dom_memL_fx <- '
#Domain parameters
Imem =~ 1*Ilmtotal + 1.43596*Ivpatotal + 0.68896*Idigback
Smem =~ 1*Slmtotal + 1.28890*Svpatotal + 0.28354*Sdigback

Ilmtotal ~ 0*1
Slmtotal ~ 0*1
Ivpatotal ~ -8.29597*1
Svpatotal ~ -0.09392*1
Idigback ~ 6.78607*1
Sdigback ~ -0.16222*1
Imem ~ 24.28297*1
Smem ~ -0.11742*1

# negative variances fixed at 0
Slmtotal  ~~ 0*Slmtotal

#estimate covariance within task parameters
Ivpatotal ~~ 0.10839*Svpatotal
Idigback ~~ -0.12994*Sdigback
Imem ~~ Smem
'
# Speed
dom_speL_fx <- '
#Domain parameters
Ispeed =~ 1*Iittotal + 1.83967*Idigsym + 1.74383*Isymsear + 1.08968*Icrtmean
Sspeed =~ 1*Sittotal + 1.15276*Sdigsym + 1.08326*Ssymsear + 1.02040*Scrtmean

Iittotal ~ 0*1
Sittotal ~ 0*1
Isymsear ~ -72.88260*1
Ssymsear ~ 0.04588*1
Idigsym ~ -74.69080*1
Sdigsym ~ -0.01646*1
Icrtmean ~ -93.11872*1
Scrtmean ~ -0.04997*1
Ispeed ~ 56.18920*1
Sspeed ~ -0.38091*1

#estimate covariance within task parameters
Isymsear ~~ 0.04337*Ssymsear
Idigsym ~~ -0.23396*Sdigsym
Iittotal ~~ -0.00384*Sittotal
Icrtmean ~~ 0.05624*Scrtmean
Ispeed ~~ Sspeed
'
```

4. Estimating associations between cognitive change from ages 11 to 70 and ages 70 to 82.

Note

- Standardized CI and p-values were extracted using Lavaan function: *standardizedsolution(fit, "std.all")*
- Significance value was adjusted for multiple comparisons using the function: *p.adjust(pvalue, method = "fdr")*

```
#-----------------------------------------------------------------------
### General and domain-specific level and slope (from bifactor model)
#-----------------------------------------------------------------------

resAI_bifAll_ses11 <- "
# add predictors
IG + Ivis + Imem + Ispeed + SG + Svis + Smem + Sspeed ~ res_w1A + gnd + resgndA +
mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 + yrsedu_w1
"
# bif_NC_fx || fixed loadings and intercepts
# bif_NC_task_cov_fx || task covariances var_bif_NC ||
# variances fixed at 0

fitBifNC_fx.pAI_ses11 <- lavaan(model = c(pgmodel1, pgmodel2,
    pgmodel3, pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, bif_NC_fx, bif_NC_task_cov_fx, var_bif_NC,
    resAI_bifAll_ses11), dset_mod, missing = "ml.x", fixed.x = T,
    meanstructure = T, int.ov.free = F, int.lv.free = T, auto.fix.first = T,
    auto.fix.single = T, auto.var = T, auto.cov.lv.x = F, auto.efa = T,
    auto.th = T, auto.delta = T, auto.cov.y = F)



#-----------------------------------------------------------------------
### Individual domain models
#-----------------------------------------------------------------------

### Visuospatial
resAI_vis_ses11 <- "
# add predictors
Ivis ~ res_w1A + gnd + resgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
Svis ~ res_w1A + gnd + resgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
"
fitVis_fx.pAI_ses11 <- growth(model = c(pgmodel1, pgmodel2, pgmodel3,
    dom_visL_fx, resAI_vis_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)
```

```
### Memory
resAI_mem_ses11 <- "
# add predictor
Imem ~ res_w1A + gnd + resgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
Smem ~ res_w1A + gnd + resgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
"
fitMem_fx.pAI_ses11 <- growth(model = c(pgmodel7, pgmodel8, pgmodel9,
    dom_memL_fx, resAI_mem_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)

### Speed
resAI_spe_ses11 <- "
# add predictor
Ispeed ~ res_w1A + gnd + resgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
Sspeed ~ res_w1A + gnd + resgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
"
fitSpe_fx.pAI_ses11 <- growth(model = c(pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, dom_speL_fx, resAI_spe_ses11), dset_mod,
    missing = "ml.x", fixed.x = T)
```

4.1 FDR correction for multiple comparisons

```
ResAI_NC_coeff <- bind_rows
select(standardizedsolution(fitBifNC_fx.pAI_ses11, "std.all")[c(199:262), ],
    lhs:rhs, est.std, ci.lower, ci.upper, pvalue),
select(standardizedsolution(fitVis_fx.pAI_ses11, "std.all")[c(49:64), ], lhs:rhs,
    est.std, ci.lower, ci.upper, pvalue),
select(standardizedsolution(fitMem_fx.pAI_ses11, "std.all")[c(49:64), ], lhs:rhs,
    est.std, ci.lower, ci.upper, pvalue),
select(standardizedsolution(fitSpe_fx.pAI_ses11, "std.all")[c(64:79), ], lhs:rhs,
    est.std, ci.lower, ci.upper, pvalue), )

ResAI_NC_fdrValue <- select(ResAI_NC_coeff, pvalue) %>%
    unlist() %>%
    p.adjust(method = "fdr")

ResAI_NC_coeff$fdr_value <- ResAI_NC_fdrValue
ResAI_NC_coeff$ci <- paste0("[", round(ResAI_NC_coeff$ci.lower,
    2), ", ", round(ResAI_NC_coeff$ci.upper, 2), "]")
```

4.2 Follow-up: Cognitive Change vs. Age-70 cognitive level

To examine the individual effects of baseline level at age 70 and cognitive change from age 11 to 70), we fitted a multiple regression model with general cognitive decline from 70 to 82 as a dependent variable and the FOCUS g baseline level and change between ages 11 and 70 as simultaneous predictors of slope. We included our covariates set.

Note: As in the previous regression model, factor loadings, intercepts and low-level covariances are fixed at the values estimated from the measurement model. The only exception is the g intercept - g slope covariance (which will be replaced by a regression)

```
# parameters from the bifactor model, no I~~S covariance

bif_NC_regr_fx <- '
# Intercepts
IG =~ 3.22117*Imatreas + 3.35180*Iblkdes + 1.63358*Ispantot + 3.63190*Ivpatotal +
2.69092*Ilmtotal + 3.49043*Idigback + 4.26303*Isymsear + 3.62410*Idigsym +
2.39926*Iittotal + 2.15864*Icrtmean
Ivis =~ 1.03213*Imatreas + 2.99962*Iblkdes + 0.10452*Ispantot
Imem =~ 5.32985*Ivpatotal + 3.20082*Ilmtotal + 1.07717*Idigback
Ispeed =~ 2.32133*Isymsear + 3.48882*Idigsym + 1.24496*Iittotal + 1.88752*Icrtmean

# Slopes
SG =~ 0.13128*Smatreas + 0.14082*Sblkdes + 0.06629*Sspantot + 0.39570*Svpatotal +
0.33320*Slmtotal + 0.11145*Sdigback + 0.29210*Ssymsear + 0.30545*Sdigsym +
0.28762*Sittotal + 0.30121*Scrtmean
Svis =~ -0.00992*Smatreas + -0.12415*Sblkdes + -0.02019*Sspantot
Smem =~ 0.47940*Svpatotal + 0.28272*Slmtotal + 0.05782*Sdigback
Sspeed =~ 0.10067*Ssymsear + 0.04327*Sdigsym + 0.07518*Sittotal + -
0.11115*Scrtmean

# Orthogonal factors
IG ~~ 0*Ivis
IG ~~ 0*Imem
IG ~~ 0*Ispeed

SG ~~ 0*Svis
SG ~~ 0*Smem
SG ~~ 0*Sspeed

#lv as scaling reference: var=1. int=0
IG ~~ 1*IG
Ivis ~~ 1*Ivis
Imem ~~ 1*Imem
Ispeed ~~ 1*Ispeed
SG ~~ 1*SG
Svis ~~ 1*Svis
Smem ~~ 1*Smem
Sspeed ~~ 1*Sspeed

IG ~ 0*1
Ivis ~ 0*1
Imem ~ 0*1
Ispeed ~ 0*1
SG ~ 0*1
Svis ~ 0*1
Smem ~ 0*1
Sspeed ~ 0*1
```

```
Imatreas ~ 13.43359*1
Smatreas ~ -0.15882*1
Iblkdes ~ 17.05193*1
Sblkdes ~ -0.26405*1
Ispantot ~ 14.81883*1
Sspantot ~ -0.11024*1
Ivpatotal ~ 26.45673*1
Svpatotal ~ -0.24767*1
Ilmtotal ~ 24.23269*1
Slmtotal ~ -0.12454*1
Idigback ~ 23.51142*1
Sdigback ~ -0.21074*1
Isymsear ~ 25.07959*1
Ssymsear ~ -0.36990*1
Idigsym ~ 28.68297*1
Sdigsym ~ -0.45679*1
Iittotal ~ 56.19184*1
Sittotal ~ -0.38499*1
Icrtmean ~ -31.88813*1
Scrtmean ~ -0.44324*1

# covariances
# IG ~~ SG !!!
Ivis ~~ Svis
Imem ~~ Smem
Ispeed ~~ Sspeed
'


is_res_regr_ses11 <- '
SG ~ IG + res_w1A + gnd + resgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
'
# bif_NC_task_cov_fx || lower covariances
# var_bif_NC || variances fixed at 0

fitBifNC_is.pAI_ses11 <- lavaan(model = c(pgmodel1, pgmodel2, pgmodel3, pgmodel7,
pgmodel8, pgmodel9, pgmodel10, pgmodel11, pgmodel12, pgmodel13, bif_NC_regr_fx,
bif_NC_task_cov_fx, var_bif_NC, is_res_regr_ses11),
dset_mod,
missing = "ml.x", fixed.x = T, meanstructure = T, int.ov.free = F, int.lv.free =
T, auto.fix.first = T, auto.fix.single = T, auto.var = T, auto.cov.lv.x = F,
auto.efa = T, auto.th = T, auto.delta = T, auto.cov.y = F)
```

4.3 Follow-up: Effects of personal education

We did not detect any significant association between years of education and cognitive level at age 70, in apparent contrast with previous LBC and meta-analytical investigations (Lövdén et al., 2020; Ritchie et al., 2016). We conducted a follow up analysis to test if this result could depend on the simultaneous inclusion of childhood cognitive ability and cognitive change between 11

and 70 as model predictors, both of which correlate with education and might consequently attenuate its associations with cognitive differences at age 70.

```
# Removing res_w1A AND its interaction with sex
resAI_bifAll_edu1 <- "
# add predictor
IG + Ivis + Imem + Ispeed + SG + Svis + Smem + Sspeed ~ gnd + mht1947A +
fathclass_w1 + fatheduc_w1 + hmsonum_w1 + yrsedu_w1
"
# bif_NC_fx || fixed loadings and intercepts
# bif_NC_task_cov_fx || task covariances var_bif_NC ||
# variances fixed at 0

fitBifNC_fx.pA_edu1 <- lavaan(model = c(pgmodel1, pgmodel2, pgmodel3,
    pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11, pgmodel12,
    pgmodel13, bif_NC_fx, bif_NC_task_cov_fx, var_bif_NC, resAI_bifAll_edu1),
    dset_mod, missing = "ml.x", fixed.x = T, meanstructure = T,
    int.ov.free = F, int.lv.free = T, auto.fix.first = T, auto.fix.single = T,
    auto.var = T, auto.cov.lv.x = F, auto.efa = T, auto.th = T,
    auto.delta = T, auto.cov.y = F)


# Removing mht1947A
resAI_bifAll_edu2 <- "
# add predictor
IG + Ivis + Imem + Ispeed + SG + Svis + Smem + Sspeed ~ res_w1A + gnd + resgndA +
fathclass_w1 + fatheduc_w1 + hmsonum_w1 + yrsedu_w1
"
# bif_NC_fx || fixed loadings and intercepts
# bif_NC_task_cov_fx || task covariances var_bif_NC ||
# variances fixed at 0

fitBifNC_fx.pA_edu2 <- lavaan(model = c(pgmodel1, pgmodel2, pgmodel3,
    pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11, pgmodel12,
    pgmodel13, bif_NC_fx, bif_NC_task_cov_fx, var_bif_NC, resAI_bifAll_edu2),
    dset_mod, missing = "ml.x", fixed.x = T, meanstructure = T,
    int.ov.free = F, int.lv.free = T, auto.fix.first = T, auto.fix.single = T,
    auto.var = T, auto.cov.lv.x = F, auto.efa = T, auto.th = T,
    auto.delta = T, auto.cov.y = F)
```

---

5. Peak-based measures of cognitive change

5.1 Childhood to peak (i.e., NART)

```
#-----------------------------------------------------------------
### General and domain-specific level and slope (from bifactor model)
#-----------------------------------------------------------------
elcAI_bifAll_ses11 <- "
# add predictor
```

```
IG + Ivis + Imem + Ispeed + SG + Svis + Smem + Sspeed ~ elcA + gnd + elcgndA +
mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 + yrsedu_w1
"

fitBifNC_fx.eAI_ses11 <- lavaan(model = c(pgmodel1, pgmodel2,
    pgmodel3, pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, bif_NC_fx, bif_NC_task_cov_fx, var_bif_NC,
    elcAI_bifAll_ses11), dset_mod, missing = "ml.x", fixed.x = T,
    meanstructure = T, int.ov.free = F, int.lv.free = T, auto.fix.first = T,
    auto.fix.single = T, auto.var = T, auto.cov.lv.x = F, auto.efa = T,
    auto.th = T, auto.delta = T, auto.cov.y = F)

#----------------------------------------------------------------------
### Individual domain models
#----------------------------------------------------------------------

# Visuospatial
elcAI_vis_ses11 <- "
# add predictor
Ivis ~ elcA + gnd + elcgndA + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
Svis ~ elcA + gnd + elcgndA + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
"

fitVis_fx.eAI_ses11 <- growth(model = c(pgmodel1, pgmodel2, pgmodel3,
    dom_visL_fx, elcAI_vis_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)


# Memory
elcAI_mem_ses11 <- "
# add predictor
Imem ~ elcA + gnd + elcgndA + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
Smem ~ elcA + gnd + elcgndA + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
"

fitMem_fx.eAI_ses11 <- growth(model = c(pgmodel7, pgmodel8, pgmodel9,
    dom_memL_fx, elcAI_mem_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)


# Speed
elcAI_spe_ses11 <- "
# add predictor
Ispeed ~ elcA + gnd + elcgndA + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1
+ yrsedu_w1
Sspeed ~ elcA + gnd + elcgndA + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1
+ yrsedu_w1
```

```
"
fitSpe_fx.eAI_ses11 <- growth(model = c(pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, dom_speL_fx, elcAI_spe_ses11), dset_mod,
    missing = "ml.x", fixed.x = T)
```

5.2 Peak (i.e., NART) to age 70

```
#-----------------------------------------------------------------------
### General and domain-specific level and slope (from bifactor model)
#-----------------------------------------------------------------------
mlcAI_bifAll_ses11 <- "
# add predictor
IG + Ivis + Imem + Ispeed + SG + Svis + Smem + Sspeed ~ mlc + gnd + mlcgnd +
mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 + yrsedu_w1
"

fitBifNC_fx.mAI_ses11 <- lavaan(model = c(pgmodel1, pgmodel2,
    pgmodel3, pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, bif_NC_fx, bif_NC_task_cov_fx, var_bif_NC,
    mlcAI_bifAll_ses11), dset_mod, missing = "ml.x", fixed.x = T,
    meanstructure = T, int.ov.free = F, int.lv.free = T, auto.fix.first = T,
    auto.fix.single = T, auto.var = T, auto.cov.lv.x = F, auto.efa = T,
    auto.th = T, auto.delta = T, auto.cov.y = F)


#-----------------------------------------------------------------------
### Individual domain models
#-----------------------------------------------------------------------

# Visuospatial
mlcAI_vis_ses11 <- "
# add predictor
Ivis ~ mlc + gnd + mlcgnd + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
Svis ~ mlc + gnd + mlcgnd + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
"

fitVis_fx.mAI_ses11 <- growth(model = c(pgmodel1, pgmodel2, pgmodel3,
    dom_visL_fx, mlcAI_vis_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)


# Memory
mlcAI_mem_ses11 <- "
# add predictor
Imem ~ mlc + gnd + mlcgnd + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
Smem ~ mlc + gnd + mlcgnd + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
"
fitMem_fx.mAI_ses11 <- growth(model = c(pgmodel7, pgmodel8, pgmodel9,
```

```
    dom_memL_fx, mlcAI_mem_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)


# Speed
mlcAI_spe_ses11 <- "
# add predictor
Ispeed ~ mlc + gnd + mlcgnd + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
Sspeed ~ mlc + gnd + mlcgnd + mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 +
yrsedu_w1
"
fitSpe_fx.mAI_ses11 <- growth(model = c(pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, dom_speL_fx, mlcAI_spe_ses11), dset_mod,
    missing = "ml.x", fixed.x = T)
```

---

6. Supplementary analyses

6.1 Cognitive change from age 11 to 70 as raw difference score

We calculated our main cognitive predictor (i.e., MHT change from ages 11–70) as a raw difference score, also accounting for change reliability depending on different plausible levels of MHT reliability.

There is no published period-free reliability coefficient for the MHT instrument, so, based on its psychometric properties and correlation with the validated Stanford-Binet scale, we used an approximate value of .90 to indicate good reliability and, separately, an approximate value of .80 for a more conservative model.

6.1.1 Identify participants with reliable change depending on MHT reliability

RCI = (x2 - x1)/ SEdiff SEdiff = sqrt[2*SEm^2] = sqrt[2*SD1^2*(1-Rxx)] SEm = SD1*sqrt[(1-Rxx)] Rxx = test-retest reliability

```
# Compute SE of the difference (-> SE of measurement and then SE of the difference)
SEdiff_80 <- sqrt((sd(data2$mht1947_o, na.rm = T)^2) * 0.4)
SEdiff_90 <- sqrt((sd(data2$mht1947_o, na.rm = T)^2) * 0.2)

# Compute RCI for different levels of reliability Using raw score difference
data2 <- mutate(data2, RCI_80 = delta_w1/SEdiff_80, RCI_90 = delta_w1/SEdiff_90,
    reliable = ifelse(abs(RCI_80) >= 1.96, 2, ifelse(abs(RCI_90) >=
        1.96, 1, 0)))

# For any level of reliability, all observations of that same level OR HIGHER are
reliable.
# E.g. if Rxx = .90 >=
# 1.96 (reliable = 1), then all observations tagged 1 OR 2
# are reliable
sum(data2$reliable == 2, na.rm = T)
```

```
sum(data2$reliable >= 1, na.rm = T)

range(abs(data2[data2$reliable == 2, "delta_w1"]), na.rm = T)
range(abs(data2[data2$reliable >= 1, "delta_w1"]), na.rm = T)
```

6.1.2 Full sample

```
#-----------------------------------------------------------------------
### General and domain-specific level and slope (from bifactor model)
#-----------------------------------------------------------------------
deltaAI_bifAll_ses11 <- "
# add predictor
IG + Ivis + Imem + Ispeed + SG + Svis + Smem + Sspeed ~ delta_w1A + gnd + delgndA
+ mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 + yrsedu_w1
"
# bif_NC_fx || fixed loadings and intercepts
# bif_NC_task_cov_fx || task covariances var_bif_NC ||
# variances fixed at 0

fitBifNC_fx.dAI_ses11 <- lavaan(model = c(pgmodel1, pgmodel2,
    pgmodel3, pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, bif_NC_fx, bif_NC_task_cov_fx, var_bif_NC,
    deltaAI_bifAll_ses11), dset_mod, missing = "ml.x", fixed.x = T,
    meanstructure = T, int.ov.free = F, int.lv.free = T, auto.fix.first = T,
    auto.fix.single = T, auto.var = T, auto.cov.lv.x = F, auto.efa = T,
    auto.th = T, auto.delta = T, auto.cov.y = F)


#-----------------------------------------------------------------------
### Individual domain models
#-----------------------------------------------------------------------

# Visuospatial
deltaAI_vis_ses11 <- "
# add predictor
Ivis ~ delta_w1A + gnd + delgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
Svis ~ delta_w1A + gnd + delgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
"

fitVis_fx.dAI_ses11 <- growth(model = c(pgmodel1, pgmodel2, pgmodel3,
    dom_visL_fx, deltaAI_vis_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)


# Memory
deltaAI_mem_ses11 <- "
# add predictor
Imem ~ delta_w1A + gnd + delgndA  + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
```

```
Smem ~ delta_w1A + gnd + delgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
"
fitMem_fx.dAI_ses11 <- growth(model = c(pgmodel7, pgmodel8, pgmodel9,
    dom_memL_fx, deltaAI_mem_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)


# Speed
deltaAI_spe_ses11 <- "
# add predictor
Ispeed ~ delta_w1A + gnd + delgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
Sspeed ~ delta_w1A + gnd + delgndA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
"
fitSpe_fx.dAI_ses11 <- growth(model = c(pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, dom_speL_fx, deltaAI_spe_ses11), dset_mod,
    missing = "ml.x", fixed.x = T)
```

6.1.3 Assuming MHT reliability = .90

Dataset

We re-scaled or re-computed variables to account for the smaller dataset

```
dset_mod_rel <- mutate(
  filter(data2,reliable >= 1), #include only the reliable observations

  # rescale / recompute on the sub-sample
  agedays_w1C = scale(agedays_w1, center = T, scale = F),
  agedays_w2C = scale(agedays_w2, center = T, scale = F),
  agedays_w3C = scale(agedays_w3, center = T, scale = F),
  agedays_w4C = scale(agedays_w4, center = T, scale = F),
  agedays_w5C = scale(agedays_w5, center = T, scale = F),
  gnd = scale(sex, center = T, scale = F),

  delta_w1A = residuals(lm(delta_w1 ~ agedays_SMS, na.action= na.exclude)),
  delta_w1AA = residuals(lm(delta_w1 ~ agedays_SMS+agedays_w1, na.action=
na.exclude)),
  delgndA = delta_w1A * gnd,
  delgndAA = delta_w1AA * gnd,

  # small or large variance
  blkdes_w1 = blkdes_w1/2,
  blkdes_w2 = blkdes_w2/2,
  blkdes_w3 = blkdes_w3/2,
  blkdes_w4 = blkdes_w4/2,
  blkdes_w5 = blkdes_w5/2,
  vftot_w1 = vftot_w1/2,
  vftot_w2 = vftot_w2/2,
  vftot_w3 = vftot_w3/2,
```

```
  vftot_w4 = vftot_w4/2,
  vftot_w5 = vftot_w5/2,
  lmtotal_w1 = lmtotal_w1/3,
  lmtotal_w2 = lmtotal_w2/3,
  lmtotal_w3 = lmtotal_w3/3,
  lmtotal_w4 = lmtotal_w4/3,
  lmtotal_w5 = lmtotal_w5/3,
  digback_w1 = 3*digback_w1,
  digback_w2 = 3*digback_w2,
  digback_w3 = 3*digback_w3,
  digback_w4 = 3*digback_w4,
  digback_w5 = 3*digback_w5,
  digsym_w1 = digsym_w1/2,
  digsym_w2 = digsym_w2/2,
  digsym_w3 = digsym_w3/2,
  digsym_w4 = digsym_w4/2,
  digsym_w5 = digsym_w5/2,
  ittotal_w1 = ittotal_w1/2,
  ittotal_w2 = ittotal_w2/2,
  ittotal_w3 = ittotal_w3/2,
  ittotal_w4 = ittotal_w4/2,
  ittotal_w5 = ittotal_w5/2,
  crtmean_w1 = -50 * crtmean_w1,
  crtmean_w2 = -50 * crtmean_w2,
  crtmean_w3 = -50 * crtmean_w3,
  crtmean_w4 = -50 * crtmean_w4,
  crtmean_w5 = -50 * crtmean_w5,
)
```

Measurement models

The **measurement models** were fit on the "reliable-change" subsample and the new parameter estimates (i.e., for factor loadings, intercepts and low-level covariances) were fixed to aid the convergence of the regression model. The parameter estimates on the reliable-change subsample differed only slightly from those obtained on the full sample

```
#-------------------------------------------------------------------
### General and domain-specific level and slope (from bifactor model)
#-------------------------------------------------------------------
Rbif_NC_fx <- '
# Intercepts
IG =~ 3.09790*Imatreas + 3.19361*Iblkdes + 1.45627*Ispantot + 3.35546*Ivpatotal +
2.19937
*Ilmtotal + 2.89385*Idigback + 3.94474*Isymsear + 3.27727*Idigsym +
2.04316*Iittotal + 1.77763*Icrtmean
Ivis =~ 0.73090*Imatreas + 2.94698*Iblkdes + 0.18530*Ispantot
Imem =~ 5.73571*Ivpatotal + 2.86734*Ilmtotal + 1.08201*Idigback
Ispeed =~ -2.33401*Isymsear + -3.53925*Idigsym + -0.82020*Iittotal + -
1.55752*Icrtmean

# Slopes
```

```
SG =~ 0.11161*Smatreas + 0.12607*Sblkdes + 0.06016*Sspantot + 0.37655*Svpatotal +
0.32286
*Slmtotal + 0.09540*Sdigback + 0.22755*Ssymsear + 0.28270*Sdigsym +
0.22743*Sittotal + 0.29983*Scrtmean
Svis =~ -0.00664*Smatreas + -0.14006*Sblkdes + -0.02117*Sspantot
Smem =~ 0.46619*Svpatotal + 0.27382*Slmtotal + 0.03228*Sdigback
Sspeed =~ -0.11067*Ssymsear + -0.12551*Sdigsym + -0.01653*Sittotal +
0.03746*Scrtmean

# Orthogonal factors
IG ~~ 0*Ivis
IG ~~ 0*Imem
IG ~~ 0*Ispeed

SG ~~ 0*Svis
SG ~~ 0*Smem
SG ~~ 0*Sspeed

#lv as scaling reference: var=1. int=0
IG ~~ 1*IG
Ivis ~~ 1*Ivis
Imem ~~ 1*Imem
Ispeed ~~ 1*Ispeed
SG ~~ 1*SG
Svis ~~ 1*Svis
Smem ~~ 1*Smem
Sspeed ~~ 1*Sspeed

IG ~ 0*1
Ivis ~ 0*1
Imem ~ 0*1
Ispeed ~ 0*1
SG ~ 0*1
Svis ~ 0*1
Smem ~ 0*1
Sspeed ~ 0*1

Imatreas ~ 13.46032*1
Smatreas ~ -0.16036*1
Iblkdes ~ 16.91373*1
Sblkdes ~ -0.24103*1
Ispantot ~ 14.91176*1
Sspantot ~ -0.10811*1
Ivpatotal ~ 26.30199*1
Svpatotal ~ -0.21245*1
Ilmtotal ~ 23.90279*1
Slmtotal ~ -0.08512*1
Idigback ~ 23.14965*1
Sdigback ~ -0.18351*1
Isymsear ~ 24.94714*1
Ssymsear ~ -0.32694*1
```

```
Idigsym ~ 28.54474*1
Sdigsym ~ -0.42399*1
Iittotal ~ 56.54219*1
Sittotal ~ -0.36508*1
Icrtmean ~ -31.70902*1
Scrtmean ~ -0.42159*1

# covariances
IG ~~ SG
Ivis ~~ Svis
Imem ~~ Smem
Ispeed ~~ Sspeed
'

Rbif_NC_task_cov_fx <- '
Imatreas ~~ -0.09975*Smatreas
Ilmtotal ~~ 0.05026*Slmtotal
Idigback ~~ -0.15292*Sdigback
Idigsym ~~ -0.20469*Sdigsym

vpatotal_w2 ~~  6.43510*lmtotal_w2 #different from the full sample
'
# var_bif_NCAA || residual variances fixed at 0


#------------------------------------------------------------------
### Individual domain models
#------------------------------------------------------------------

# Visuospatial
dom_visL_fxr <- '
#domain parameters
Ivis =~ 1*Imatreas + 1.08382*Iblkdes + 0.42602*Ispantot
Svis =~ 1*Sspantot + 2.09124*Sblkdes + 1.50511*Smatreas

Imatreas ~ 0*1
Sspantot ~ 0*1
Smatreas ~ 0.00416*1
Iblkdes ~ 2.32861*1
Sblkdes ~ -0.02034*1
Ispantot ~ 9.17622*1
Ivis ~ 13.45287*1
Svis ~ -0.10011*1

# negative lv variances at 0
Smatreas ~~ 0*Smatreas
Sspantot ~~ 0*Sspantot

# covariances between task parameters
Iblkdes ~~ -0.05329*Sblkdes
Ivis ~~ Svis
```

```
'

# Memory
dom_memL_fxr <-'
#Domain parameters
Imem =~ 1*Ilmtotal + 1.61680*Ivpatotal + 0.66173*Idigback
Smem =~ 1*Slmtotal + 1.34555*Svpatotal + 0.22175*Sdigback

#indicator as scaling reference: int=0
Ilmtotal ~ 0*1
Slmtotal ~ 0*1
Ivpatotal ~ -12.32260*1
Svpatotal ~ -0.09982*1
Idigback ~ 7.29166*1
Sdigback ~ -0.15344*1
Imem ~ 23.95713*1
Smem ~ -0.08599*1

# negative variances fixed at 0
Slmtotal  ~~ 0*Slmtotal

#estimate covariance within task parameters
Ivpatotal ~~ -0.04420*Svpatotal
Idigback ~~ -0.201*Sdigback
Imem ~~ Smem
'

# Speed
dom_speL_fxr <- '
#Domain parameters
Ispeed =~ 1*Isymsear + 0.48712*Iittotal + 1.03298*Idigsym + 0.55364*Icrtmean
Sspeed =~ 1*Ssymsear + 0.92187*Sittotal + 1.17818*Sdigsym + 1.13259*Scrtmean

#indicator as scaling reference: loading=1. int=0
Isymsear ~ 0*1
Ssymsear ~ 0*1
Idigsym ~ 2.74198*1
Sdigsym ~ -0.03854*1
Iittotal ~ 44.37380*1
Sittotal ~ -0.06060*1
Icrtmean ~ -45.55817*1
Scrtmean ~ -0.04487*1
Ispeed ~ 24.97077*1
Sspeed ~ -0.32782*1

#negative variances
Ssymsear ~~ 0*Ssymsear
Sittotal ~~ 0*Sittotal

#estimate covariance within task parameters
Idigsym ~~ -0.30492*Sdigsym
```

```
Icrtmean ~~ -0.03897*Scrtmean
Ispeed ~~ Sspeed
'
```

Regression models

```
#-----------------------------------------------------------------------
### General and domain-specific level and slope (from bifactor model)
#-----------------------------------------------------------------------
# Rbif_NC_fx || bif_NC fixed on reliable data
# Rbif_NC_task_cov_fx || bif_NC_task_cov fixed on reliable
# data var_bif_NCAA || variances fixed at 0 for reliable
# data deltaAI_bifAll_ses11 || delta & covariates
# predicting g + domains

RfitBifNC_fx.dAI_ses11 <- lavaan(model = c(pgmodel1, pgmodel2,
    pgmodel3, pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, Rbif_NC_fx, Rbif_NC_task_cov_fx, var_bif_NCAA,
    deltaAI_bifAll_ses11), dset_mod_rel, missing = "ml.x", fixed.x = T,
    meanstructure = T, int.ov.free = F, int.lv.free = T, auto.fix.first = T,
    auto.fix.single = T, auto.var = T, auto.cov.lv.x = F, auto.efa = T,
    auto.th = T, auto.delta = T, auto.cov.y = F)

#-----------------------------------------------------------------------
### Individual domain models
#-----------------------------------------------------------------------

# Visuospatial
RfitVis_fx.dAI_ses11 <- growth(model = c(pgmodel1, pgmodel2,
    pgmodel3, dom_visL_fxr, deltaAI_vis_ses11), dset_mod_rel,
    missing = "ml.x", fixed.x = T)

# Memory
RfitMem_fx.dAI_ses11 <- growth(model = c(pgmodel7, pgmodel8,
    pgmodel9, dom_memL_fxr, deltaAI_mem_ses11), dset_mod_rel,
    missing = "ml.x", fixed.x = T)

# Speed
RfitSpe_fx.dAI_ses11 <- growth(model = c(pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, dom_speL_fxr, deltaAI_spe_ses11), dset_mod_rel,
    missing = "ml.x", fixed.x = T)
```

6.1.4 Assuming MHT reliability = .80

Dataset

We re-scaled or re-computed variables to account for the smaller dataset

```
dset_mod_rel80 <- mutate(
  filter(data2,reliable >= 2), #include only the reliable observations

  # rescale / recompute on the sub-sample
  agedays_w1C = scale(agedays_w1, center = T, scale = F),
```

```
  agedays_w2C = scale(agedays_w2, center = T, scale = F),
  agedays_w3C = scale(agedays_w3, center = T, scale = F),
  agedays_w4C = scale(agedays_w4, center = T, scale = F),
  agedays_w5C = scale(agedays_w5, center = T, scale = F),
  gnd = scale(sex, center = T, scale = F),

  delta_w1A = residuals(lm(delta_w1 ~ agedays_SMS, na.action= na.exclude)),
  delta_w1AA = residuals(lm(delta_w1 ~ agedays_SMS+agedays_w1, na.action=
na.exclude)),
  delgndA = delta_w1A * gnd,
  delgndAA = delta_w1AA * gnd,

  # small or large variance (dset_mod)
  blkdes_w1 = blkdes_w1/2,
  blkdes_w2 = blkdes_w2/2,
  blkdes_w3 = blkdes_w3/2,
  blkdes_w4 = blkdes_w4/2,
  blkdes_w5 = blkdes_w5/2,
  vftot_w1 = vftot_w1/2,
  vftot_w2 = vftot_w2/2,
  vftot_w3 = vftot_w3/2,
  vftot_w4 = vftot_w4/2,
  vftot_w5 = vftot_w5/2,
  lmtotal_w1 = lmtotal_w1/3,
  lmtotal_w2 = lmtotal_w2/3,
  lmtotal_w3 = lmtotal_w3/3,
  lmtotal_w4 = lmtotal_w4/3,
  lmtotal_w5 = lmtotal_w5/3,
  digback_w1 = 3*digback_w1,
  digback_w2 = 3*digback_w2,
  digback_w3 = 3*digback_w3,
  digback_w4 = 3*digback_w4,
  digback_w5 = 3*digback_w5,
  digsym_w1 = digsym_w1/2,
  digsym_w2 = digsym_w2/2,
  digsym_w3 = digsym_w3/2,
  digsym_w4 = digsym_w4/2,
  digsym_w5 = digsym_w5/2,
  ittotal_w1 = ittotal_w1/2,
  ittotal_w2 = ittotal_w2/2,
  ittotal_w3 = ittotal_w3/2,
  ittotal_w4 = ittotal_w4/2,
  ittotal_w5 = ittotal_w5/2,
  crtmean_w1 = -50 * crtmean_w1,
  crtmean_w2 = -50 * crtmean_w2,
  crtmean_w3 = -50 * crtmean_w3,
  crtmean_w4 = -50 * crtmean_w4,
  crtmean_w5 = -50 * crtmean_w5,
)

length(dset_mod_rel80$lbc36no)/length(dset_mod$lbc36no) # 534 48.95%
```

Regression models

```
#-----------------------------------------------------------------
### General and domain-specific level and slope (from bifactor model)
#-----------------------------------------------------------------

# Rbif_NC_fx || bif_NC fixed on reliable data
# Rbif_NC_task_cov_fx || bif_NC_task_cov fixed on reliable
# data var_bif_NCAA || variances fixed at 0 for reliable
# data deltaAI_bifAll_ses11 || delta predicting g + domains

RfitBifNC_fx.dAI80_ses11 <- lavaan(model = c(pgmodel1, pgmodel2,
    pgmodel3, pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, Rbif_NC_fx, Rbif_NC_task_cov_fx, var_bif_NCAA,
    deltaAI_bifAll_ses11), dset_mod_rel80, missing = "ml.x",
    fixed.x = T, meanstructure = T, int.ov.free = F, int.lv.free = T,
    auto.fix.first = T, auto.fix.single = T, auto.var = T, auto.cov.lv.x = F,
    auto.efa = T, auto.th = T, auto.delta = T, auto.cov.y = F)

#-----------------------------------------------------------------
### Individual domain models
#-----------------------------------------------------------------
# Visuospatial
RfitVis_fx.dAI80_ses11 <- growth(model = c(pgmodel1, pgmodel2,
    pgmodel3, dom_visL_fxr, deltaAI_vis_ses11), dset_mod_rel80,
    missing = "ml.x", fixed.x = T)

# Memory
RfitMem_fx.dAI80_ses11 <- growth(model = c(pgmodel7, pgmodel8,
    pgmodel9, dom_memL_fxr, deltaAI_mem_ses11), dset_mod_rel80,
    missing = "ml.x", fixed.x = T)

# Speed
RfitSpe_fx.dAI80_ses11 <- growth(model = c(pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, dom_speL_fxr, deltaAI_spe_ses11), dset_mod_rel80,
    missing = "ml.x", fixed.x = T)
```

6.2 Age-adjusted models

Even though the data benefited from a narrow age range, there were small age differences for each assessment wave in older age. To ensure that these age differences did not substantially impact our results, we fitted a second version of the cognitive measurement model, covarying the observed task scores with mean-centered age in days at the time of assessment.

6.2.1 Measurement models

New **measurement models** including age covariates were fit and the new parameter estimates (i.e., for factor loadings, intercepts and low-level covariances) were fixed to aid the convergence of the regression model.

Parameters were extracted using the Lavaan function partable(fit) and rounding to 5 significant figures

```
#------------------------------------------------------------------
### General and domain-specific level and slope (from bifactor model)
#------------------------------------------------------------------
bif_NCAA_fx <- '
# Intercepts
IG =~ 3.18439*Imatreas + 3.30923*Iblkdes + 1.60986*Ispantot + 3.52164*Ivpatotal +
2.55220*Ilmtotal + 3.39854*Idigback + 4.12840*Isymsear + 3.50329*Idigsym +
2.38249*Iittotal + 2.09378*Icrtmean
Ivis =~ 1.01592*Imatreas + 2.98562*Iblkdes + 0.09534*Ispantot
Imem =~ 5.27938*Ivpatotal + 3.35199*Ilmtotal + 1.06368*Idigback
Ispeed =~ 2.28874*Isymsear + 3.47377*Idigsym + 1.24685*Iittotal + 1.88296*Icrtmean

# Slopes
SG =~ 0.13276*Smatreas + 0.14167*Sblkdes + 0.06625*Sspantot + 0.40005*Svpatotal +
0.33988*Slmtotal +0.11063*Sdigback + 0.29232*Ssymsear + 0.30742*Sdigsym +
0.28911*Sittotal + 0.30144*Scrtmean
Svis =~ 0.00685*Smatreas + 0.12308*Sblkdes + 0.01962*Sspantot
Smem =~ 0.47550*Svpatotal + 0.30069*Slmtotal + 0.05458*Sdigback
Sspeed =~ -0.09186*Ssymsear + -0.03358*Sdigsym + -0.09084*Sittotal +
0.11517*Scrtmean

# Orthogonal factors
IG ~~ 0*Ivis
IG ~~ 0*Imem
IG ~~ 0*Ispeed

SG ~~ 0*Svis
SG ~~ 0*Smem
SG ~~ 0*Sspeed

#lv as scaling reference: var=1. int=0
IG ~~ 1*IG
Ivis ~~ 1*Ivis
Imem ~~ 1*Imem
Ispeed ~~ 1*Ispeed
SG ~~ 1*SG
Svis ~~ 1*Svis
Smem ~~ 1*Smem
Sspeed ~~ 1*Sspeed

IG ~ 0*1
Ivis ~ 0*1
Imem ~ 0*1
Ispeed ~ 0*1
SG ~ 0*1
Svis ~ 0*1
Smem ~ 0*1
Sspeed ~ 0*1

Imatreas ~ 13.43652*1
Smatreas ~ -0.15715*1
```

```
Iblkdes ~ 17.05467*1
Sblkdes ~ -0.26202*1
Ispantot ~ 14.82165*1
Sspantot ~ -0.10901*1
Ivpatotal ~ 26.56875*1
Svpatotal ~ -0.25271*1
Ilmtotal ~ 24.30612*1
Slmtotal ~ -0.12921*1
Idigback ~ 23.51317*1
Sdigback ~ -0.20766*1
Isymsear ~ 25.0765003*1
Ssymsear ~ -0.36413*1
Idigsym ~ 28.68432*1
Sdigsym ~ -0.45293*1
Iittotal ~ 56.18734*1
Sittotal ~ -0.38238*1
Icrtmean ~ -31.88689*1
Scrtmean ~ -0.44071*1

# covariances
IG ~~ SG
Ivis ~~ Svis
Imem ~~ Smem
Ispeed ~~ Sspeed

# age as covariates
blkdes_w1 ~ -0.00135*agedays_w1C
matreas_w1 ~ -0.00152*agedays_w1C
spantot_w1 ~ -0.00120*agedays_w1C
lmtotal_w1 ~ -0.00332*agedays_w1C
vpatotal_w1 ~ -0.00231*agedays_w1C
digback_w1 ~ -0.00257*agedays_w1C
symsear_w1 ~ -0.00392*agedays_w1C
digsym_w1 ~ -0.00256*agedays_w1C
ittotal_w1 ~ 0.00018*agedays_w1C
crtmean_w1 ~ -0.00108*agedays_w1C

blkdes_w2 ~ -0.00165*agedays_w2C
matreas_w2 ~ -0.00090*agedays_w2C
spantot_w2 ~ -0.00052*agedays_w2C
lmtotal_w2 ~ -0.00167*agedays_w2C
vpatotal_w2 ~ -0.00068*agedays_w2C
digback_w2 ~ -0.00142*agedays_w2C
symsear_w2 ~ -0.00167*agedays_w2C
digsym_w2 ~ -0.00248*agedays_w2C
ittotal_w2 ~ -0.00054*agedays_w2C
crtmean_w2 ~ -0.00147*agedays_w2C

blkdes_w3 ~ -0.00078*agedays_w3C
matreas_w3 ~ -0.00003*agedays_w3C
spantot_w3 ~ 0.00073*agedays_w3C
```

```
lmtotal_w3 ~ -0.00187*agedays_w3C
vpatotal_w3 ~ 0.00072*agedays_w3C
digback_w3 ~ -0.00048*agedays_w3C
symsear_w3 ~ -0.00247*agedays_w3C
digsym_w3 ~ -0.00239*agedays_w3C
ittotal_w3 ~ -0.00351*agedays_w3C
crtmean_w3 ~ -0.00102*agedays_w3C

blkdes_w4 ~ -0.00171*agedays_w4C
matreas_w4 ~ -0.00140*agedays_w4C
spantot_w4 ~ -0.00099*agedays_w4C
lmtotal_w4 ~ -0.00368*agedays_w4C
vpatotal_w4 ~ -0.00466*agedays_w4C
digback_w4 ~ -0.00255*agedays_w4C
symsear_w4 ~ -0.00283*agedays_w4C
digsym_w4 ~ -0.00167*agedays_w4C
ittotal_w4 ~ -0.00168*agedays_w4C
crtmean_w4 ~ -0.00284*agedays_w4C

blkdes_w5 ~ -0.00140*agedays_w5C
matreas_w5 ~ -0.00157*agedays_w5C
spantot_w5 ~ -0.00121*agedays_w5C
lmtotal_w5 ~ -0.00386*agedays_w5C
vpa_total_w5 ~ -0.00671*agedays_w5C
digback_w5 ~ -0.00375*agedays_w5C
symsear_w5 ~ -0.00290*agedays_w5C
digsym_w5 ~ -0.00293*agedays_w5C
ittotal_w5 ~ -0.00076*agedays_w5C
crtmean_w5 ~ -0.00357*agedays_w5C
'

bif_NC_task_covAA_fx <- '
Imatreas ~~ -0.06842*Smatreas
Ilmtotal ~~ 0.16558*Slmtotal
Idigback ~~ -0.07971*Sdigback
Idigsym ~~ -0.21940*Sdigsym
'

# var_bif_NCAA_2 || variances = 0



#-----------------------------------------------------------------------
### Individual domain models
#-----------------------------------------------------------------------

# Visuospatial
dom_visLAA_fx <- '
#domain parameters
Ivis =~ 1*Iblkdes + 0.93396*Imatreas + 0.38681*Ispantot
Svis =~ 1*Sblkdes + 0.83475*Smatreas + 0.50237*Sspantot
```

```
Iblkdes ~ 0*1
Sblkdes ~ 0*1
Imatreas ~ -2.49564*1
Smatreas ~ 0.06569*1
Ispantot ~ 8.22204*1
Sspantot ~ 0.02501*1
Ivis ~ 17.04946*1
Svis ~ -0.24556*1

#negative lv variances at 0
Sspantot ~~ 0*Sspantot

# covariances between task parameters (not the zero ones)
Imatreas ~~ -0.00023*Smatreas
Iblkdes ~~ -0.06808*Sblkdes
Ivis ~~ Svis

# age as covariates
blkdes_w1 ~ -0.00157*agedays_w1C
matreas_w1 ~ -0.00174*agedays_w1C
spantot_w1 ~ -0.00133*agedays_w1C

blkdes_w2 ~ -0.00189*agedays_w2C
matreas_w2 ~ -0.00115*agedays_w2C
spantot_w2 ~ -0.00066*agedays_w2C

blkdes_w3 ~ -0.00106*agedays_w3C
matreas_w3 ~ -0.00033*agedays_w3C
spantot_w3 ~ 0.00057*agedays_w3C

blkdes_w4 ~ -0.00200*agedays_w4C
matreas_w4 ~ -0.00171*agedays_w4C
spantot_w4 ~ -0.00115*agedays_w4C

blkdes_w5 ~ -0.00179*agedays_w5C
matreas_w5 ~ -0.00203*agedays_w5C
spantot_w5 ~ -0.00142*agedays_w5C
'

# Memory
dom_memLAA_fx <-'
#Domain parameters
Imem =~ 1*Ilmtotal + 1.46894*Ivpatotal + 0.68250*Idigback
Smem =~ 1*Slmtotal + 1.27272*Svpatotal + 0.27906*Sdigback

Ilmtotal ~ 0*1
Slmtotal ~ 0*1
Ivpatotal ~ -9.08316*1
Svpatotal ~ -0.09978*1
Idigback ~ 6.94741*1
```

```
Sdigback ~ -0.16074*1
Imem ~ 24.27913*1
Smem ~ -0.11293*1

# negative variances fixed at 0
Slmtotal  ~~ 0*Slmtotal

# covariances between task parameters (not the zero ones)
Ivpatotal ~~ 0.10048*Svpatotal
Idigback ~~ -0.11636*Sdigback
Imem ~~ Smem

# age as covariates
lmtotal_w1 ~ -0.00346*agedays_w1C
vpatotal_w1 ~ -0.00248*agedays_w1C
digback_w1 ~ -0.00288*agedays_w1C

lmtotal_w2 ~ -0.00180*agedays_w2C
vpatotal_w2 ~ -0.00085*agedays_w2C
digback_w2 ~ -0.00175*agedays_w2C

lmtotal_w3 ~ -0.00205*agedays_w3C
vpatotal_w3 ~ 0.00057*agedays_w3C
digback_w3 ~ -0.00083*agedays_w3C

lmtotal_w4 ~-0.00388*agedays_w4C
vpatotal_w4 ~ -0.00489*agedays_w4C
digback_w4 ~ -0.00308*agedays_w4C

lmtotal_w5 ~ -0.00404*agedays_w5C
vpa_total_w5 ~ -0.00703*agedays_w5C
digback_w5 ~ -0.00436*agedays_w5C
'



# Speed
dom_speLAA_fx <- '
#Domain parameters
Ispeed =~ 1*Iittotal + 1.81338*Idigsym + 1.70714*Isymsear + 1.07610*Icrtmean
Sspeed =~ 1*Sittotal + 1.18212*Sdigsym + 1.10048*Ssymsear + 1.03640*Scrtmean

Iittotal ~ 0*1
Sittotal ~ 0*1
Isymsear ~ -70.82161*1
Ssymsear ~ 0.05570*1
Idigsym ~ -73.20586*1
Sdigsym ~ -0.00454*1
Icrtmean ~ -92.34933*1
Scrtmean ~ -0.04466*1
Ispeed ~ 56.18506*1
Sspeed ~ -0.37799*1
```

```
# covariances between task parameters (not the zero ones)
Isymsear ~~ 0.03166*Ssymsear
Idigsym ~~ -0.23023*Sdigsym
Iittotal ~~ -0.00184*Sittotal
Icrtmean ~~ 0.05207*Scrtmean
Ispeed ~~ Sspeed

# age as covariates
symsear_w1 ~ -0.00410*agedays_w1C
digsym_w1 ~ -0.00263*agedays_w1C
ittotal_w1 ~ 0.00009*agedays_w1C
crtmean_w1 ~ -0.00110*agedays_w1C

symsear_w2 ~ -0.00184*agedays_w2C
digsym_w2 ~ -0.00256*agedays_w2C
ittotal_w2 ~ -0.00065*agedays_w2C
crtmean_w2 ~ -0.00150*agedays_w2C

symsear_w3 ~ -0.00265*agedays_w3C
digsym_w3 ~ -0.00249*agedays_w3C
ittotal_w3 ~ -0.00363*agedays_w3C
crtmean_w3 ~ -0.00109*agedays_w3C

symsear_w4 ~ -0.00296*agedays_w4C
digsym_w4 ~ -0.00174*agedays_w4C
ittotal_w4 ~ -0.00169*agedays_w4C
crtmean_w4 ~ -0.00288*agedays_w4C

symsear_w5 ~ -0.00303*agedays_w5C
digsym_w5 ~ -0.00305*agedays_w5C
ittotal_w5 ~ -0.00088*agedays_w5C
crtmean_w5 ~ -0.00366*agedays_w5C
'
```

6.2.2 Regression models

```
#-----------------------------------------------------------------------
### General and domain-specific level and slope (from bifactor model)
#-----------------------------------------------------------------------

resAAI_bifAll_ses11 <- "
# add predictor
IG + Ivis + Imem + Ispeed + SG + Svis + Smem + Sspeed ~ res_w1AA + gnd + resgndAA
+ mht1947A + fathclass_w1 + fatheduc_w1 + hmsonum_w1 + yrsedu_w1
"
# bif_NC_task_covAA_fx || task covariances var_bif_NCAA ||
# variances fixed at 0

fitBifNC_fx.pAAI_ses11 <- lavaan(model = c(pgmodel1, pgmodel2,
    pgmodel3, pgmodel7, pgmodel8, pgmodel9, pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, bif_NCAA_fx, bif_NC_task_covAA_fx,
```

```
    var_bif_NCAA, resAAI_bifAll_ses11), dset_mod, missing = "ml.x",
    fixed.x = T, meanstructure = T, int.ov.free = F, int.lv.free = T,
    auto.fix.first = T, auto.fix.single = T, auto.var = T, auto.cov.lv.x = F,
    auto.efa = T, auto.th = T, auto.delta = T, auto.cov.y = F)



#-----------------------------------------------------------------------
### Individual domain models
#-----------------------------------------------------------------------

# Visuospatial
resAAI_vis_ses11 <- "
# add predictor
Ivis ~ res_w1AA + gnd + resgndAA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
Svis ~ res_w1AA + gnd + resgndAA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
"

fitVis_fx.pAAI_ses11 <- growth(model = c(pgmodel1, pgmodel2,
    pgmodel3, dom_visLAA_fx, resAAI_vis_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)
fitmeasures(fitVis_fx.pAAI_ses11, c("cfi", "tli", "RMSEA", "SRMR"))
summary(fitVis_fx.pAAI_ses11, standardized = T)


# Memory
resAAI_mem_ses11 <- "
# add predictor
Imem ~ res_w1AA + gnd + resgndAA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
Smem ~ res_w1AA + gnd + resgndAA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
"
fitMem_fx.pAAI_ses11 <- growth(model = c(pgmodel7, pgmodel8,
    pgmodel9, dom_memLAA_fx, resAAI_mem_ses11), dset_mod, missing = "ml.x",
    fixed.x = T)


# Speed
resAAI_spe_ses11 <- "
# add predictor
Ispeed ~ res_w1AA + gnd + resgndAA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
Sspeed ~ res_w1AA + gnd + resgndAA + mht1947A + fathclass_w1 + fatheduc_w1 +
hmsonum_w1 + yrsedu_w1
"

fitSpe_fx.pAAI_ses11 <- growth(model = c(pgmodel10, pgmodel11,
    pgmodel12, pgmodel13, dom_speLAA_fx, resAAI_spe_ses11), dset_mod,
```

```
    missing = "ml.x", fixed.x = T)
```

---

7. Plots

7.1 Res_w1 density

```
windowsFonts(helvetica = windowsFont("TT Helvetica"))
ggplot(data = data2, aes(x = res_w1A)) + geom_density(color = "black") +
    scale_x_continuous(breaks = seq(-40, 10, 10)) + labs(x = "Residual Change",
    y = "Probability", title = NULL) + theme_light(base_size = 10)
```

7.2 G trajectories

```
# data: participant ID, wave reached, cognitive change from age 11 to 70 plus
individual estimates of baseline level and slope of general and domain-specific
abilities (predicted from the bifactor measurement model)
dataPlot <- cbind(select(data2, lbc36no, wave, res_w1A), lavPredict(fitBifNC,
    method = "regression", level = 2))

dataPlot <- mutate(dataPlot, res_w1A_quart = cut(res_w1A, quantile(res_w1A,
    na.rm = T), include.lowest = T, labels = c("q1", "q2", "q3",
    "q4")), xaxis = sample(c(1:12), size = nrow(dataPlot), replace = T))


# Select only participants with complete data
dP1 <- filter(dataPlot, !is.na(res_w1A) & !is.na(IG)) %>%
    select(lbc36no, wave, res_w1A, res_w1A_median, res_w1A_quart,
        IG, SG)

### Quartiles
ggplot(dP1) + geom_segment(aes(x = 0, xend = 13, y = 0, yend = SG *
    13), color = "gray", alpha = 0.2) + geom_segment(aes(x = 0,
    xend = 13, y = 0, yend = mean(dataPlot$SG, na.rm = T) * 13,
    color = "Sample Mean", linetype = "Sample Mean"), size = 1) +
    geom_segment(aes(x = 0, xend = 13, y = 0, yend = mean(dP1[dP1$res_w1A_quart ==
        "q1", "SG"]) * 13, color = "q1", linetype = "q1"), size = 1) +
    geom_segment(aes(x = 0, xend = 13, y = 0, yend = mean(dP1[dP1$res_w1A_quart ==
        "q2", "SG"]) * 13, color = "q2", linetype = "q2"), size = 1) +
    geom_segment(aes(x = 0, xend = 13, y = 0, yend = mean(dP1[dP1$res_w1A_quart ==
        "q3", "SG"]) * 13, color = "q3", linetype = "q3"), size = 1) +
    geom_segment(aes(x = 0, xend = 13, y = 0, yend = mean(dP1[dP1$res_w1A_quart ==
        "q4", "SG"]) * 13, color = "q4", linetype = "q4"), size = 1) +
    theme_light(base_family = "sans", base_size = 10) + coord_cartesian(xlim =
c(0,
    12), ylim = c(-20, 20)) + scale_x_continuous(breaks = seq(0,
    12, 3), labels = function(breaks) (70 + breaks), minor_breaks = seq(0,
    12, 1)) + scale_color_manual(name = "Cognitive change\nfrom 11 to 70",
    values = c(`Sample Mean` = "black", q1 = "#d7191c", q2 = "#4dac26",
        q3 = "#d01c8b", q4 = "#2b83ba")) + scale_linetype_manual(name = "Cognitive
change\nfrom 11 to 70",
```

```
    values = c(`Sample Mean` = "solid", q1 = "twodash", q2 = "dashed",
        q3 = "dotted", q4 = "longdash")) + labs(title = NULL,
    x = "Age", y = "g (arbitrary units)")
```