Latent Growth Models

A Course in `MplusAutomation`

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Lesson 10 preparation

Data sources:

1. The first 3 models utilize a public use data subset the *Longitudinal Survey of American Youth (LSAY)* See documentation here
2. The 4th model utilizes a public use data subset the *High School Longitudinal Study (HSLS)* See documentation here

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Load packages

```
library(gganimate)
library(tidyverse)
library(haven)
library(janitor)
library(MplusAutomation)
library(rhdf5)
library(here)
library(gt)
library(gtsummary)
library(semPlot)
```

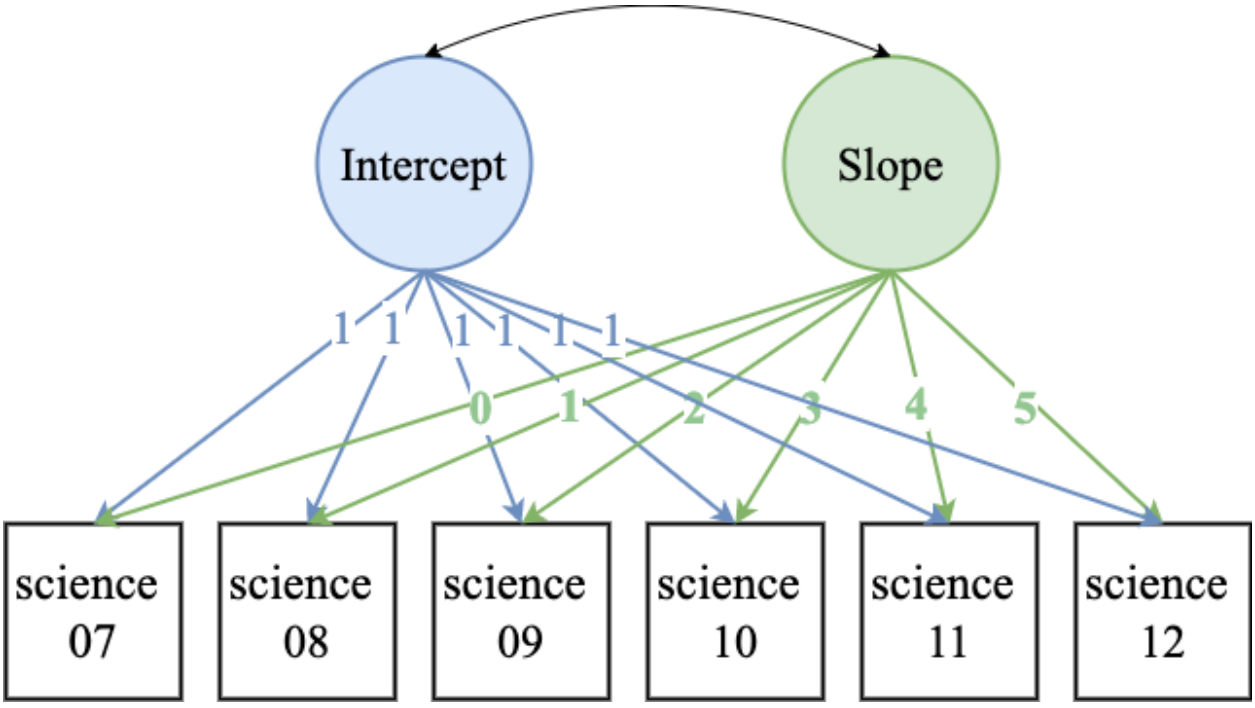
`LSAY` data example - `Math Scores` across 6 timepoints

Read in the `CSV` file

```
lsay <- read_csv("https://garberadamc.github.io/project-site/data/lsay_lab6_data.csv")
```

Take a look at `LSAY` repeated measures

Name	Labels
math_07	7th grade math score
math_08	8th grade math score
math_09	9th grade math score
math_10	10th grade math score
math_11	11th grade math score
math_12	12th grade math score



Model 1 - Latent growth model with `fixed time effects` (equal intervals)

```
m1_growth  <- mplusObject(

  TITLE = "m1 growth model fixed time scores",
```

```
  VARIABLE =
    "usevar =
    math_07-math_12; ",

  ANALYSIS =
    "estimator = ML" ,

  MODEL =
   "i s | math_07@0 math_08@1 math_09@2 math_10@3 math_11@4 math_12@5; " ,

  OUTPUT = "sampstat standardized;",

  PLOT = "type=plot3;
          series = math_07-math_12(*)",

  usevariables = colnames(lsay),
  rdata = lsay)

m1_growth_fit <- mplusModeler(m1_growth,
                      dataout=here("10-growth-models", "mplus_files", "lsay.dat"),
                      modelout=here("10-growth-models", "mplus_files", "m1_growth_lsay.inp"),
                      check=TRUE, run = TRUE, hashfilename = FALSE)
```

Load in the `mplus.R` functions

```
source(here("10-growth-models", "mplus.R.txt"))
```

```
## [1] "Loaded rhdf5 package"
```

Plotting using gh5 plot data generated by `Mplus`

1. View plots available for a given model
2. Generate plots using the `get.plot.___` function
3. Extract data and transform to tidy format
4. Plot with `ggplot`

```
mplus.view.plots(here("10-growth-models", "mplus_files", "m1_growth_lsay.gh5"))
```

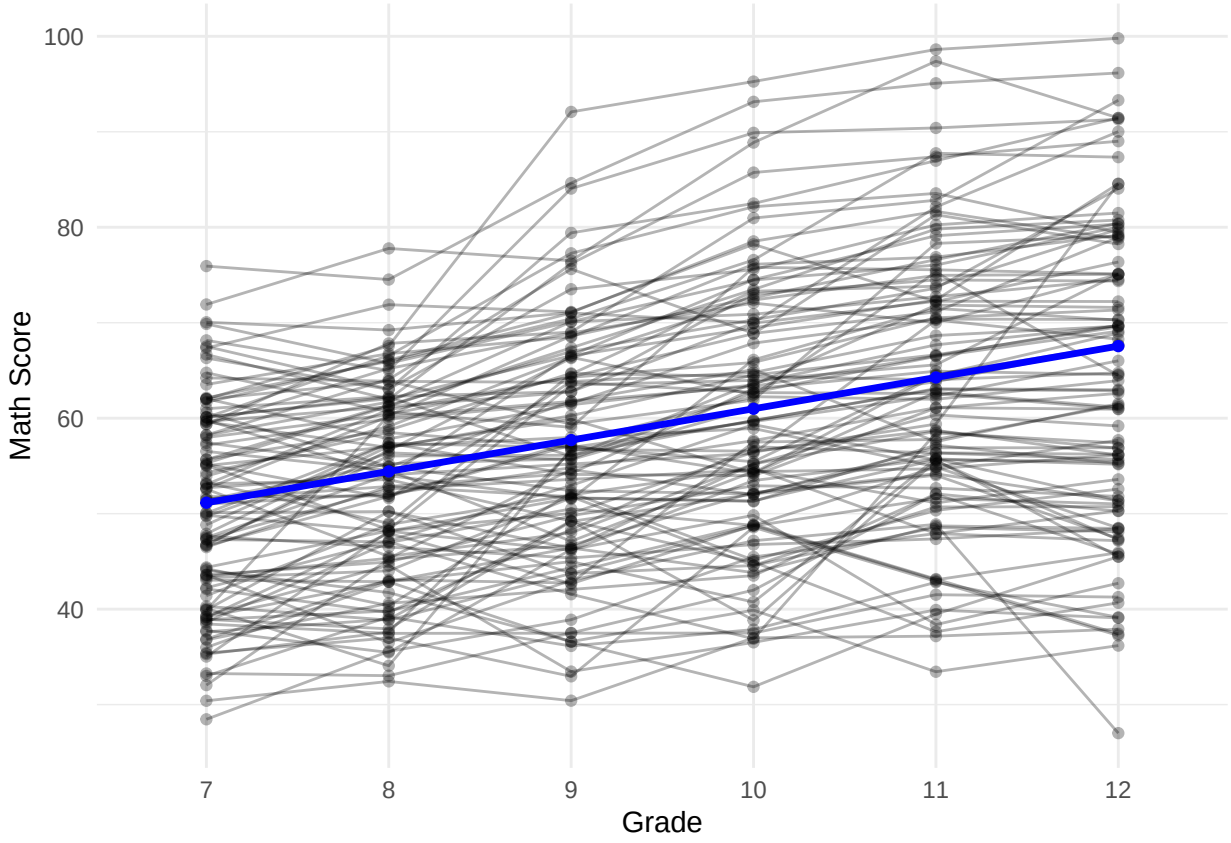
Prepare plot data

```
observed <- lsay %>%
  select(starts_with("math")) %>%
  rownames_to_column() %>%
  drop_na()

obs100 <- observed[1:100,]

plot_obs <- obs100 %>%
```

```
  pivot_longer(`math_07`:`math_12`, # The columns I'm gathering together
               names_to = "grade", # new column name for existing names
              values_to = "value") # new column name to store values

gradelevels <- colnames(observed[,2:7])

mean_est <- as.data.frame(
  mplus.get.estimated_means(here("10-growth-models", "mplus_files", "m1_growth_lsay.gh5"))) %>%
  mutate(grade = gradelevels)
```

Plot the model estimated means superimposted on the obserbed individual values

```
growth_plot <- ggplot() +
  geom_point(data = plot_obs, aes(x = grade, y = value, group = rowname), alpha = .3) +
  geom_line(data = plot_obs, aes(x = grade, y = value, group = rowname), alpha = .3) +
  geom_point(data=mean_est, aes(x=grade, y = V1), color = "Blue", size = 1.5) +
  geom_line(data=mean_est, aes(x=grade, y = V1, group = 1), color = "Blue", size = 1.2) +
  scale_x_discrete(labels = c("7", "8", "9", "10", "11", "12")) +
  labs(x="Grade", y="Math Score") +
  theme_minimal()

growth_plot
```




```
ggsave(here("10-growth-models", "figures", "spaghetti_p1.png"),
       height = 6, width = 8, dpi = "retina")
```

Animate the plot with {gganimate}

```
growth_plot +
  transition_states(rowname, transition_length = 1, state_length = 1) +
  shadow_mark(color = "Magenta", alpha = .3)
```

```
anim_save(here("10-growth-models", "figures", "spaghetti_plot.gif"),
          height = 6, width = 8, dpi = "retina")
```

Model 2 - Latent growth model with `freely estimated time scores` (level-shape model or latent basis model)

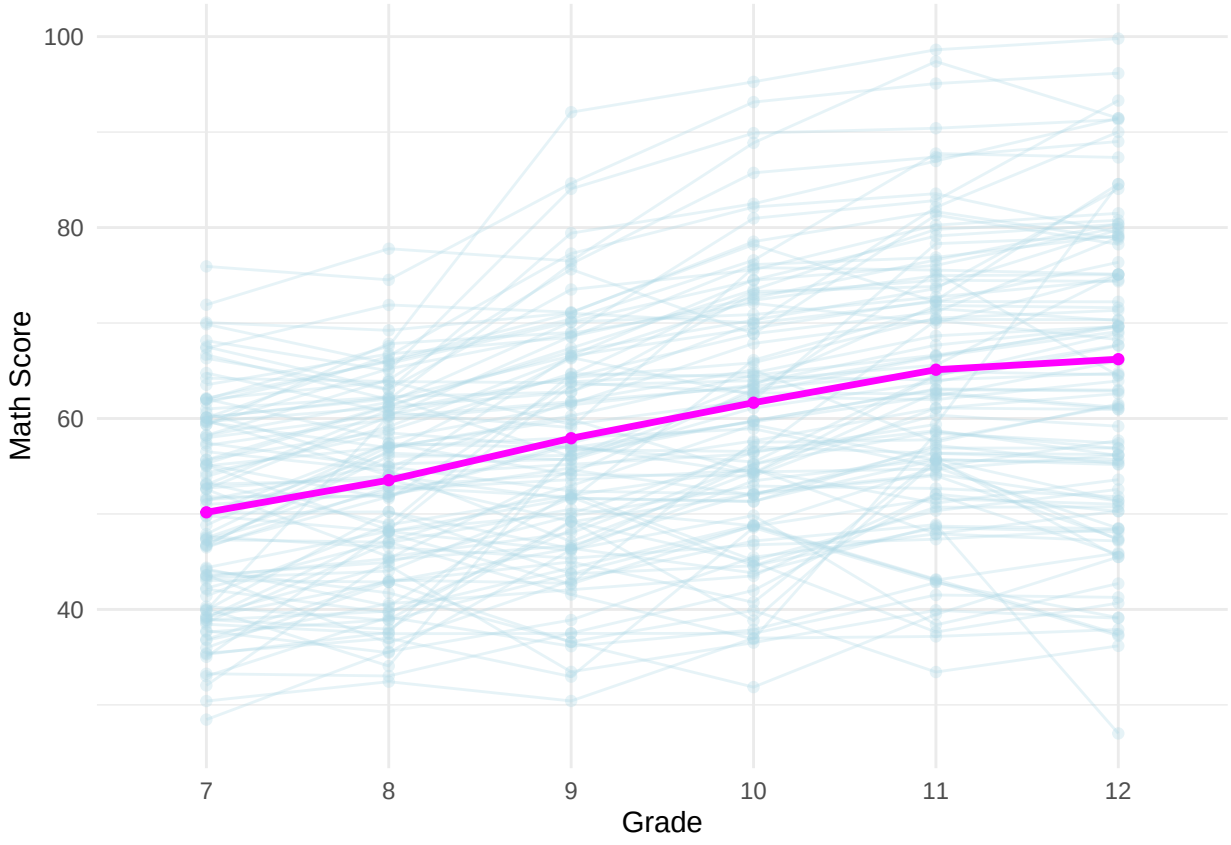
```
m2_growth  <- mplusObject(
  TITLE = "m2 growth model freely estimated time scores",
  VARIABLE =
    "usevar =
    math_07-math_12; ",

  ANALYSIS =
    "estimator = ML" ,

  MODEL =
   "i s | math_07@0 math_08@1 math_09* math_10* math_11* math_12*; " ,

  OUTPUT = "sampstat standardized;",

  PLOT = "type=plot3;
          series = math_07-math_12(*)",

  usevariables = colnames(lsay),
  rdata = lsay)

m2_growth_fit <- mplusModeler(m2_growth,
                      dataout=here("10-growth-models", "mplus_files", "lsay.dat"),
                      modelout=here("10-growth-models", "mplus_files", "m2_growth_lsay.inp"),
                      check=TRUE, run = TRUE, hashfilename = FALSE)
```

Prepare plot data

```
mean_est2 <- as.data.frame(
  mplus.get.estimated_means(here("10-growth-models", "mplus_files", "m2_growth_lsay.gh5"))) %>%
  mutate(grade = gradelevels)
```

Plot the model estimated means superimposted on the obserbed individual values

```
growth_plot <- ggplot() +
  geom_point(data = plot_obs, aes(x = grade, y = value, group = rowname),
             color = "lightblue", alpha = .3) +
  geom_line(data = plot_obs, aes(x = grade, y = value, group = rowname),
            color = "lightblue", alpha = .3) +
  geom_point(data=mean_est2, aes(x=grade, y = V1), color = "magenta", size = 1.5) +
  geom_line(data=mean_est2, aes(x=grade, y = V1, group = 1), color = "magenta", size = 1.2) +
  scale_x_discrete(labels = c("7", "8", "9", "10", "11", "12")) +
  labs(x="Grade", y="Math Score") +
  theme_minimal()

growth_plot
```



Model 3 - Latent growth model with `covariate and freely estimated time scores`

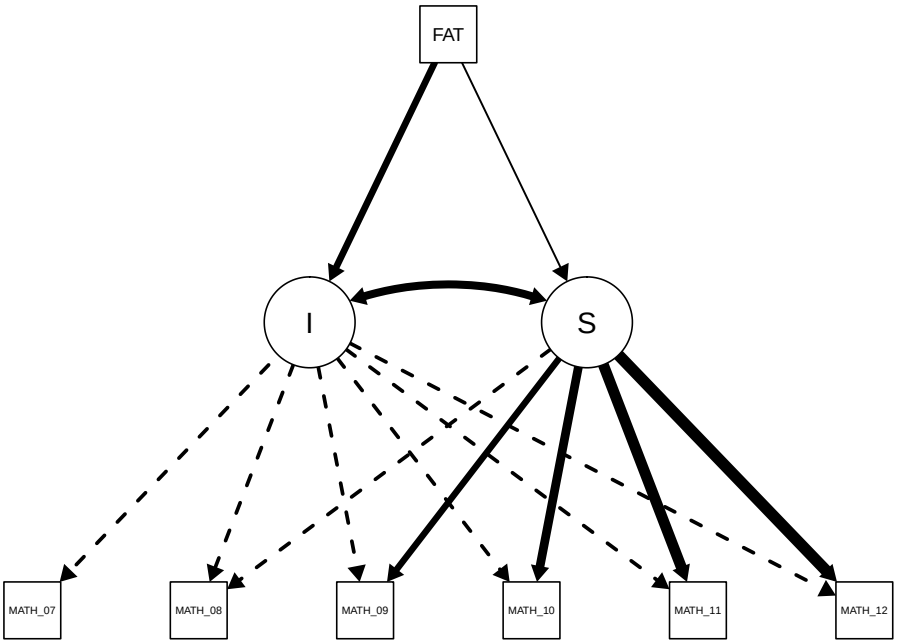
```
m3_growth  <- mplusObject(
  TITLE = "m3 growth model with covariate and freely estimated time scores",
  VARIABLE =
    "usevar =
    math_07-math_12 fathed; ",

  ANALYSIS =
    "estimator = ML" ,

  DEFINE = "center fathed (grandmean);",

  MODEL =
   "i s | math_07@0 math_08@1 math_09* math_10* math_11* math_12*;
    i s on fathed; " ,

  OUTPUT = "sampstat standardized;",

  PLOT = "type=plot3;
          series = math_07-math_12(*)",

  usevariables = colnames(lsay),
  rdata = lsay)

m3_growth_fit <- mplusModeler(m3_growth,
                      dataout=here("10-growth-models", "mplus_files", "lsay.dat"),
                      modelout=here("10-growth-models", "mplus_files", "m3_growth_lsay.inp"),
                      check=TRUE, run = TRUE, hashfilename = FALSE)
```

Check the path diagram of the model with {semPlot}

```
m3_output <- readModels(here("10-growth-models", "mplus_files", "m3_growth_lsay.out"))
```

```
## Reading model:  /Users/agarber/github/Quant-Fish-END/10-growth-models/mplus_files/m3_growth_lsay.out
```

```
semPaths(m3_output,  "est",
         intercepts=FALSE, residuals = FALSE, fade = FALSE,
         edge.color = "black",  edgeLabels = "")
```



HSLS data example - `Academic expectations`

```
hsls_rep <- read_csv(here("10-growth-models", "data", "hsls_rep_lab6.csv"))
```

Table. HSLS repeated measures

Question stem - `Highest level of education expected...`

Name	Labels	Levels
s1eduexp	9th grade (2009)	1 = less HS, 2 = HS, 3 = Bach, 5 = Master, 6 = Ph.D
s2eduexp	11th grade (2012)	1 = less HS, 2 = HS, 3 = Bach, 5 = Master, 6 = Ph.D
s4eduexp	3 years post high school (2016)	1 = less HS, 2 = HS, 3 = Bach, 5 = Master, 6 = Ph.D

Model 4 - Latent growth model with `categorical outcomes`

```
m4_growth  <- mplusObject(
  TITLE = "m4 growth model - HSLS ",

  VARIABLE =
    "usevar = s1eduexp-s4eduexp;
     categorical = s1eduexp-s4eduexp; !!! key difference !!!",

  ANALYSIS = "" ,

  MODEL =
   "! 0=09 1=10 2=11 3=12 | 4=13 5=14 6=15 7=16

    i s | s1eduexp@0 s2eduexp@3 s4eduexp@7;  ",

  OUTPUT = "sampstat standardized;",

  PLOT = "type=plot3;
          series = s1eduexp-s4eduexp(*);",

  usevariables = colnames(hsls_rep),
  rdata = hsls_rep)

m4_growth_fit <- mplusModeler(m4_growth,
                      dataout=here("10-growth-models", "mplus_files", "hsls_rep.dat"),
                      modelout=here("10-growth-models", "mplus_files", "m4_growth_hsls.inp"),
                      check=TRUE, run = TRUE, hashfilename = FALSE)
```

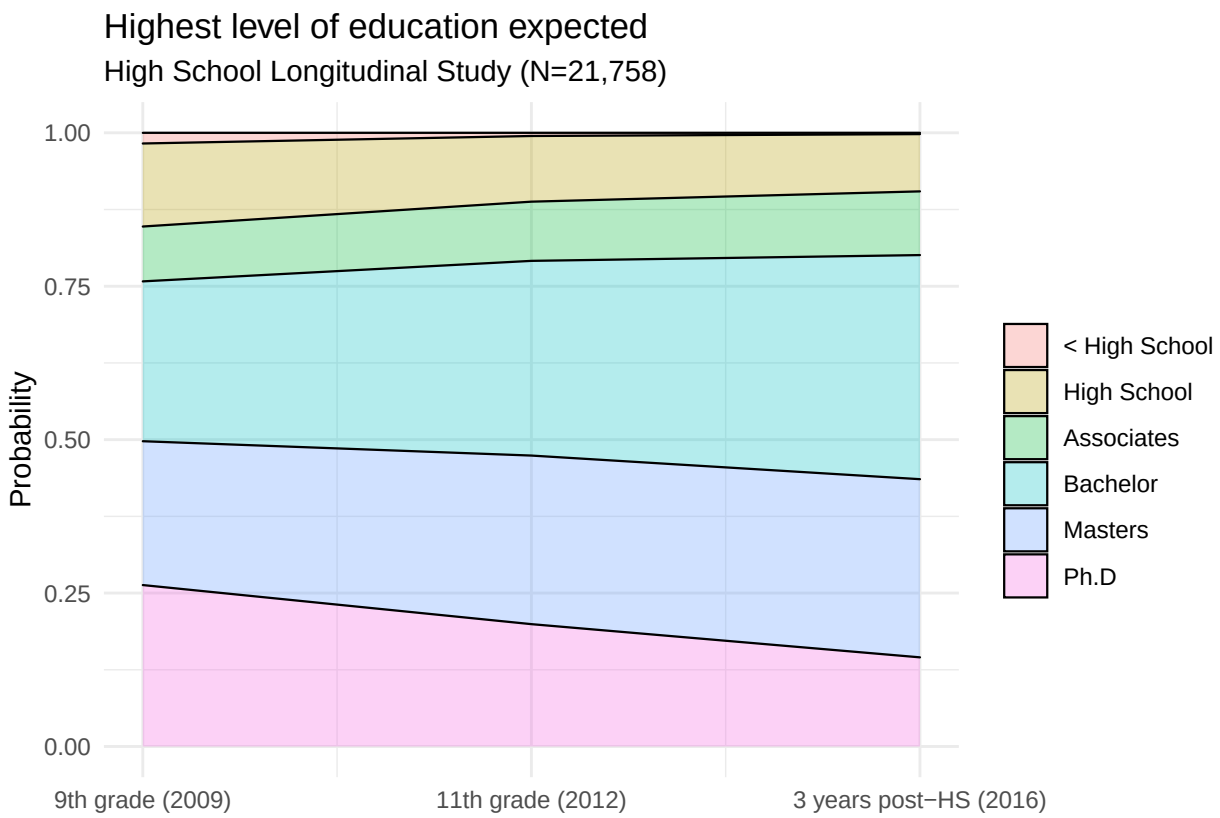
Prepare plot data

```
loop_data <- lapply(1:6, function(k) {
  probs <- mplus.get.estimated_probabilities(
    here("10-growth-models","mplus_files", "m4_growth_hsls.gh5"),'process1',k,k)

  loop_data <- as.data.frame(probs) %>%
    mutate(cat = factor(k))
})

plot_data <- bind_rows(loop_data)

observed <- hsls_rep %>% select(contains("eduexp")) %>%
  rownames_to_column() %>% drop_na()

obs100 <- observed[1:100,]

plot_obs <- obs100 %>%
  pivot_longer(`s1eduexp`:`s4eduexp`,     # The columns I'm gathering together
               names_to = "year",         # new column name for existing names
```

```
            values_to = "value") %>%     # new column name to store values
  mutate(year = case_when(
         year == "s1eduexp" ~ 1,
         year == "s2eduexp" ~ 2,
         year == "s4eduexp" ~ 3,
  ))

yearlevels <- colnames(observed[,2:4])

prob_est <- plot_data %>%
  mutate(year = rep(1:3, 6))
```

Plot the model estimated probabilities (`categorical outcomes`)

```
ggplot(data=prob_est, aes(x=year, y=V1, fill=cat)) +
  geom_area(alpha=0.3 , size=.4, colour="black") +
  scale_x_continuous(breaks = 1:3,
    labels = c("9th grade (2009)","11th grade (2012)","3 years post-HS (2016)")) +
  scale_y_continuous("Probability") +
  scale_fill_discrete("",
    labels = c("< High School", "High School", "Associates", "Bachelor", "Masters", "Ph.D")) +
  labs(title="Highest level of education expected",
       subtitle = "High School Longitudinal Study (N=21,758)", y="Probability", x="") +
  theme_minimal()
```



```
ggsave(here("10-growth-models", "figures", "cat_growth_plot.png"),
       height = 6, width = 8, dpi = "retina")
```

Create an animated plot with {gganimate}

```
cat_plot <- ggplot(data = plot_obs, aes(x = year, y = value, group = rowname)) +
  geom_jitter(color = "black", alpha = 0, width = 0.1, height = .3) +
  geom_line(color = "black") +
  scale_x_continuous(breaks = 1:3,
    labels = c("9th grade (2009)","11th grade (2012)","3 years post-HS (2016)")) +
  scale_y_reverse(breaks = 1:6, labels = c("< HS", "HS", "AA", "BA/BS", "MA", "Ph.D")) +
  theme_minimal() + theme(panel.grid.minor = element_blank()) +
  labs(y="", title="Highest level of education expected",
       subtitle = "High School Longitudinal Study (N=100, sub-sample)")

cat_plot + transition_states(rowname, transition_length = 3, state_length = 3) +
  shadow_mark(color = "blue", alpha = .15)
```

```
anim_save(here("10-growth-models", "figures", "cat_growth_anim.gif"),
          height = 6, width = 8, dpi = "retina")
```

References

Hallquist, M. N., & Wiley, J. F. (2018). MplusAutomation: An R Package for Facilitating Large-Scale Latent Variable Analyses in Mplus. Structural equation modeling: a multidisciplinary journal, 25(4), 621-638.

Ingels, S. J., Pratt, D. J., Herget, D. R., Burns, L. J., Dever, J. A., Ottem, R., ... & Leinwand, S. (2011). High School Longitudinal Study of 2009 (HSLS: 09): Base-Year Data File Documentation. NCES 2011-328. National Center for Education Statistics.

Miller, J. D., Hoffer, T., Suchner, R., Brown, K., & Nelson, C. (1992). LSAY codebook. Northern Illinois University.

Muthén, B. O., Muthén, L. K., & Asparouhov, T. (2017). Regression and mediation analysis using Mplus. Los Angeles, CA: Muthén & Muthén.

Muthén, L.K. and Muthén, B.O. (1998-2017). Mplus User's Guide. Eighth Edition. Los Angeles, CA: Muthén & Muthén

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/

Wickham et al., (2019). Welcome to the tidyverse. Journal of Open Source Software, 4(43), 1686, https://doi.org/10.21105/joss.01686

Further resources & examples here:

https://garberadamc.github.io/project-site/

https://www.adam-garber.com/