Observed Response Patterns in Latent Class Analysis

A Course in `MplusAutomation`

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Preparation

Data source: Longitudinal Study of American Youth, Science Attitudes

See documentation about the LSAY here.

Load packages

```
library(tidyverse)
library(glue)
library(MplusAutomation)
library(here)
library(janitor)
library(DT)
library(gt)
library(plotly)
library(gg3D)
library(gganimate)
library(viridis)
```

Exploring observed response patterns

Load data

```
lsay_data <- read_csv("https://garberadamc.github.io/project-site/data/lca_lsay_sci.csv",
                      na = c("9999", "9999.00")) %>%
  clean_names() %>%
  dplyr::select(1:5, Enjoy = ab39m, Useful = ab39t,
                     Logical = ab39u, Job = ab39w, Adult = ab39x)
```

Use {`DT::datatable()`} to take a look at the data

```
datatable(lsay_data, rownames = FALSE, filter="top",
          options = list(pageLength = 5, scrollX=T) )
```

Show 5 entries Search:

Enjoy	Useful	Logical	Job	Adult
All	All	All	All	All
1	1	1	1	1
0	0	1	0	0
1	1	0	0	0
0	0	0	1	1
0	1	1	0	0

Showing 1 to 5 of 3,061 entries Previous 1 2 3 4 5 … 613 Next

Figure. Path diagram of science attitude indicators.

Save response frequencies for the 4 class model with `response is _____.dat`.

```
patterns  <- mplusObject(

  TITLE = "C4 LCA - Save response patterns",

  VARIABLE =
  "categorical = Enjoy-Adult;
   usevar = Enjoy-Adult;

   classes = c(4);",

  ANALYSIS =
   "estimator = mlr;
    type = mixture;
    starts = 500 100;",

  SAVEDATA =
   "File=3step_savedata.dat;
    Save=cprob;
    Missflag= 999;

    !!!!!!!! Code to save response frequency data !!!!!!!!
```

```
    response is resp_patterns.dat;

    !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!",

  OUTPUT = "sampstat residual patterns tech10 tech11 tech14",

  PLOT =
    "type = plot3;
    series = Enjoy-Adult(*);",

  usevariables = colnames(lsay_data),
  rdata = lsay_data)

patterns_fit <- mplusModeler(patterns,
                dataout=here("13-response-patterns", "mplus_files", "LSAY.dat"),
                modelout=here("13-response-patterns", "mplus_files", "patterns.inp") ,
                check=TRUE, run = TRUE, hashfilename = FALSE)
```

Read in observed respnse pattern data

```
patterns <- read_table2(here("13-response-patterns", "mplus_files", "resp_patterns.dat"),
                        col_names=FALSE, na = "*")

colnames(patterns) <- c("Frequency", "ENJOY", "USEFUL", "LOGICAL", "JOB", "ADULT",
                        "CPROB1", "CPROB2", "CPROB3", "CPROB4", "C_MODAL")
```

Order responses by highest frequency

```
order_highest <- patterns %>%
  arrange(desc(Frequency))
```

```
loop_cond  <- lapply(1:4, function(k) {
order_cond <- patterns %>%
  filter(C_MODAL == k) %>%
  arrange(desc(Frequency)) %>%
  head(5)
  })

table_data1 <- bind_rows(loop_cond) %>%
  as.data.frame()

table_data2 <-  rbind(order_highest[1:5,], table_data1)
```

Use {gt} to make a nicely formatted table

```
table_data2 %>%
  gt() %>%
    tab_header(
    title = md("**Observed Response Patterns**"),
    subtitle = md(" ")) %>%
    tab_source_note(
    source_note = md("Data Source: **Longitudinal Study of American Youth.**")) %>%
    cols_label(
    ENJOY = "Enjoy",
    USEFUL = "Useful",
    LOGICAL = "Logical",
    JOB = "Job",
    ADULT = "Adult",
    CPROB1 = html("Pk=1"),
    CPROB2 = html("Pk=2"),
    CPROB3 = html("Pk=3"),
    CPROB4 = html("Pk=4"),
    C_MODAL = md("*k*")) %>%
  tab_row_group(
    group = "Unconditional response patterns",
    rows = 1:5) %>%
  tab_row_group(
    group = "k=1 conditional response patterns",
    rows = 6:10) %>%
  tab_row_group(
    group = "k=2 conditional response patterns",
    rows = 11:15)  %>%
  tab_row_group(
    group = "k=3 conditional response patterns",
    rows = 16:20) %>%
  tab_row_group(
    group = "k=4 conditional response patterns",
    rows = 21:25) %>%
    row_group_order(
      groups = c("Unconditional response patterns",
                 "k=1 conditional response patterns",
                 "k=2 conditional response patterns",
                 "k=3 conditional response patterns",
                 "k=4 conditional response patterns")) %>%
  tab_options(column_labels.font.weight = "bold")
```

Observed Response Patterns

	Frequency	Enjoy	Useful	Logical	Job	Adult	Pk=1	Pk=2	Pk=3	Pk=4	*k*
Unconditional response patterns											
	558	0	0	0	0	0	0.000	0.117	0.000	0.883	4
	529	1	1	1	1	1	0.957	0.000	0.043	0.000	1
	313	1	0	0	0	0	0.000	0.307	0.000	0.693	4
	135	1	0	1	0	0	0.002	0.977	0.000	0.021	2
	94	1	1	1	0	1	0.687	0.000	0.313	0.000	1

k=1 conditional response patterns										
529	1	1	1	1	1	0.957	0.000	0.043	0.000	1
94	1	1	1	0	1	0.687	0.000	0.313	0.000	1
78	0	1	1	1	1	0.859	0.000	0.141	0.000	1
62	1	1	0	1	1	0.580	0.000	0.420	0.000	1
55	1	1	1	1	0	0.650	0.350	0.000	0.000	1
k=2 conditional response patterns										
135	1	0	1	0	0	0.002	0.977	0.000	0.021	2
88	0	0	1	0	0	0.000	0.934	0.000	0.066	2
74	1	1	1	0	0	0.063	0.937	0.000	0.000	2
47	1	1	0	0	0	0.006	0.994	0.000	0.000	2
44	1	0	0	1	0	0.004	0.643	0.000	0.353	2
k=3 conditional response patterns										
91	1	0	0	0	1	0.003	0.000	0.937	0.060	3
88	1	0	1	1	1	0.337	0.000	0.663	0.000	3
76	1	0	1	0	1	0.048	0.000	0.951	0.001	3
70	1	0	0	1	1	0.031	0.000	0.964	0.006	3
53	0	0	0	0	1	0.001	0.000	0.763	0.236	3
k=4 conditional response patterns										
558	0	0	0	0	0	0.000	0.117	0.000	0.883	4
313	1	0	0	0	0	0.000	0.307	0.000	0.693	4
53	0	0	0	1	0	0.000	0.353	0.000	0.647	4
11	0	0	NA	0	0	0.000	0.231	0.000	0.769	4
9	0	NA	0	0	0	0.000	0.170	0.000	0.829	4

Data Source: **Longitudinal Study of American Youth.**

Visualizing observed response patterns

Order response patterns (rows) by modal assignment (K)

```
order_modal <- patterns %>%
  arrange(desc(C_MODAL)) %>%
  rownames_to_column() %>%
  rename('pat_num' = "rowname") %>%
  drop_na(ENJOY:ADULT)
```

Prepare plot data

```
p1_long <- order_modal %>%
  dplyr::select(pat_num:ADULT, C_MODAL) %>%
  pivot_longer(`ENJOY`:`ADULT`,
               names_to = "var",
```

```
               values_to = "value") %>%
  mutate(obs = rep(1:32, each=5)) %>%
  mutate(Class = factor(C_MODAL)) %>%
  mutate(var = ordered(var,
                       levels = c("ENJOY","USEFUL","LOGICAL","JOB","ADULT"))) %>%
  select(-pat_num, -C_MODAL)

out_c4 <- readModels(here("13-response-patterns", "mplus_files"),
                     filefilter = "patterns", quiet = TRUE)

# extract posterior probabilities
probs_c4 <- as.data.frame(
  out_c4[["gh5"]][["means_and_variances_data"]]
  [["estimated_probs"]][["values"]]
  [seq(2, 10, 2),])

rownames(probs_c4) <- c("ENJOY","USEFUL","LOGICAL","JOB","ADULT")

long_c4 <- probs_c4 %>% rownames_to_column() %>%
  rename('var' = "rowname") %>%
  pivot_longer(`V1`:`V4`, # The columns I'm gathering together
               names_to = "c", # new column name for existing names
               values_to = "value") %>% # new column name to store values
  mutate(Class = rep(1:4,5)) %>%
  arrange(Class) %>%
  mutate(obs = rep(33:36,each=5)) %>%
  mutate(Frequency = rep(c(829,782,619,833),each=5)) %>%
  mutate(var = ordered(var,
                       levels = c("ENJOY","USEFUL","LOGICAL","JOB","ADULT"))) %>%
  select(6,1,3,5,4)

p2_long <- rbind(p1_long, long_c4) %>%
  mutate(Class = as.numeric(Class))
```

Visualize observed response patterns with {plotly}

```
gg <- ggplot(p2_long, aes(x=var, y=value, color = Class, size=Frequency)) +
  geom_line(aes(as.numeric(var), frame = obs)) +
  scale_color_viridis() + labs(x="Indicator", y= "Probability")

ggplotly(gg) %>%  animation_opts(frame = 1000, transition = 0) %>%
  animation_slider(currentvalue =
                     list(prefix = "Pattern ", font = list(color="red")))
```

Make a 3D plot with packages {ggplot2}, {gg3D}, and {gganimate}.

```
theta= 170    # change perspective (tilt)
phi=40        # change perspective (rotation)

resp3d <- ggplot(p1_long, aes(x=as.numeric(var),
                              y=as.numeric(value),
                              z = as.numeric(obs)),
                 alpha = .8) +
```

```
  axes_3D(theta=theta, phi=phi) +
  stat_3D(theta=theta, phi=phi, geom="path",
          aes(colour = Class, size = Frequency), alpha = .8) +
  scale_color_manual(values=c("#FDE725FF", "#DE7065FF", "#238A8DFF", "#482677FF")) +
  theme_void() +
  annotate("text", x = -.3, y = 0.05, label = "Indicators ") +
  annotate("text", x = .35, y = -.4, label = "Probability") +
  annotate("text", x = .25, y = .42, label = "Pattern") +
  annotate("text", x = .2, y = 0, label = "0.0") +
  annotate("text", x = .34, y = -.33, label = "1.0") +
  annotate("text", x = -.05, y = 0, angle = 6,
           label = "Enjoy - Useful - Logical - Job - Adult") +
  transition_states(obs, transition_length=1, state_length=5) +
  shadow_mark(alpha = .1,) +
  labs(title = "Observed response pattern = {closest_state}")


animate(resp3d, fps = 2)
```

```
anim_save(here("13-response-patterns", "figures", "responses_3d_anim.gif"),
          height = 6, width = 8, dpi = "retina")
```

References

Drew A. Linzer, Jeffrey B. Lewis (2011). poLCA: An R Package for Polytomous Variable Latent Class Analysis. Journal of Statistical Software, 42(10), 1-29. URL http://www.jstatsoft.org/v42/i10/.

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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/