

Conditional Indirect Effects

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Preparation

```
library(mediation)
library(tidyverse)
library(rhdf5)
library(MplusAutomation)
library(here)
library(gt)
library(gtsummary)
library(carData)
library(plotly)
library(viridis)
```

Change starting location to folder 16-cond-mediation

```
source("rep_functions.R")

change_here(glue("{project_location}/16-cond-mediation"))

here()
```

```
## [1] "/Users/agarber/github/NTNU-workshop/16-cond-mediation"
```

Upload list of mplus.R functions

<http://www.statmodel.com/mplus-R/mplus.R>

```
source(here("mplus.R.txt"))
```

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

Lab outline

1. Run a simple moderation model with binary moderator (re-coded)
 2. Plot simple slopes with `ggplot` using data extracted from `gh5` file produced by Mplus output
 3. Run a parallel model with interaction between two continuous variables
 4. Estimate a conditional mediation model with the `teams` data
-

Data sources:

Models are adapted to demonstrate moderation and conditional mediation effects:

1. The first two examples utilize the *Vocabulary and Education* dataset from the National Opinion Research Center General Social Survey. GSS Cumulative Datafile 1972-2016 (Fox, 2008) [See documentation here](#)

To see metadata run - `?carData::Vocab`

2. The third example is from chapter 3 of the book, *Regression and mediation analysis using Mplus*, by Muthen et al., 2017. The dataset is called `teams` and is from a study about automobile parts work teams (Cole et al., 2008). This model is also discussed in the Hayes (2013) book on mediation.
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Read the `Vocab` dataframe into your R-environment from package `{carData}`

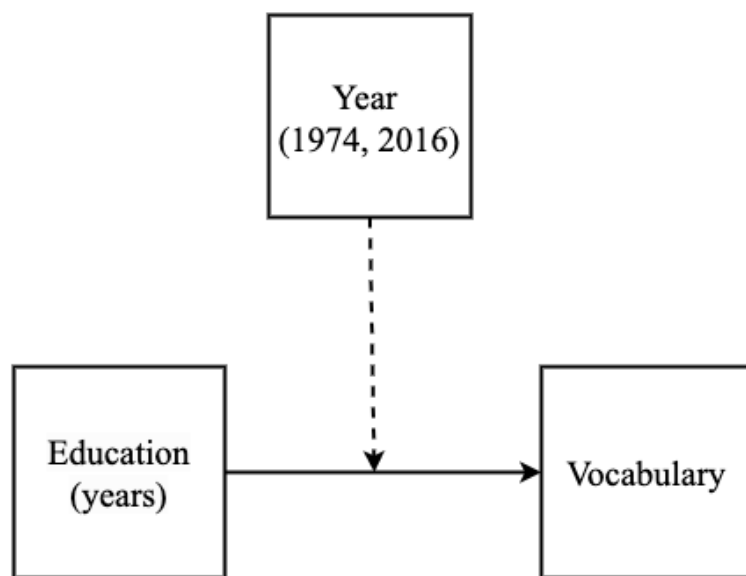
```
data(Vocab)

vocab <- as.data.frame(Vocab) %>%
  mutate(year_new = year - 1973)

vocab2 <- vocab %>%
  filter(year %in% c(1974, 2016)) %>%
  mutate(year = droplevels(factor(year)))
```

Starting with a familiar example

Name	Labels
year	Year of the survey (1974 - 2016)
sex	Sex of the respondent (Female or Male)
education	Students education in years
vocabulary	Vocabulary test score: number correct on a 10-word test



$$\text{vocabulary} = \alpha + \beta_1(\text{year}) + \beta_2(\text{education}) + \beta_3(\text{year} \times \text{education}) + \epsilon$$

Model 1: Run moderation with binary moderator variable year

```

m1_lev2mod <- mplusObject(
  TITLE = "m1 model conditional mediation ",
  VARIABLE =
    "usevar =
    year education vocabulary int_yred; ",

  DEFINE =
    "!center education (grandmean); ! leave un-centered for plot
    int_yred = year*education;      ! create interaction term ",

  ANALYSIS =
    "estimator = MLR" ,

  MODEL =
    "[vocabulary](b0);
    vocabulary on
    year(b1)
    education(b2)
    int_yred(b3); " ,

  MODELCONSTRAINT =

```

```

"LOOP(x,6.62,19.18,0.01); ! 2SD above-below mean
PLOT(y1974 y2016);
y1974 = b0 + b2*x;
y2016 = b0 + b1 + (b2+b3)*x;

new(hi_y1974 lo_y1974 hi_y2016 lo_y2016 diff_hi);
hi_y1974 = b0 + b2*(6.28);
lo_y1974 = b0 + b2*(-6.28);
hi_y2016 = b0 + b1 + (b2 + b3)*(6.28);
lo_y2016 = b0 + b1 + (b2 + b3)*(-6.28);
diff_hi = hi_y2016 - hi_y1974; ",

OUTPUT = "sampstat standardized modindices (3.84)",

PLOT = "type=plot3;",

usevariables = colnames(vocab2),
rdata = vocab2)

m1_lev2mod_fit <- mplusModeler(m1_lev2mod,
  dataout=here("mplus_files", "vocab.dat"),
  modelout=here("mplus_files", "m1_lev2mod_vocab.inp"),
  check=TRUE, run = TRUE, hashfilename = FALSE)

```

Plotting using data extracted from gh5 files produced 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("mplus_files", "m1_lev2mod_vocab.gh5"))
```

```
mplus.plot.loop(here("mplus_files", "m1_lev2mod_vocab.gh5"),label =1)
```

Prepare plot data -

```

loop_data <- lapply(1:2, function(k) {
  y_val <- mplus.get.loop.estimates(here("mplus_files", "m1_lev2mod_vocab.gh5"),label=k)
  lower <- mplus.get.loop.lowerci(here("mplus_files", "m1_lev2mod_vocab.gh5"),label=k)
  upper <- mplus.get.loop.upperci(here("mplus_files", "m1_lev2mod_vocab.gh5"),label=k)
  x_val <- mplus.get.loop.xvalues(here("mplus_files", "m1_lev2mod_vocab.gh5"))

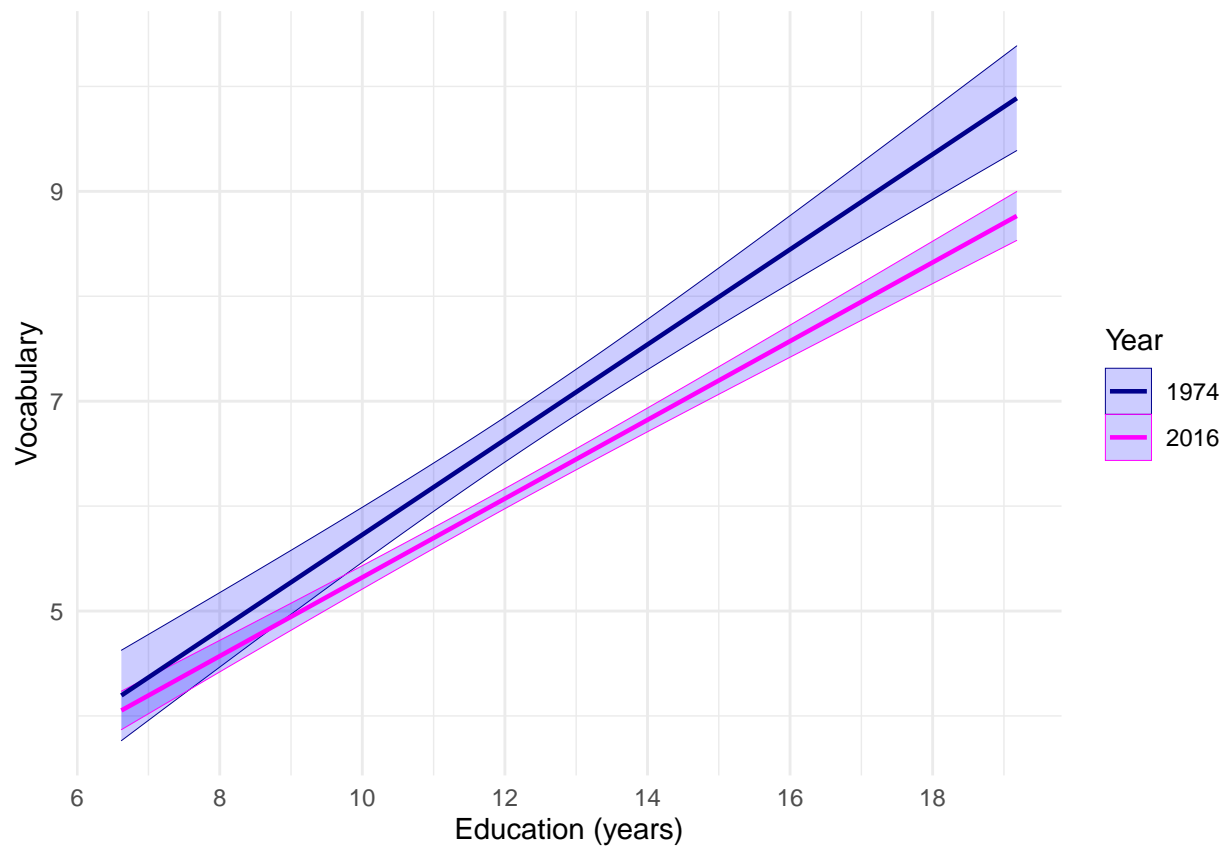
  loop_data <- as.data.frame(cbind(y_val, x_val, lower, upper)) %>%
    mutate(group = factor(k))
})

```

```
plot_data <- bind_rows(loop_data)
```

Plot simple slopes moderation with standard error ribbons

```
ggplot(plot_data, aes(x=x_val, y=y_val,
                      group = group,
                      color = group)) +
  geom_ribbon(aes(ymin = lower, ymax = upper),
            fill = "blue", alpha = .2, size = 0) +
  geom_line(size=.8) +
  scale_color_manual(
    values=c("darkblue", "magenta"),
    name = "Year", labels = c("1974", "2016")) +
  scale_x_continuous(breaks = c(seq(6,20,2))) +
  labs(y = "Vocabulary",
       x = "Education (years)") +
  theme_minimal()
```



Model 2: Run moderation with continuous moderator variable year (range: 1-42)

```
m2_contmod <- mplusObject(
  TITLE = "m2 condition mediation (continuous moderator)",
  VARIABLE =
    "usevar =
      year_new education vocabulary int_yred; ",

  DEFINE =
    "!center education (grandmean);      ! leave un-centered for plot
    int_yred = year_new*education;      ! create interaction term ",

  ANALYSIS =
    "estimator = MLR" ,

  MODEL =
    "[vocabulary](b0);
    vocabulary on
    year_new(b1)
    education(b2)
    int_yred(b3); " ,

  MODELCONSTRAINT =
    "LOOP(x,6.62,19.18,0.01);
    PLOT(y1974 y1984 y1995 y2005 y2016);
    y1974 = b0 + b1*1 + b2*x + b3*x*1;
    y1984 = b0 + b1*10 + b2*x + b3*x*10;
    y1995 = b0 + b1*21 + b2*x + b3*x*21;
    y2005 = b0 + b1*31 + b2*x + b3*x*31;
    y2016 = b0 + b1*42 + b2*x + b3*x*42; ",

  OUTPUT = "sampstat standardized modindices (3.84)",

  PLOT = "type=plot3;",

  usevariables = colnames(vocab),
  rdata = vocab)

m2_contmod_fit <- mplusModeler(m2_contmod,
  dataout=here("mplus_files", "vocab.dat"),
  modelout=here("mplus_files", "m2_contmod_vocab.inp"),
  check=TRUE, run = TRUE, hashfilename = FALSE)
```

Prepare plot data

```
loop_data2 <- lapply(1:5, function(k) {
  y_val <- mplus.get.loop.estimates(here("mplus_files", "m2_contmod_vocab.gh5"),label=k)
  lower <- mplus.get.loop.lowerci(here("mplus_files", "m2_contmod_vocab.gh5"),label=k)
  upper <- mplus.get.loop.upperci(here("mplus_files", "m2_contmod_vocab.gh5"),label=k)
```

```

x_val <- mplus.get.loop.xvalues(here("mplus_files", "m2_contmod_vocab.gh5"))

loop_data2 <- as.data.frame(cbind(y_val, x_val, lower, upper)) %>%
  mutate(group = factor(k))

})

plot_data2 <- bind_rows(loop_data2)

```

Plot simple slopes moderation plot with standard error bands

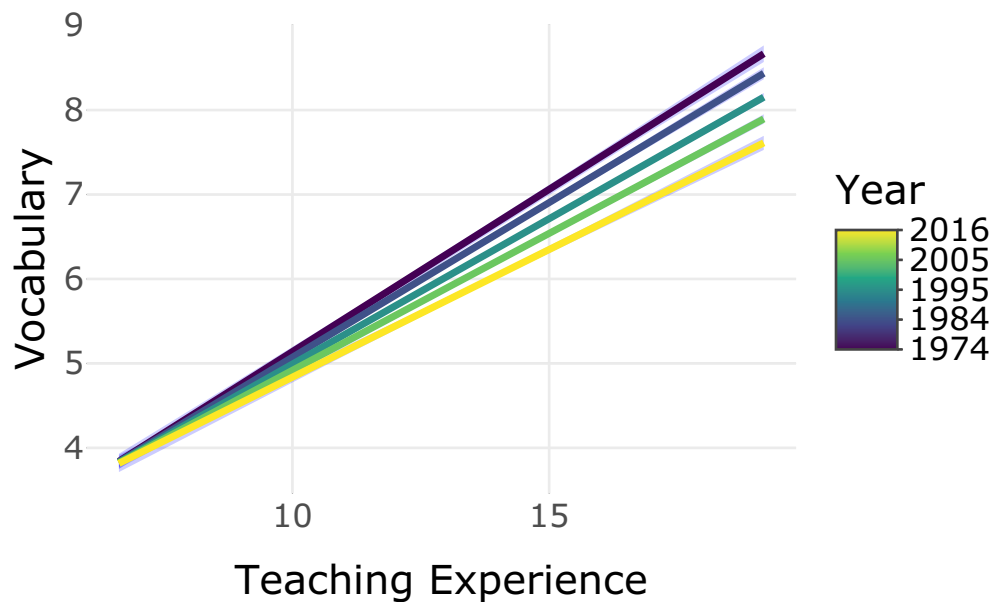
```

cont_plot <- ggplot(plot_data2, aes(x=x_val, y=y_val,
                                   group = group, color = as.numeric(group))) +
  geom_ribbon(aes(ymin = lower, ymax = upper),
            fill = "blue", alpha = .2, size = 0) +
  geom_line(size=.7) +
  scale_color_viridis_c(name = "Year", labels = c("1974", "1984", "1995", "2005", "2016")) +
  labs(y = "Vocabulary" , x = "Teaching Experience") +
  theme_minimal()

```

Create interactive plot with ggplotly

```
ggplotly(cont_plot)
```

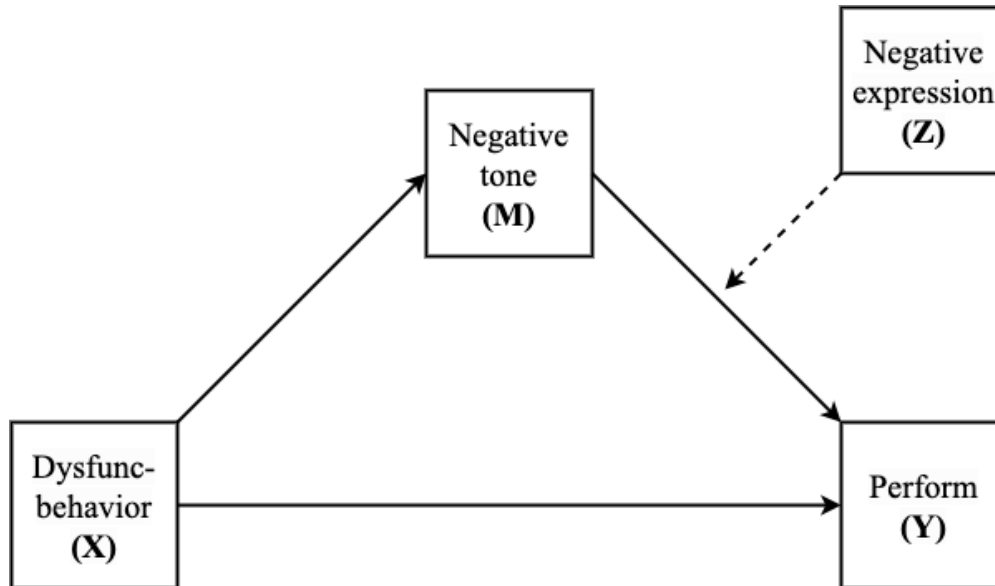


Conditional indirect effect model

This version of moderated mediation is described as **case 2** in the Muthen et al. (2016) text.

Name	Labels
------	--------

dysfunc (X)	Dysfunctional behavior of team members
negexp (Z)	Nonverbal negative expressibility between team members (measured by supervisor)
negtone (M)	Negative affective tone expressed by team members
perform (Y)	Team performance using measures of efficiency, timeliness, and objectives



Read in data

```
teams <- read_table(here("data", "teams.txt"), col_names = FALSE)
colnames(teams) <- c("dysfunc", "negtone", "negexp", "perform")
```

Model 3: Estimate conditional indirect effect model

```
m3_teams <- mplusObject(
  TITLE =
    "Data source - Hayes (2013) TEAMS Case 2 moderation of M -> Y ",
  VARIABLE =
    "usevar = dysfunc negtone negexp perform mz;",
  DEFINE =
    "MZ = negtone*negexp; ! create interaction term ",
  ANALYSIS =
    "! set number of bootstrap draws (small # for demonstration purposes)
    bootstrap = 500; " ,
  MODEL =
    "perform on negtone dysfunc negexp mz;
    negtone on dysfunc;

    Model indirect:
```



```

perform MOD
negtone negexp(-0.4,0.6,0.1) mz dysfunc(0.4038 0.035); ",

OUTPUT =
"sampstat standardized cinterval (bcbootstrap); ! bias-corrected bootstrap",

PLOT = "type=plot3;",

usevariables = colnames(teams),
rdata = teams)

m3_teams_fit <- mplusModeler(m3_teams,
  dataout=here("mplus_files", "teams.dat"),
  modelout=here("mplus_files", "m3_teams.inp"),
  check=TRUE, run = TRUE, hashfilename = FALSE)

```

Model 3 Mplus output

TOTAL, INDIRECT, AND DIRECT EFFECTS BASED ON COUNTERFACTUALS (CAUSALLY-DEFINED EFFECTS)

Effects from DYSFUNC to PERFORM for NEGEXP = -0.100

Tot natural IE	-0.088	0.045	-1.939	0.052
Pure natural DE	0.135	0.069	1.962	0.050
Total effect	0.047	0.071	0.664	0.507

Effects from DYSFUNC to PERFORM for NEGEXP = 0.000

Tot natural IE	-0.100	0.045	-2.194	0.028
Pure natural DE	0.135	0.069	1.962	0.050
Total effect	0.035	0.073	0.488	0.626

Effects from DYSFUNC to PERFORM for NEGEXP = 0.100

Tot natural IE	-0.111	0.047	-2.391	0.017
Pure natural DE	0.135	0.069	1.962	0.050
Total effect	0.024	0.075	0.316	0.752

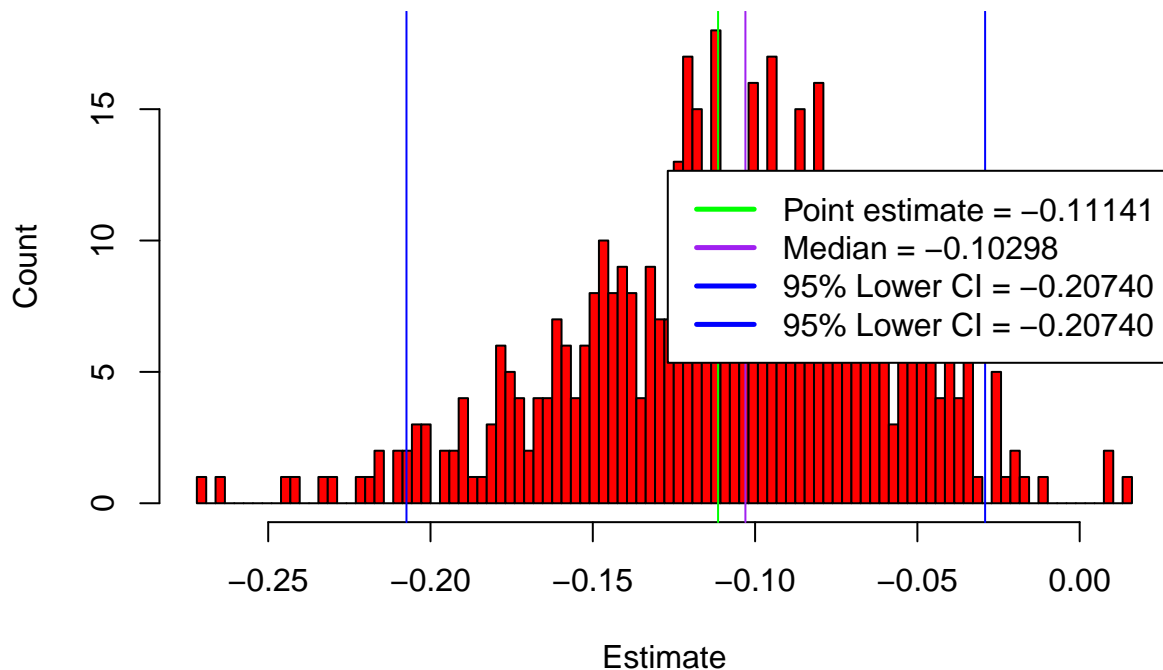
View available plots from the Mplus model

```
mplus.view.plots(here("mplus_files", "m3_teams.gh5"))
```

Take a look at bootstrap distribution of the indirect effect to view asymptotic shape.

```
mplus.plot.bootstrap.distribution(here("mplus_files", "m3_teams.gh5"), parameter = 38)
```

bootstrap distribution of: DYSFUNC to PERFORM for NEGEXP = 0.100: Pure



To see animation of how the bootstrap distribution changes with increasing sample draws (N) go here:
https://raw.githubusercontent.com/minimaxir/frames-to-gif-osx/master/examples/uni_frames.gif

Create plot of moderated direct and indirect effects

```
label <- c('Total natural DE', 'Total natural IE')

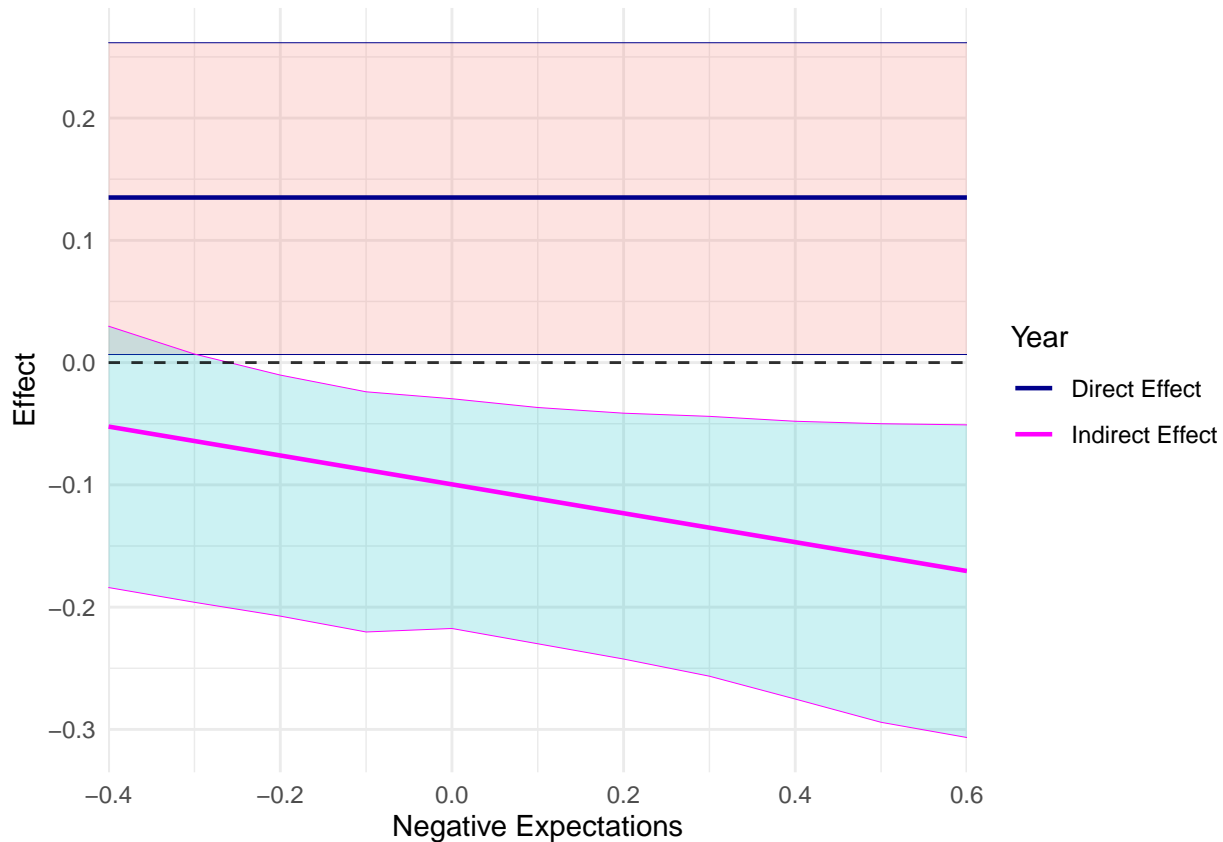
mod_data <- lapply(1:2, function(k) {
  y_val <- mplus.get.moderation.estimates(here("mplus_files", "m3_teams.gh5"), label[k])
  lower <- mplus.get.moderation.lowerci(here("mplus_files", "m3_teams.gh5"), label[k])
  upper <- mplus.get.moderation.upperci(here("mplus_files", "m3_teams.gh5"), label[k])
  x_val <- mplus.get.moderation.xvalues(here("mplus_files", "m3_teams.gh5"))

  mod_data <- as.data.frame(cbind(y_val, x_val, lower, upper)) %>%
    mutate(group = factor(k))
})

plot_data2 <- bind_rows(mod_data)

ggplot(plot_data2, aes(x=x_val, y=y_val,
                      group = group, color = group, fill = group)) +
  geom_ribbon(aes(ymin = lower, ymax = upper),
            alpha = .2, size = 0, show.legend = FALSE) +
  geom_line(size=.8) +
```

```
geom_hline(yintercept = 0, alpha = .8, linetype = 2) +
scale_x_continuous(expand = c(0,0)) +
scale_color_manual(values=c("darkblue", "magenta"),
                    name = "Year", labels = c("Direct Effect", "Indirect Effect")) +
labs(y = "Effect" , x = "Negative Expectations") +
theme_minimal()
```



References

- Brader T, Valentino NA, Suhart E (2008). What Triggers Public Opposition to Immigration? Anxiety, Group Cues, and Immigration. *American Journal of Political Science*, 52(4), 959–978.
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- 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.
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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/>

Tingley, D., Yamamoto, T., Hirose, K., Keele, L., & Imai, K. (2014). Mediation: R package for causal mediation analysis.

Vinokur AD, Price RH, Schul Y (1995). Impact of the JOBS Intervention on Unemployed Workers Varying in Risk for Depression. *American Journal of Community Psychology*, 23(1), 39–74.

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