

Visualizing Multilevel Models

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Introduction

An evolving set of notes on visualizing results from multilevel models.

When this document is presented in *slide show format*, some slides may be long, and you may need to *scroll down* to see the full slide. In slide show format use the left and right arrow keys to navigate through the slides. **b** will make the text bigger. **s** will make the text smaller.

The examples below use the `simulated_multilevel_data.dta` file from *Multilevel Thinking*. Here is a direct link to download the data.

Setup

I am not terrifically fond of Stata's default `s2color` graph scheme. Therefore I make use of the `michigan` graph scheme available at: <https://agrogan1.github.io/Stata/michigan-graph-scheme/>

```
. set scheme michigan
```

Stata's `s1color` scheme would also be an option as would be Asjad Naqvi's incredible `schemepack`: <https://github.com/asjadnaqvi/stata-schemepack>

Get Data

```
. use "https://github.com/agrogan1/multilevel-thinking/raw/main/simulate-and-analyze-m
> ultilevel-data/simulated_multilevel_data.dta", clear
```

Scatterplots

```
. twoway scatter outcome warmth

. graph export myscatter.png, width(1500) replace
file /Users/agrogan/Desktop/GitHub/multilevel/visualizing-MLM/myscatter.png saved as
  PNG format
```

Simple Linear Fit

```
. twoway lfit outcome warmth

. graph export mylinear.png, width(1500) replace
file /Users/agrogan/Desktop/GitHub/multilevel/visualizing-MLM/mylinear.png saved as
  PNG format
```

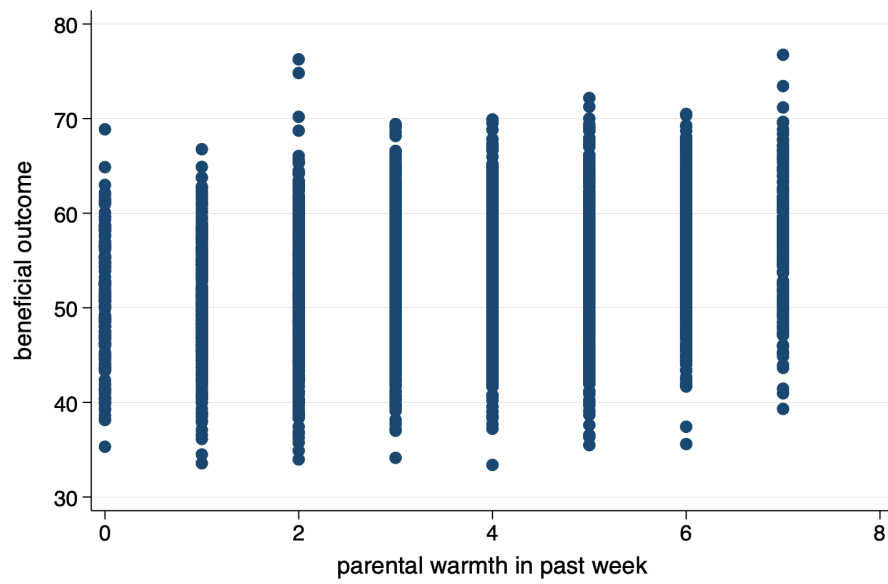


Figure 1: Scatterplot

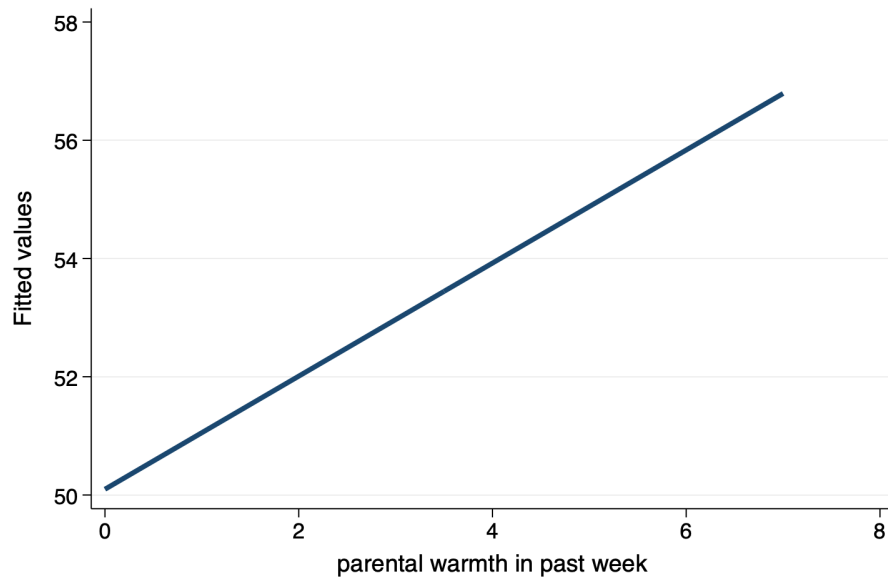


Figure 2: Linear Fit

Linear Fit With Confidence Interval

```
. twoway lfitci outcome warmth  
  
. graph export mylfitci.png, width(1500) replace  
file /Users/agrogan/Desktop/GitHub/multilevel/visualizing-MLM/mylfitci.png saved as  
PNG format
```

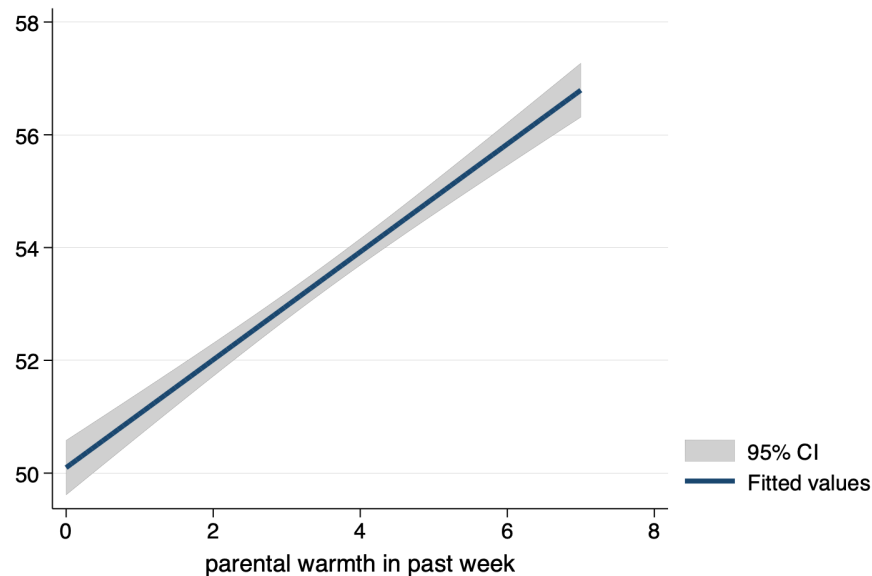


Figure 3: Linear Fit With Confidence Interval

Combine Scatterplot and Linear Fit

```
. twoway (scatter outcome warmth) (lfit outcome warmth)  
  
. graph export myscatterlinear.png, width(1500) replace  
file /Users/agrogan/Desktop/GitHub/multilevel/visualizing-MLM/myscatterlinear.png  
saved as PNG format
```

Spaghetti Plots (spagplot)

```
. spagplot outcome warmth, id(country)  
  
. graph export myspaghetti.png, width(1500) replace  
file /Users/agrogan/Desktop/GitHub/multilevel/visualizing-MLM/myspaghetti.png saved  
as PNG format
```

Small Multiples

I use the `aspect` option to adjust the *aspect ratio* of the graph for better visual presentation. I also use the `mcolor(%30)` option to create some transparency in the dots of the scatterplot, which helps the presentation of these small multiples. The `mcolor(%30)` option could be useful in the other graphs in this tutorial as well.

```
. twoway (scatter outcome warmth, mcolor(%30)) (lfit outcome warmth), by(country) aspe  
> ct(1)  
  
. graph export mysmallmultiples.png, width(1500) replace
```

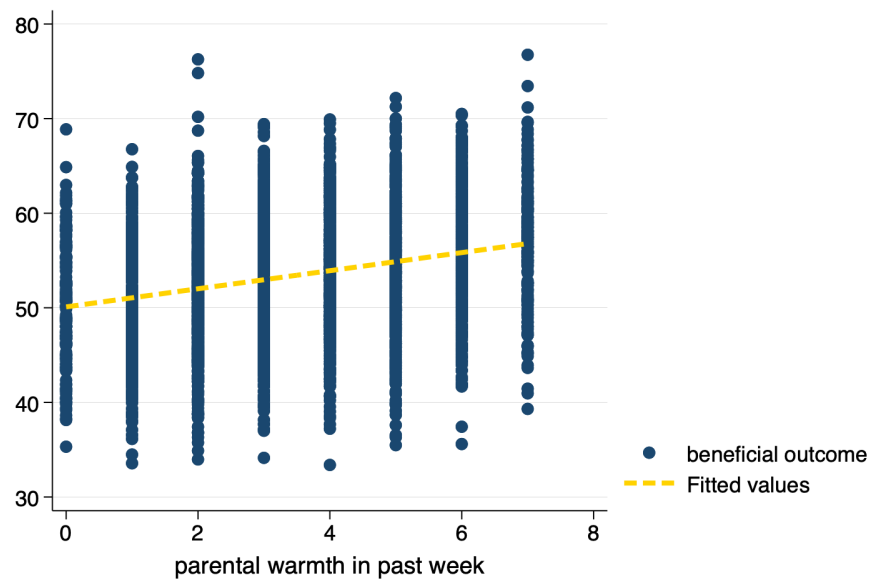


Figure 4: Scatterplot and Linear Fit

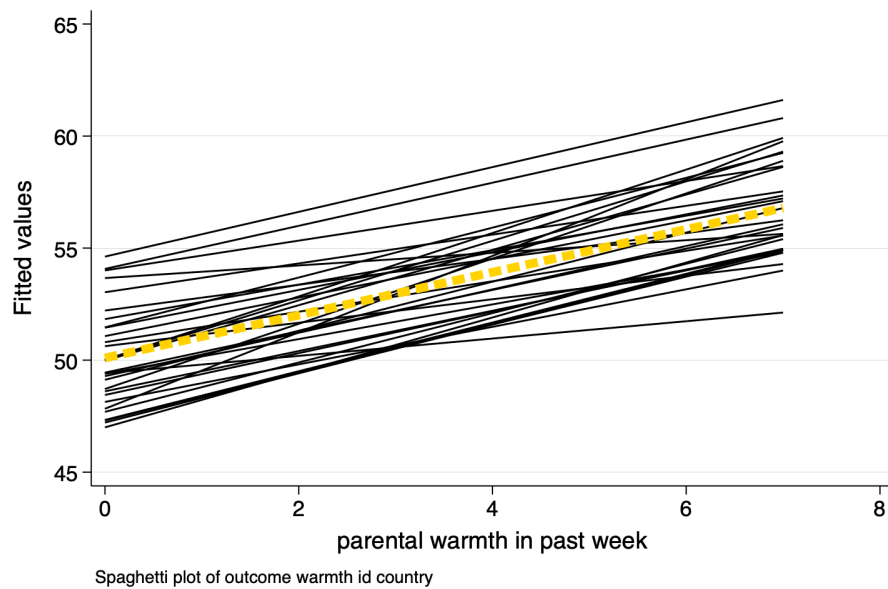


Figure 5: Spaghetti Plot

file /Users/agrogan/Desktop/GitHub/multilevel/visualizing-MLM/mysmallmultiples.png
 saved as PNG format

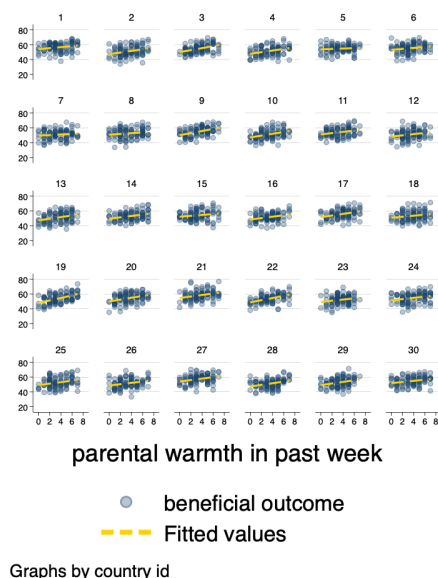


Figure 6: Small Multiples

Multivariate (Predicted) Relationships

A sometimes unacknowledged point is that graphs—unless we take steps to correct this—reflect *unadjusted*, or *bivariate* associations. We may sometimes wish to develop a graphs that reflect the *adjusted* or *predicted* estimates from our models.

In multilevel models, *prediction* is a complex question. The procedures below outline graphs that incorporate predictions using the variables, but do not include predictions that incorporate the random effects. (This will be added!)

Using Predicted Values

Estimate The Model

```
. mixed outcome warmth physical_punishment i.group || country: // estimate MLM
Performing EM optimization:
Performing gradient-based optimization:
Iteration 0:   log likelihood = -9668.0859
Iteration 1:   log likelihood = -9668.0859
Computing standard errors:
Mixed-effects ML regression              Number of obs      =       3,000
Group variable: country                  Number of groups   =        30
Obs per group:                           min =          100
                                           avg  =       100.0
                                           max  =          100
                                           Wald chi2(3)      =       401.00
                                           Prob > chi2       =       0.0000
```

| outcome | Coefficient | Std. err. | z | P> z | [95% conf. interval] | |
|---------|-------------|-----------|-------|-------|----------------------|----------|
| warmth | .961837 | .0581809 | 16.53 | 0.000 | .8478046 | 1.075869 |

| | | | | | | |
|---------------------|-----------|----------|--------|-------|-----------|-----------|
| physical_punishment | -.8457672 | .0798128 | -10.60 | 0.000 | -1.002197 | -.6893369 |
| 2.group | 1.084409 | .2200548 | 4.93 | 0.000 | .6531099 | 1.515709 |
| _cons | 51.64797 | .4645466 | 111.18 | 0.000 | 50.73748 | 52.55847 |

| Random-effects parameters | Estimate | Std. err. | [95% conf. interval] | |
|---------------------------|----------|-----------|----------------------|----------|
| country: Identity | | | | |
| var(_cons) | 3.403 | .9717558 | 1.944438 | 5.955659 |
| var(Residual) | 36.01911 | .9346952 | 34.23295 | 37.89847 |

LR test vs. linear model: chibar2(01) = 200.29 Prob >= chibar2 = 0.0000

Generate Predicted Values

```
. predict outcome_hat // predict yhat
(option xb assumed)
```

Graph With twoway Syntax

```
. twoway (scatter outcome_hat warmth) (lfit outcome_hat warmth)
. graph export mypredictedvalues.png, width(1500) replace
file /Users/agrogan/Desktop/GitHub/multilevel/visualizing-MLM/mypredictedvalues.png
saved as PNG format
```

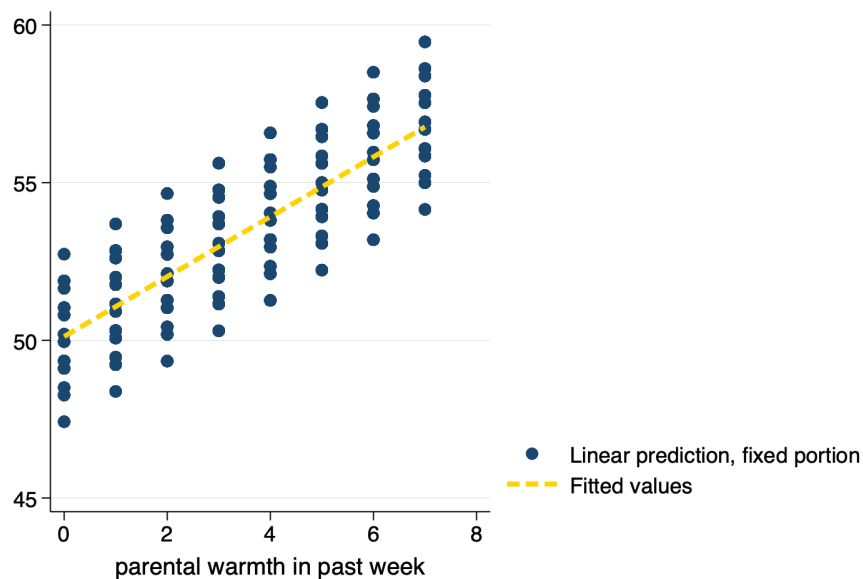


Figure 7: Predicted Values From predict

Spaghetti Plot With Predicted Values

```
. spagplot outcome_hat warmth, id(country)
. graph export myspaghetti2.png, width(1500) replace
file /Users/agrogan/Desktop/GitHub/multilevel/visualizing-MLM/myspaghetti2.png saved
as PNG format
```

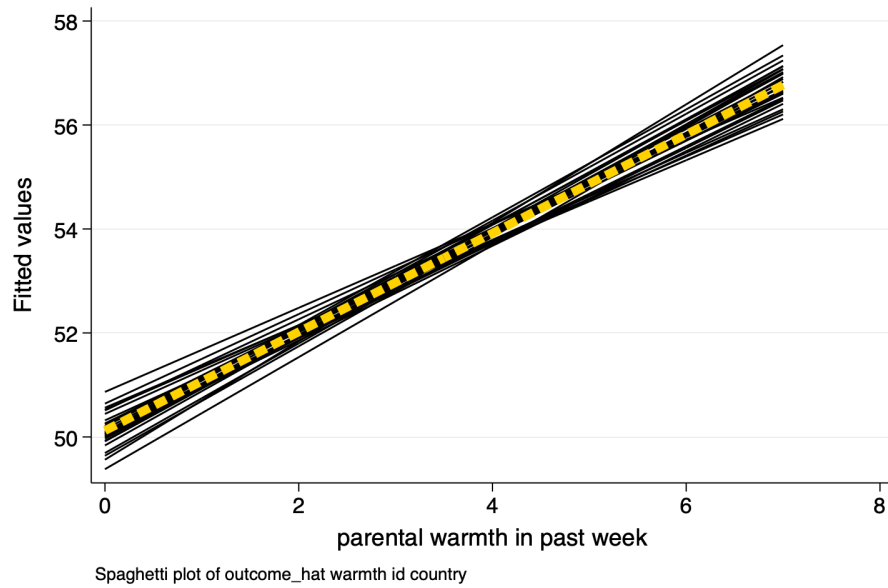


Figure 8: Spaghetti Plot With Predicted Values

margins and marginsplot

Estimate The Model

```
. mixed outcome warmth physical_punishment i.group || country: // estimate MLM
```

Performing EM optimization:

Performing gradient-based optimization:

Iteration 0: log likelihood = -9668.0859

Iteration 1: log likelihood = -9668.0859

Computing standard errors:

Mixed-effects ML regression

Group variable: country

Number of obs = 3,000

Number of groups = 30

Obs per group:

min = 100

avg = 100.0

max = 100

Wald chi2(3) = 401.00

Prob > chi2 = 0.0000

Log likelihood = -9668.0859

| outcome | Coefficient | Std. err. | z | P> z | [95% conf. interval] | |
|---------------------|-------------|-----------|--------|-------|----------------------|-----------|
| warmth | .961837 | .0581809 | 16.53 | 0.000 | .8478046 | 1.075869 |
| physical_punishment | -.8457672 | .0798128 | -10.60 | 0.000 | -1.002197 | -.6893369 |
| 2.group | 1.084409 | .2200548 | 4.93 | 0.000 | .6531099 | 1.515709 |
| _cons | 51.64797 | .4645466 | 111.18 | 0.000 | 50.73748 | 52.55847 |

| Random-effects parameters | | Estimate | Std. err. | [95% conf. interval] | |
|---------------------------|---------------|----------|-----------|----------------------|----------|
| country: Identity | | | | | |
| | var(_cons) | 3.403 | .9717558 | 1.944438 | 5.955659 |
| | var(Residual) | 36.01911 | .9346952 | 34.23295 | 37.89847 |

LR test vs. linear model: chibar2(01) = 200.29

Prob >= chibar2 = 0.0000

Generate Predicted Values *At Specified Values* With margins

```
. margins group, at(warmth = (1 2 3 4 5 6 7)) // predictive *margins*
Predictive margins                                     Number of obs = 3,000
Expression: Linear prediction, fixed portion, predict()
1._at: warmth = 1
2._at: warmth = 2
3._at: warmth = 3
4._at: warmth = 4
5._at: warmth = 5
6._at: warmth = 6
7._at: warmth = 7
```

| | Delta-method | | | | | |
|-----------|--------------|-----------|--------|-------|----------------------|----------|
| | Margin | std. err. | z | P> z | [95% conf. interval] | |
| _at#group | | | | | | |
| 1 1 | 50.4999 | .3983539 | 126.77 | 0.000 | 49.71914 | 51.28066 |
| 1 2 | 51.58431 | .3994365 | 129.14 | 0.000 | 50.80143 | 52.36719 |
| 2 1 | 51.46174 | .3809288 | 135.10 | 0.000 | 50.71513 | 52.20834 |
| 2 2 | 52.54615 | .38173 | 137.65 | 0.000 | 51.79797 | 53.29432 |
| 3 1 | 52.42357 | .371884 | 140.97 | 0.000 | 51.6947 | 53.15245 |
| 3 2 | 53.50798 | .3723656 | 143.70 | 0.000 | 52.77816 | 54.23781 |
| 4 1 | 53.38541 | .3718315 | 143.57 | 0.000 | 52.65664 | 54.11419 |
| 4 2 | 54.46982 | .3719738 | 146.43 | 0.000 | 53.74077 | 55.19888 |
| 5 1 | 54.34725 | .3807751 | 142.73 | 0.000 | 53.60094 | 55.09355 |
| 5 2 | 55.43166 | .3805823 | 145.65 | 0.000 | 54.68573 | 56.17759 |
| 6 1 | 55.30909 | .398109 | 138.93 | 0.000 | 54.52881 | 56.08937 |
| 6 2 | 56.3935 | .397607 | 141.83 | 0.000 | 55.6142 | 57.17279 |
| 7 1 | 56.27092 | .4228024 | 133.09 | 0.000 | 55.44225 | 57.0996 |
| 7 2 | 57.35533 | .4220306 | 135.90 | 0.000 | 56.52817 | 58.1825 |

Graph With marginsplot

```
. marginsplot // plot of predicted values
Variables that uniquely identify margins: warmth group

. graph export mymarginsplot.png, width(1500) replace
file /Users/agrogan/Desktop/GitHub/multilevel/visualizing-MLM/mymarginsplot.png
saved as PNG format
```

Curvilinear and Linear Fits

Random Effects

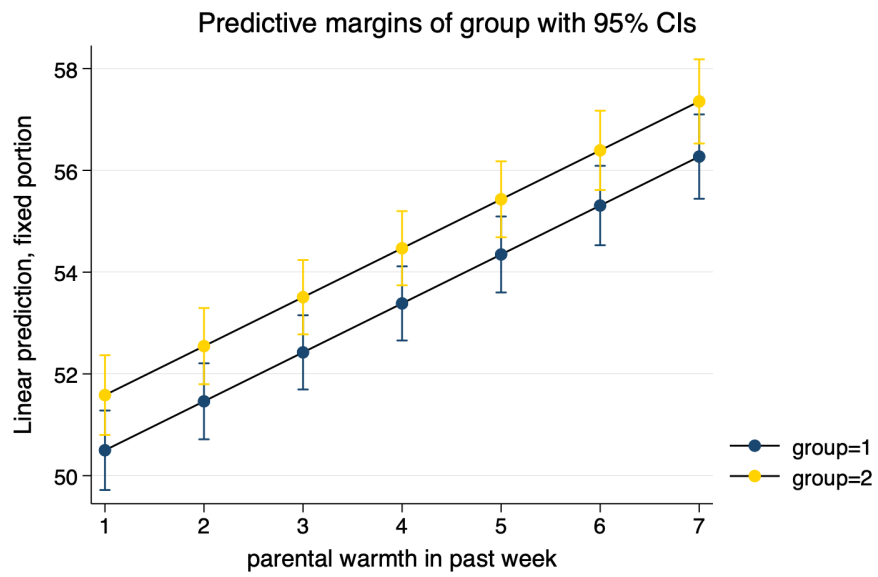


Figure 9: Predicted Values From `margins` and `marginsplot`