Visualizing Multilevel Models

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1 Mar 2023 15:07:48

Introduction

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

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 would 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-multi
> level-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
```

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
```

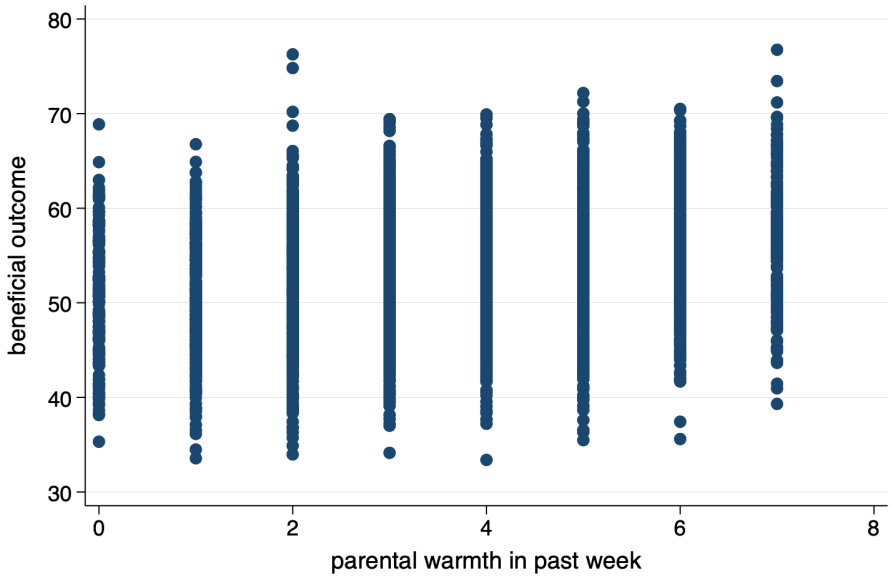

Figure 1: Scatterplot

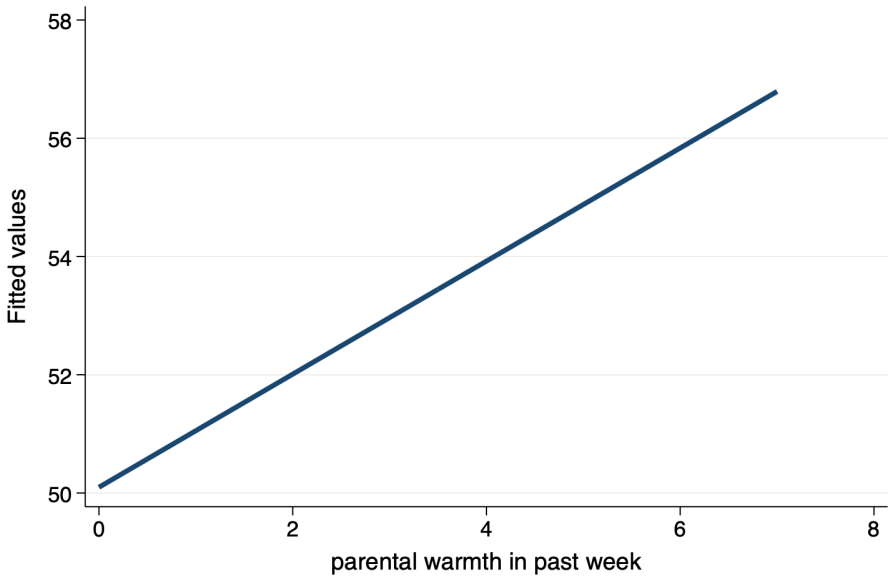

Figure 2: Scatterplot

```
as PNG format
```

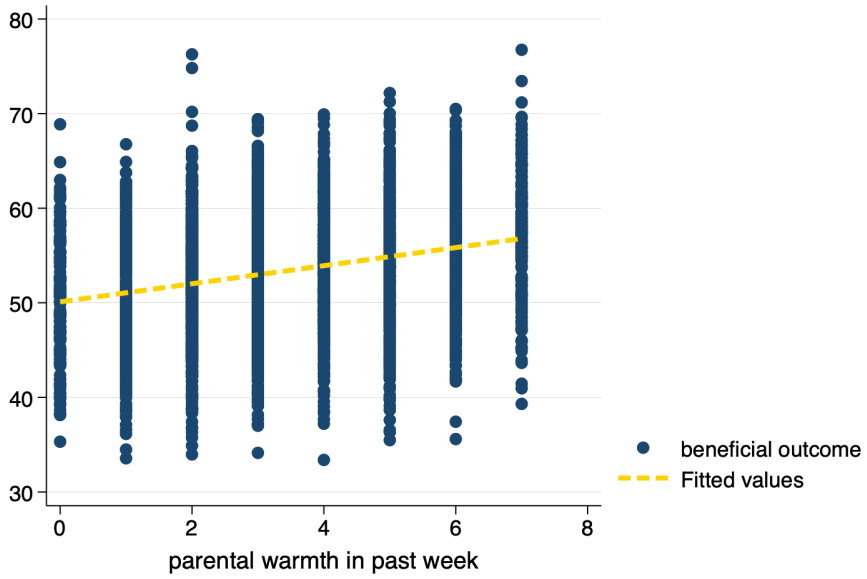

Figure 3: Scatterplot and Linear Fit

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
```

Spaghetti Plot With Predicted Values

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) aspect(1
> )

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

Multivariate (Predicted) Relationships

Using Predicted Values

Estimate The Model

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

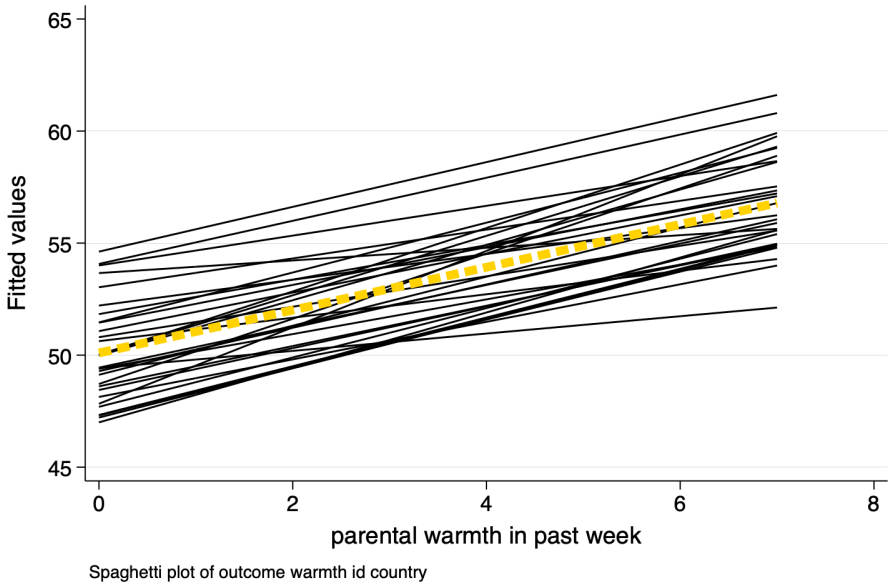

Figure 4: Spaghetti Plot

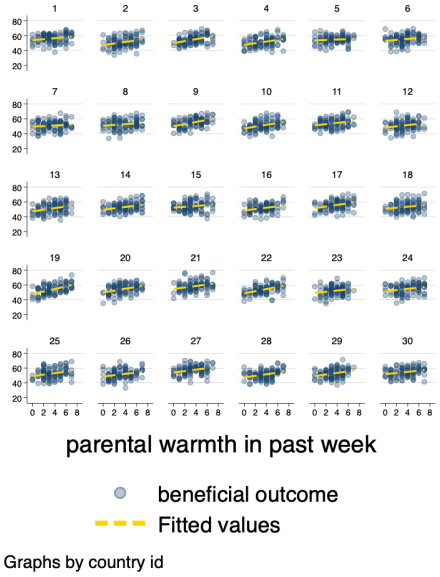

Figure 5: Small Multiples

```
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
Log likelihood = -9668.0859                     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
```

`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                     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
Log likelihood = -9668.0859                     Prob > chi2       =     0.0000
```

outcome	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]

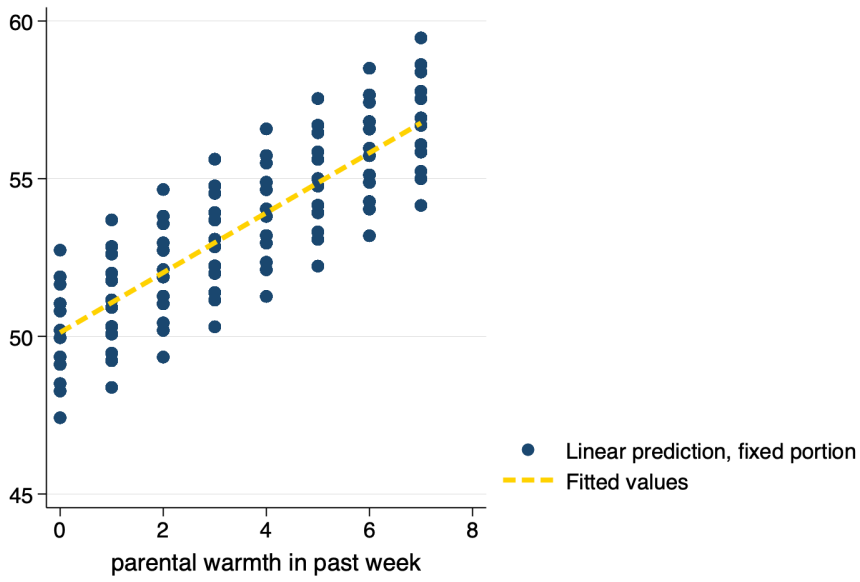

Figure 6: Predicted Values From `predict`

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
```

	Margin	Delta-method 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
```

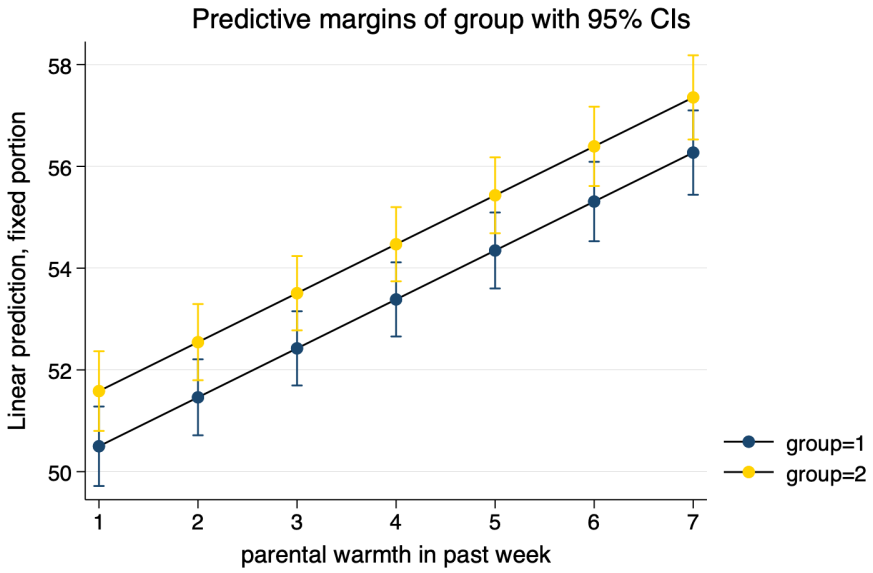

Figure 7: Predicted Values From `margins` and `marginsplot`

Curvilinear and Linear Fits

Random Effects