

Visualizing Multilevel Models

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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 `slcolor` 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-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
```

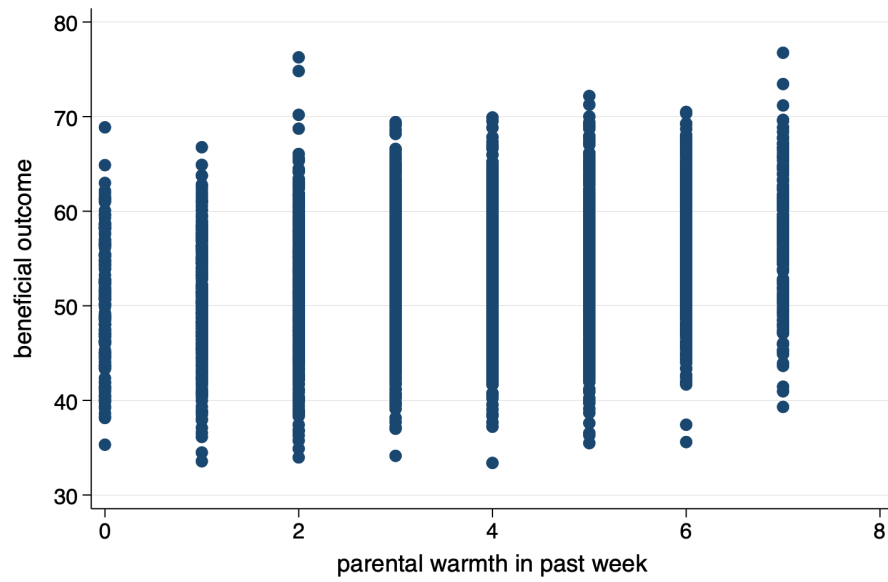


Figure 1: Scatterplot

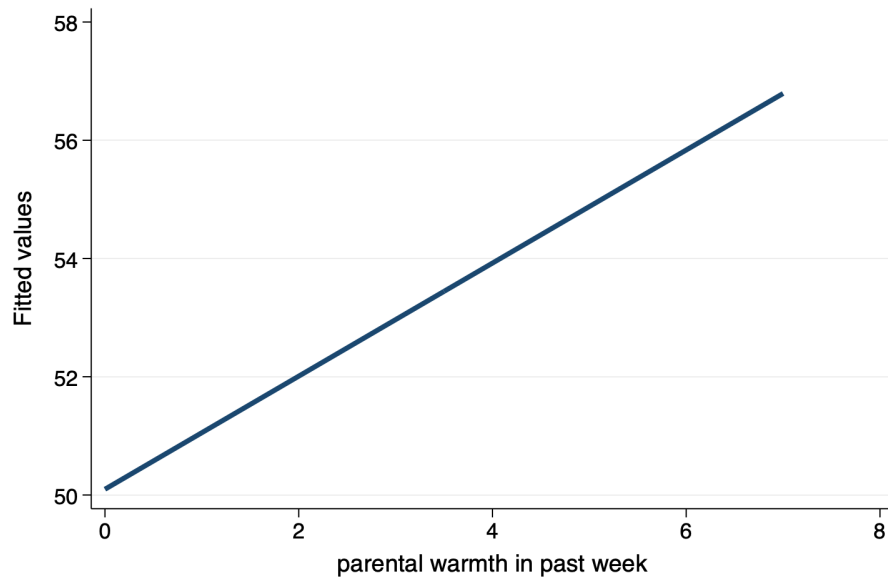


Figure 2: Scatterplot

as PNG format

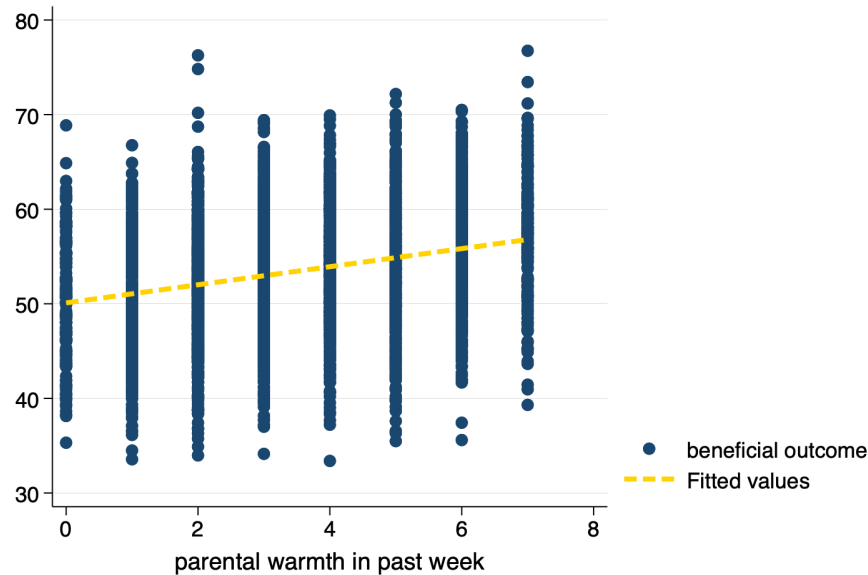


Figure 3: Scatterplot and Linear Fit

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
```

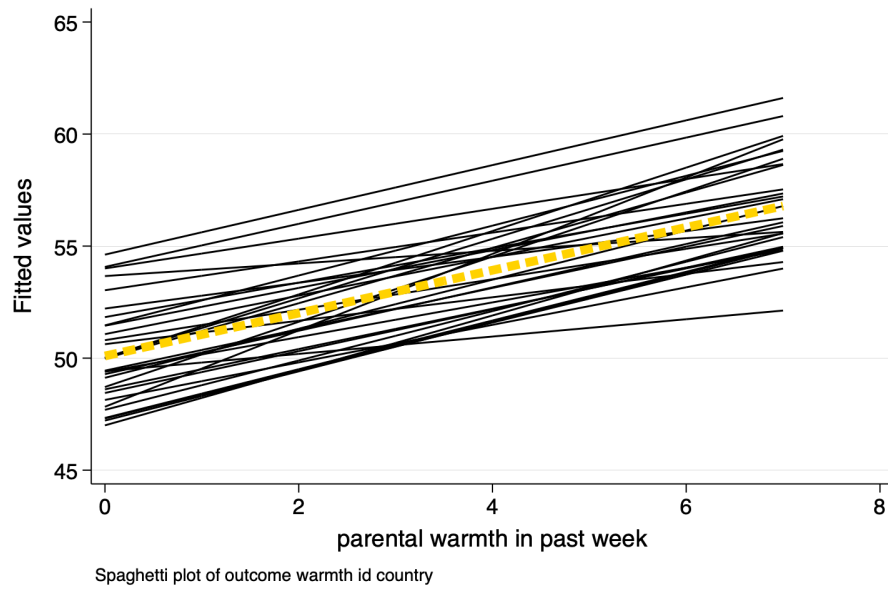
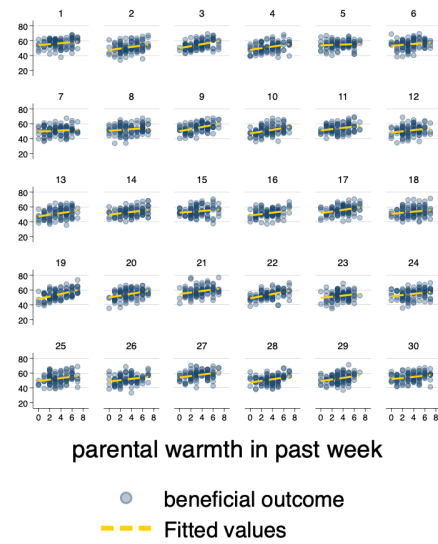


Figure 4: Spaghetti Plot



Graphs by country id

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
                                         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

```

. 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
                                         Prob > chi2     =       0.0000
Log likelihood = -9668.0859

```

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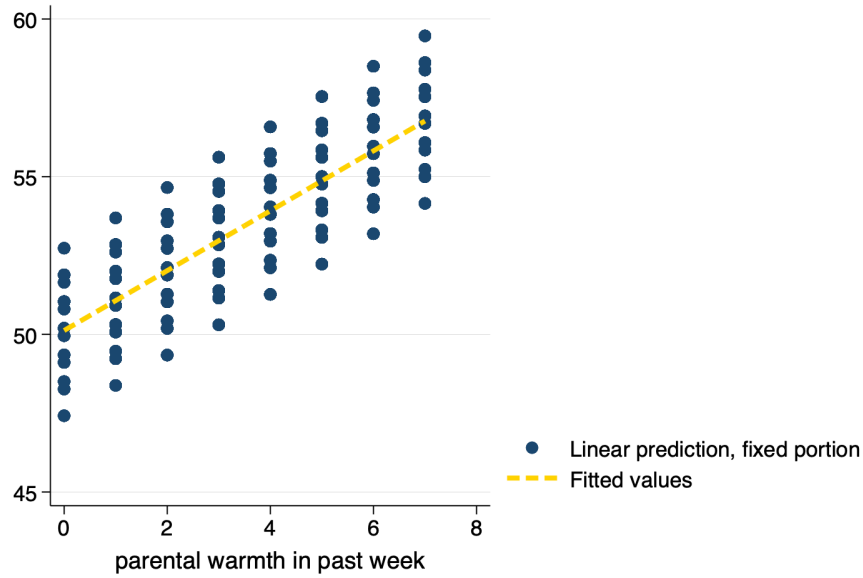


Figure 6: Predicted Values From predict

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
```

	Delta-method				[95% conf. interval]	
	Margin	std. err.	z	P> z		
_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
```

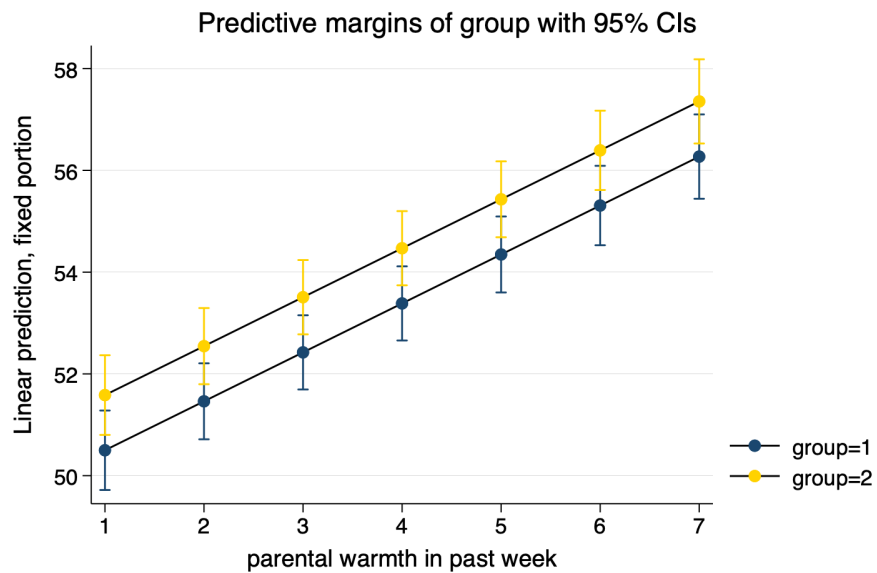


Figure 7: Predicted Values From margins and marginsplot

Curvilinear and Linear Fits

Random Effects