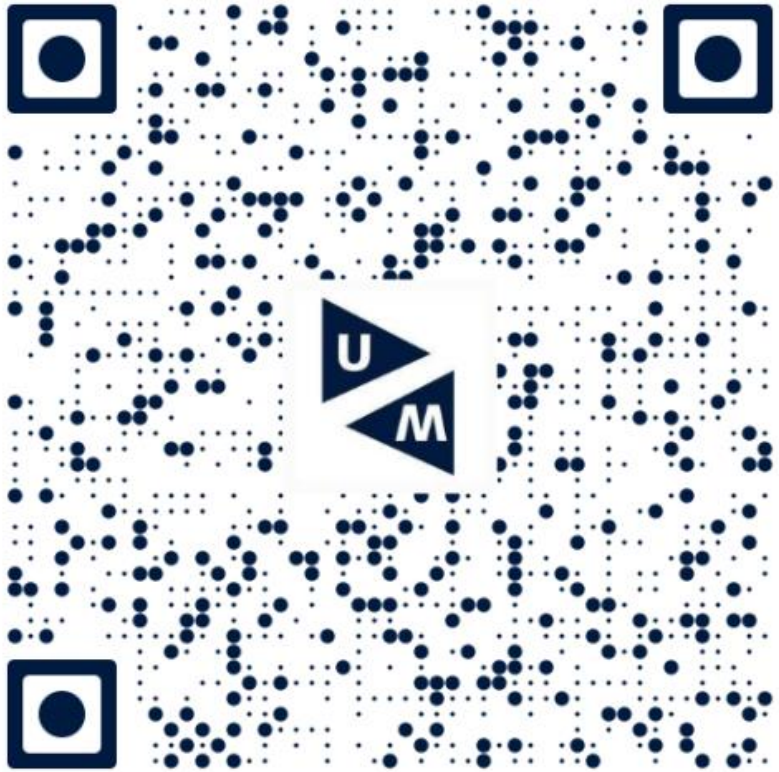
Session Evaluation



Expanding the Model

Estimated Marginal Means, Covariates, and Random Effects

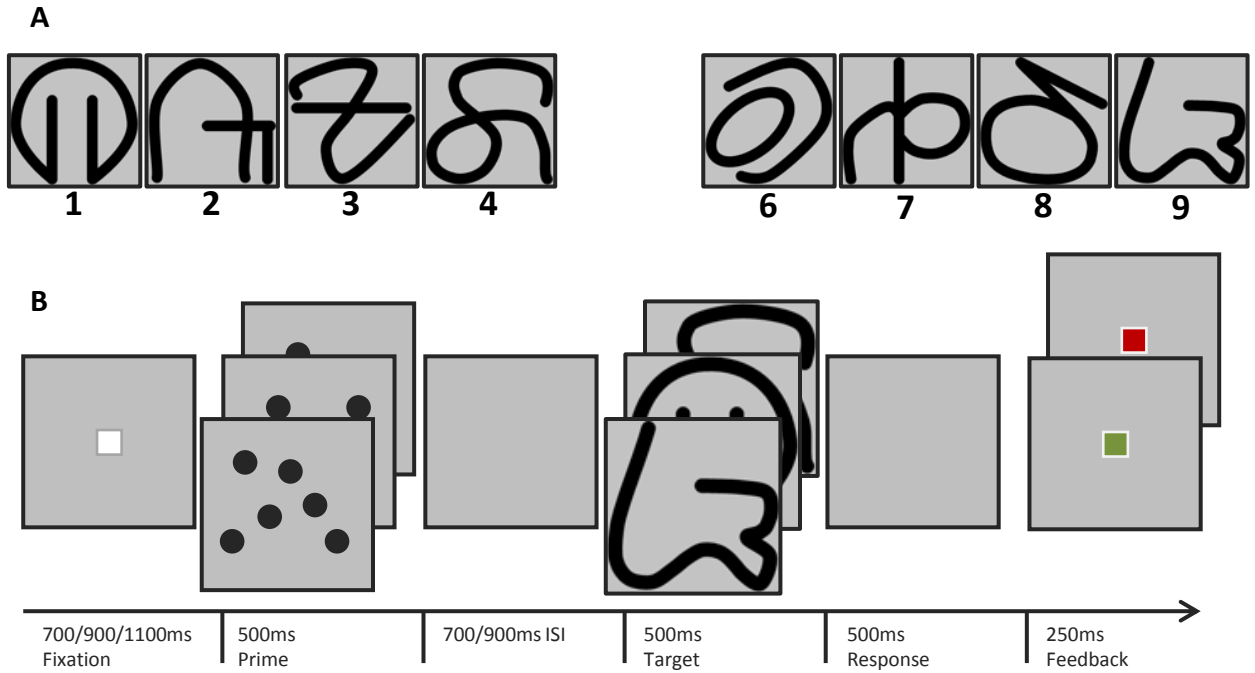
Welcome

This Session

- What are Estimated Marginal Means
- What are covariates
- Using EMMs and Covariates to check for moderation
- Dealing with Random Slopes and Intercepts

01 Estimated Marginal Means

Last Time



Type III Tests of Fixed Effects

Source	DF	F	Sig.
Intercept	24.132	18995.535	.000
Session	**343.185**	**70.955**	**.000**
Hemisphere	**343.756**	**63.420**	**.000**
Prime	**344.281**	**671.031**	**.000**
Target	**343.559**	**414.250**	**.000**
Session * Hemisphere	342.950	0.272	.603
Session * Prime	**344.428**	**186.437**	**.000**
Session * Target	340.544	0.003	.956
Hemisphere * Prime	345.203	0.073	.788
Hemisphere * Target	343.152	3.531	.061
Prime * Target	**344.165**	**19.956**	**.000**
Session * Hemisphere * Target	**347.960**	**17.249**	**.000**
Session * Prime * Target	344.887	3.624	.058

Estimated Marginal Means

```
MIXED Visual_Response BY Session Hemisphere Prime Target
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Session Hemisphere Prime Target Session*Hemisphere Session*Prime Session*Target
    Hemisphere*Prime Hemisphere*Target Prime*Target Session*Hemisphere*Target
    Session*Prime*Target  | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION R
  /REPEATED=Session*Hemisphere*Prime*Target | SUBJECT(PP) COVTYPE(CSH).
```

Estimated Marginal Means

```
MIXED Visual_Response BY Session Hemisphere Prime Target
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Session Hemisphere Prime Target Session*Hemisphere Session*Prime Session*Target
    Hemisphere*Prime Hemisphere*Target Prime*Target Session*Hemisphere*Target
    Session*Prime*Target  | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION R
  /REPEATED=Session*Hemisphere*Prime*Target | SUBJECT(PP) COVTYPE(CSH)
  /EMMEANS=TABLES(Session) COMPARE ADJ(SIDAK)
  /EMMEANS=TABLES(Session*Prime).
```

Estimated Marginal Means

```
MIXED Visual_Response BY Session Hemisphere Prime Target
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Session Hemisphere Prime Target Session*Hemisphere Session*Prime Session*Target
    Hemisphere*Prime Hemisphere*Target Prime*Target Session*Hemisphere*Target
    Session*Prime*Target  | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION R
  /REPEATED=Session*Hemisphere*Prime*Target | SUBJECT(PP) COVTYPE(CSH)
  /EMMEANS=TABLES(Session) COMPARE ADJ(SIDAK)
  /EMMEANS=TABLES(Session*Prime) COMPARE(Session) ADJ(SIDAK).
```

Estimated Marginal Means

```
MIXED Visual_Response BY Session Hemisphere Prime Target
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Session Hemisphere Prime Target Session*Hemisphere Session*Prime Session*Target
    Hemisphere*Prime Hemisphere*Target Prime*Target Session*Hemisphere*Target
    Session*Prime*Target  | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION R
  /REPEATED=Session*Hemisphere*Prime*Target | SUBJECT(PP) COVTYPE(CSH)
  /EMMEANS=TABLES(Session) COMPARE ADJ(SIDAK)
  /EMMEANS=TABLES(Session*Prime) COMPARE(Session) ADJ(SIDAK)
  /EMMEANS=TABLES(Session*Prime) COMPARE(Prime) ADJ(SIDAK)
  /EMMEANS=TABLES(Session*Prime*Target) COMPARE(Session) ADJ(SIDAK)
  /EMMEANS=TABLES(Session*Hemisphere*Target) COMPARE(Session) ADJ(SIDAK).
```

Estimated Marginal Means

Estimates of Fixed Effects

Parameter	Estimate	Std. Error	df	t	Sig.
Intercept	-2.099334 (β_0)	.095524	34.630	-21,977	.000
X_1 - [Session=1]	0.088284 (β_1)	.138783	83.107	0.636	.526
X_2 - [Hemisphere=0]	-0.268412 (β_2)	.126612	113.425	-2.120	.036
X_3 - [Prime=0]	-1.777300 (β_3)	.118407	89.862	-15.010	.000
X_4 - [Target=0]	-0.643985 (β_4)	.144279	89.972	-4.463	.000
X_5 - [Session=1] * [Hemisphere=0]	-0.511187 (β_5)	.156703	179.406	-3.262	.001
X_6 - [Session=1] * [Prime=0]	1.266037 (β_6)	.155710	189.037	8.131	.000
X_7 - [Session=1] * [Target=0]	-0.668476 (β_7)	.197265	159.145	-3.389	.001
X_8 - [Hemisphere=0] * [Prime=0]	-0.029592 (β_8)	.109820	345.203	-0.269	.788
X_9 - [Hemisphere=0] * [Target=0]	-0.248907 (β_9)	.157123	175.478	-1.584	.115
X_{10} - [Prime=0] * [Target=0]	-0.691462 (β_{10})	.156733	186.827	-4.412	.000
X_{11} - [Session=1] * [Hemisphere=0] * [Target=0]	0.908256 (β_{11})	.218691	347.960	4.153	.000
X_{12} - [Session=1] * [Prime=0] * [Target=0]	0.416681 (β_{12})	.218891	344.887	1.904	.058

$$\hat{Y} = \beta_0 + (x_1\beta_1)+(x_2\beta_2) +(x_3\beta_3) +(x_4\beta_4) +(x_5\beta_5) +(x_6\beta_6) +(x_7\beta_7) +(x_8\beta_8) +(x_9\beta_9) +(x_{10}\beta_{10}) +(x_{11}\beta_{11}) +(x_{12}\beta_{12})$$

Estimated Marginal Means

$$\hat{Y} = -2.099 + (x_1 0.088) + (x_2 - 0.268) + (x_3 - 1.777) + (x_4 - 0.644) + (x_5 - 0.511) + (x_6 1.266) + \ldots$$
$$(x_7 - 0.668) + (x_8 - 0.029) + (x_9 - 0.249) + (x_{10} - 0.691) + (x_{11} 0.908) + (x_{12} 0.417)$$

Session	Hemisphere	Prime	Target	Predicted
1	Left	Low	Low	-4,259
1	Right	Low	Low	-4,110
1	Left	High	Low	-3,444
1	Right	High	Low	-3,324
1	Left	Low	High	-3,332
1	Right	Low	High	-2,522
1	Left	High	High	-2,791
1	Right	High	High	-2,011
3	Left	Low	Low	-5,759
3	Right	Low	Low	-5,212
3	Left	High	Low	-3,261
3	Right	High	Low	-2,743
3	Left	Low	High	-4,175
3	Right	Low	High	-3,877
3	Left	High	High	-2,368
3	Right	High	High	-2,099

Session	Prime	Predicted
1	Low	-3,556
1	High	-2,892
3	Low	-4,756
3	High	-2,618

Estimated Marginal Means

2. Session * Prime

Estimates[a]

Session	Prime	Mean	Std. Error	df	95% Confidence Interval	
					Lower Bound	Upper Bound
1	Low	-3,556	,052	87,314	-3,659	-3,452
	High	-2,892	,053	86,763	-2,997	-2,788
3	Low	-4,756	,050	89,428	-4,855	-4,656
	High	-2,618	,058	89,844	-2,733	-2,503

a. Dependent Variable: Visual_Response.

Session	Prime	Predicted
1	Low	-3,556
1	High	-2,892
3	Low	-4,756
3	High	-2,618

Pairwise Comparisons[a]

Prime	(I) Session	(J) Session	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
Low	1	3	1,200*	,074	188,717	,000	1,054	1,346
	3	1	-1,200*	,074	188,717	,000	-1,346	-1,054
High	1	3	-,274*	,080	188,513	,001	-,432	-,117
	3	1	,274*	,080	188,513	,001	,117	,432

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

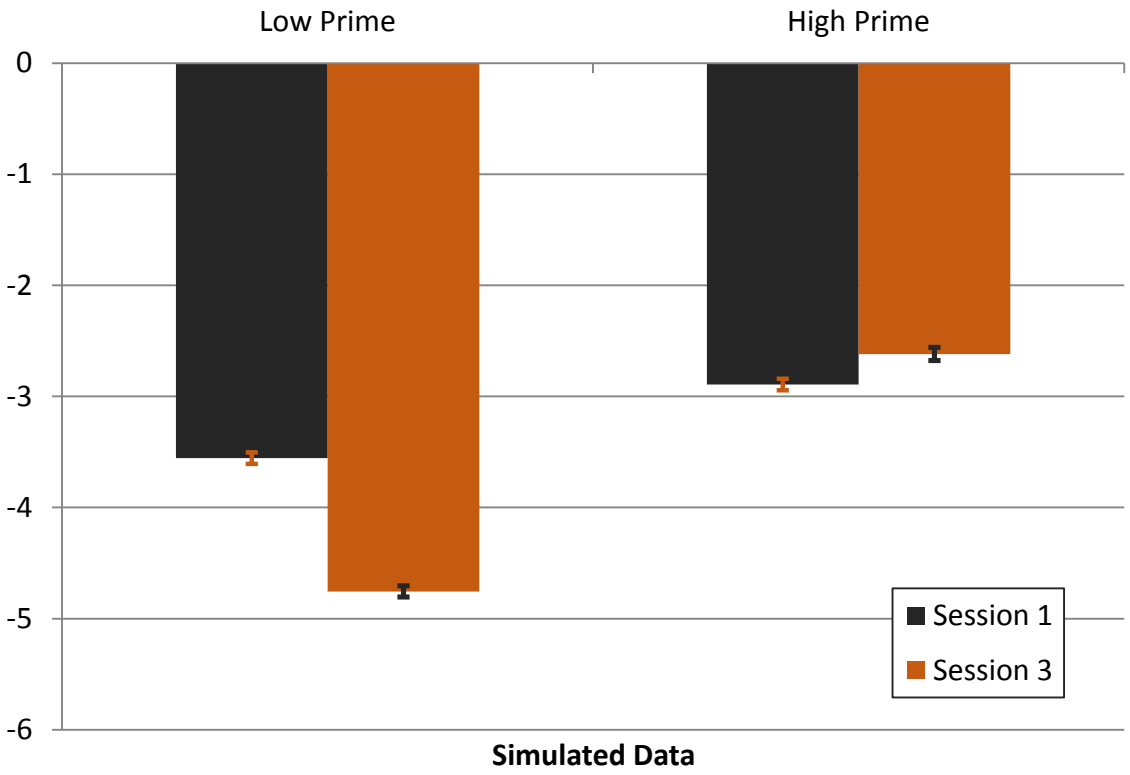
a. Dependent Variable: Visual_Response.

c. Adjustment for multiple comparisons: Sidak.

Post-Hoc Results

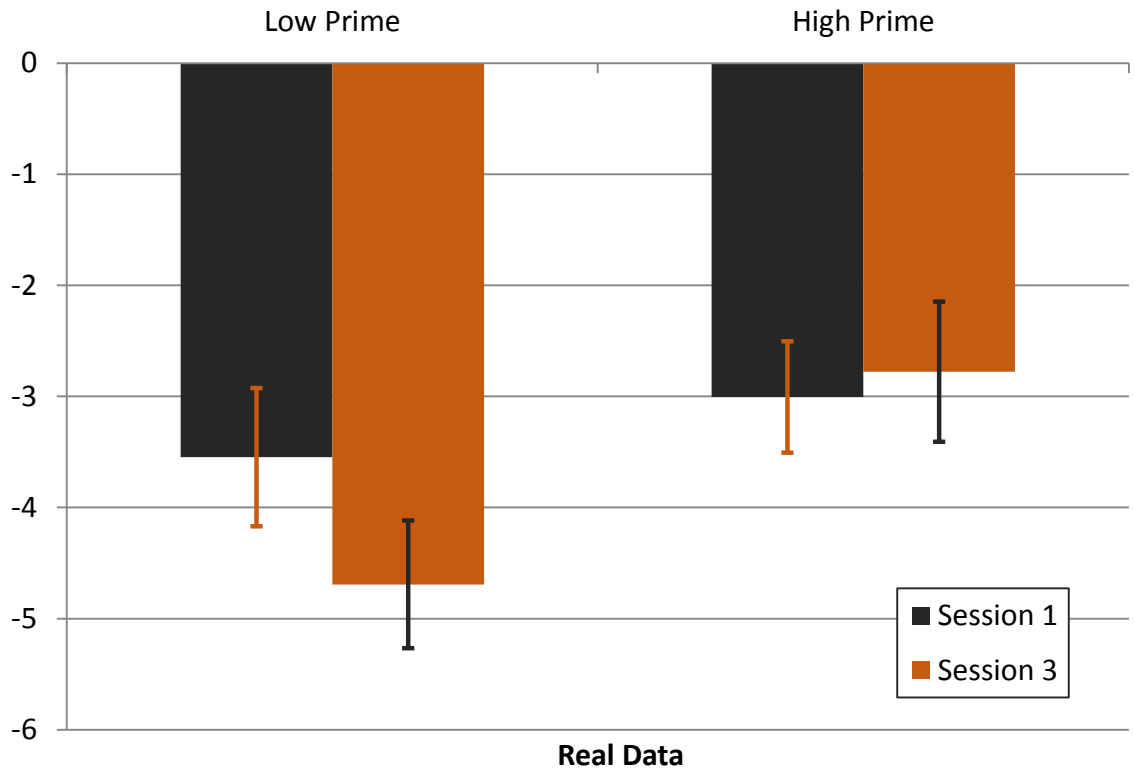
Session*Prime Pairwise Comparisons

Prime	Mean Difference (Ses1-Ses3)	SE	df	Sig.	95% CI for Difference LB	UB
Low	1,200*	,074	188,717	,000	1,054	1,346
High	-,274*	,080	188,513	,001	-,432	-,117



Session*Prime Pairwise Comparisons

Dots	Mean Difference (Ses1-Ses3)	SE	df	Sig.
Low	1,146*	,455	19,868	,020
High	-,228	,426	19,097	,599



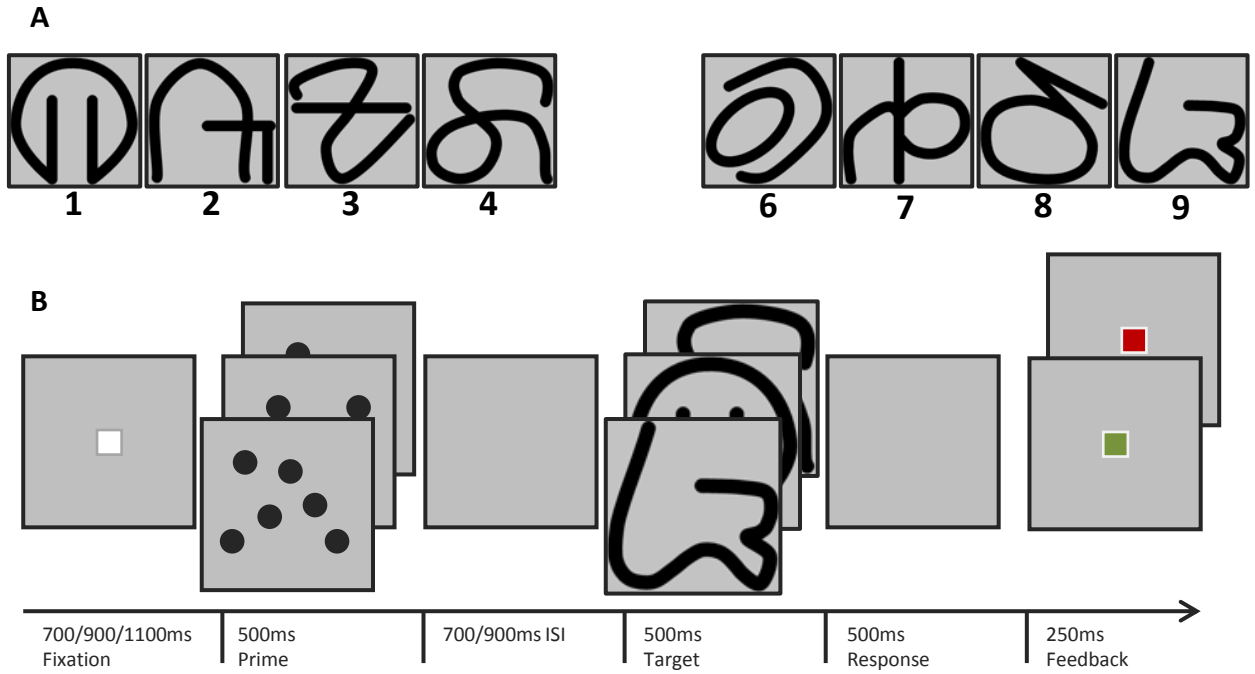
01 Covariates

Covariates

A covariate is a Continuous Predictor, nothing more

When we say **Covariate** we mean a **Continuous Predictor**, whereas **Factors are categorical**

Second Analysis



The previous analysis was done on the **Visual Response**, the brain reacting to seeing something.

Now we will analyze the **Numeric Response**, the brain processing the numerical information that the symbol represents.

First we will do the same analysis as before (without covariates), and then we will take the **Visual Response** into account (with covariates).

Without Covariates

Type III Tests of Fixed Effects

Source	Denominator df	F	Sig.
Intercept	24	2452.170	.000
Session	**360**	**46.769**	**.000**
Hemisphere	**360**	**92.950**	**.000**
Prime	**360**	**42.937**	**.000**
Target	**360**	**29.705**	**.000**
Session * Hemisphere	360	2.408	.122
Session * Prime	**360**	**6.259**	**.013**
Session * Target	**360**	**15.441**	**.000**
Hemisphere * Prime	360	0.533	.466
Hemisphere * Target	360	3.177	.076
Prime * Target	**360**	**14.304**	**.000**
Session * Hemisphere * Prime	360	0.010	.922
Session * Hemisphere * Target	360	0.122	.727
Session * Prime * Target	360	1.469	.226
Hemisphere * Prime * Target	360	1.005	.317
Session * Hemisphere * Prime * Target	360	0.373	.542

A Grand Total of 97 Levels
A Covariance Structure with 136 Values
A Total of 152 Parameters to Estimate

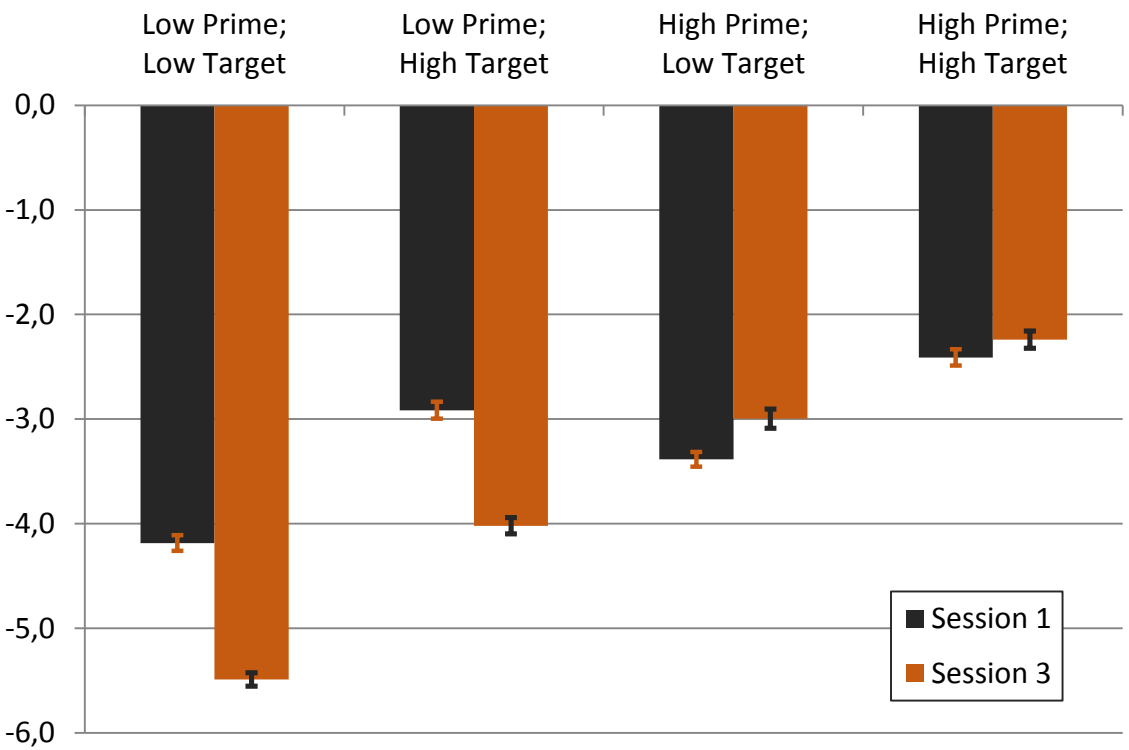
Without Covariates

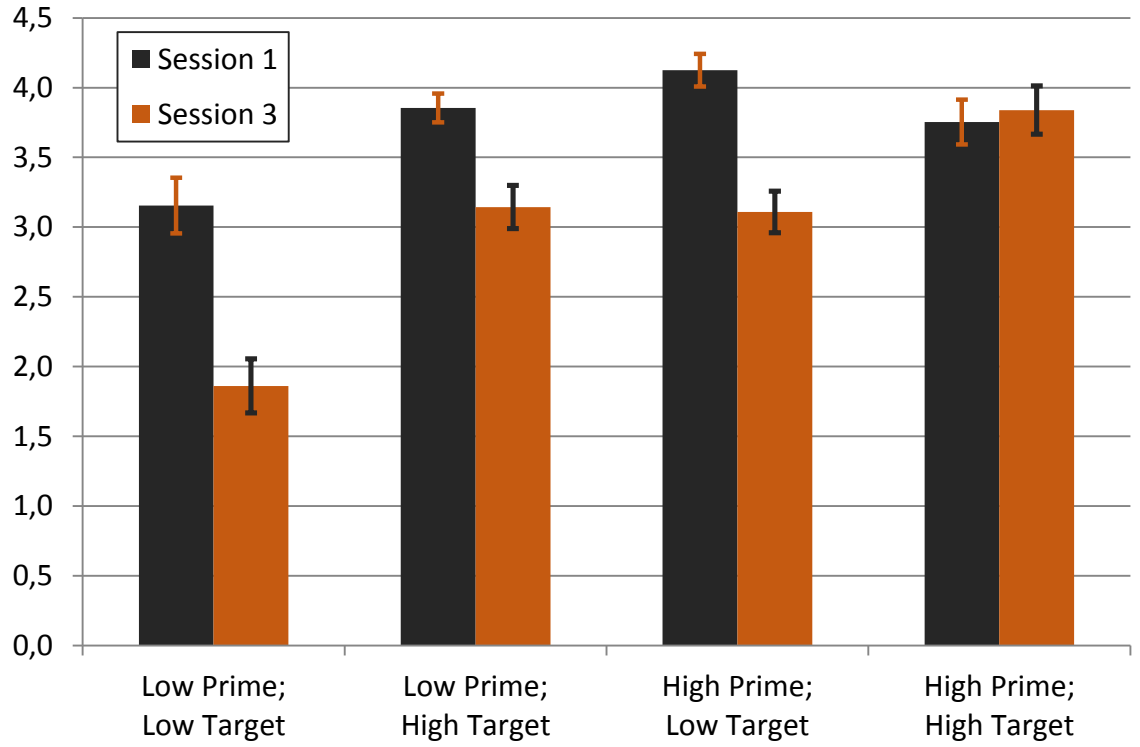
Type III Tests of Fixed Effects

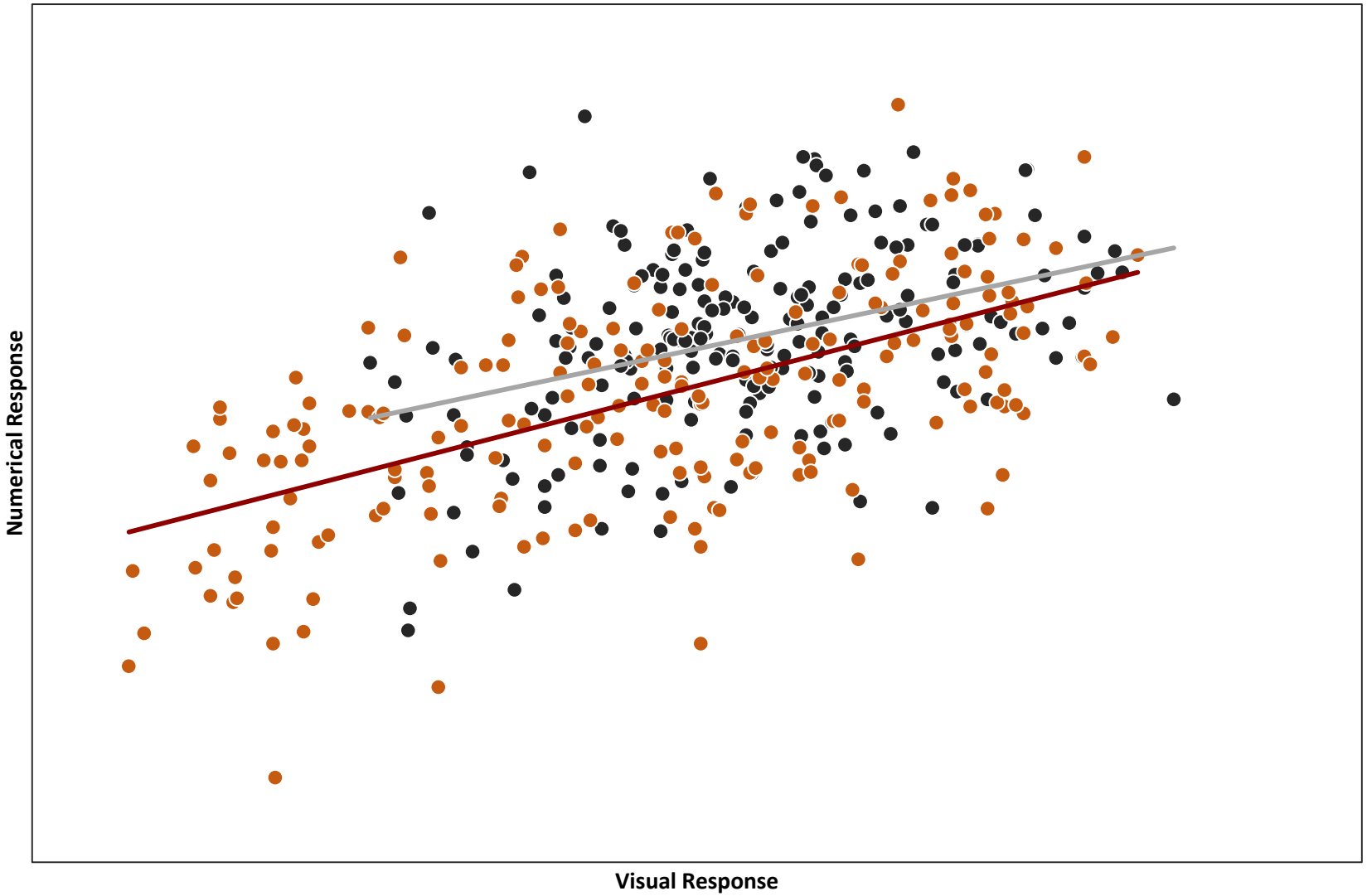
Source	Sig.	Sig.	Sig.	Sig.	Sig.	Source
Intercept	.000	.000	.000	.000	.000	Intercept
Session	.000	.000	.000	.000	.000	Session
Hemisphere	.000	.000	.000	.000	.000	Hemisphere
Prime	.000	.000	.000	.000	.000	Prime
Target	.000	.000	.000	.000	.000	Target
Session * Hemisphere	.114	.096	.106	.107	.107	Session * Hemisphere
Session * Prime	.011	.011	.013	.013	.011	Session * Prime
Session * Target	.000	.000	.000	.000	.000	Session * Target
Hemisphere * Prime	.456	.455	.472	.465	.455	Hemisphere * Prime
Hemisphere * Target	.069	.075	.054	.053	.048	Hemisphere * Target
Prime * Target	.000	.000	.000	.000	.000	Prime * Target
Session * Hemisphere * Prime	.921	.908	.912			
Session * Hemisphere * Target	.722	.783	.734	.723		
Session * Prime * Target	.217	.236	.217	.217	.211	Session * Prime * Target
Hemisphere * Prime * Target	.307	.326				
Session * Hemisphere * Prime * Target	.534					

Structure	Parameters	-2LL	AIC	BIC
UN	152	1053.529	1325.529	1862.816
TPH	47	1176.630	1238.630	1361.099
ARH(1)	33	1191.007	1225.007	1292.168
CSH	**33**	**1190.084**	**1224.084**	**1291.245**
TP	32	1192.569	1224.569	1287.779
AR(1)	18	1207.514	1211.514	1219.416
CS	18	1206.685	1210.685	1218.587

Estimated Marginal Means







Session	Correlation	Sig.
1	.387	<.001
3	.583	<.001
Overall	.537	<.001

…and now something scary…

Type III Tests of Fixed Effects

Source	Denominator df	F	Sig.
Intercept	368.000	251.145	.000
Session	366.527	.309	.579
Hemisphere	361.385	2.242	.135
Prime	359.931	1.545	.215
Target	363.405	4.668	.031
Session * Hemisphere	365.265	.000	.986
Session * Prime	367.845	1.953	.163
Session * Target	367.620	.143	.706
Hemisphere * Prime	366.721	.083	.774
Hemisphere * Target	366.152	.082	.774
Prime * Target	362.653	2.613	.107
Session * Hemisphere * Prime	362.349	.431	.512
Session * Hemisphere * Target	367.194	.318	.573
Session * Prime * Target	364.155	.267	.605
Hemisphere * Prime * Target	364.909	.239	.625
Session * Hemisphere * Prime * Target	367.777	.043	.836
Visual_Response	**363.676**	**45.150**	**.000**
Session * Visual_Response	**367.001**	**.091**	**.764**
Hemisphere * Visual_Response	**361.058**	**8.404**	**.004**
Prime * Visual_Response	**361.507**	**.471**	**.493**
Target * Visual_Response	**364.146**	**3.456**	**.064**
Session * Hemisphere * Visual_Response	**365.626**	**.028**	**.867**
Session * Prime * Visual_Response	**367.975**	**1.475**	**.225**
Session * Target * Visual_Response	**367.907**	**.006**	**.940**
Hemisphere * Prime * Visual_Response	**367.615**	**.227**	**.634**
Hemisphere * Target * Visual_Response	**364.356**	**.308**	**.579**
Prime * Target * Visual_Response	**365.326**	**2.608**	**.107**
Session * Hemisphere * Prime * Visual_Response	**363.273**	**.111**	**.739**
Session * Hemisphere * Target * Visual_Response	**366.379**	**.921**	**.338**
Session * Prime * Target * Visual_Response	**363.339**	**.047**	**.828**
Hemisphere * Prime * Target * Visual_Response	**362.762**	**.185**	**.668**
Session * Hemisphere * Prime * Target * Visual_Response	**367.786**	**.060**	**.806**

A Grand Total of 178 Levels (+81)
A Covariance Structure with 136 Values
A Total of 168 (+16) Parameters to Estimate

Structure	Parameters	-2LL	AIC	BIC
UN	168	993.295	1265.295	1796.794
TPH	63	1114.071	1176.071	1297.222
ARH(1)	49	1127.669	1161.669	1228.106
CSH	**49**	**1127.877**	**1161.877**	**1228.314**
TP	48	1131.943	1163.943	1226.473
AR(1)	34	1145.948	1149.948	1157.764
CS	34	1146.344	1150.344	1158.161

Model Including Covariate

Type III Tests of Fixed Effects

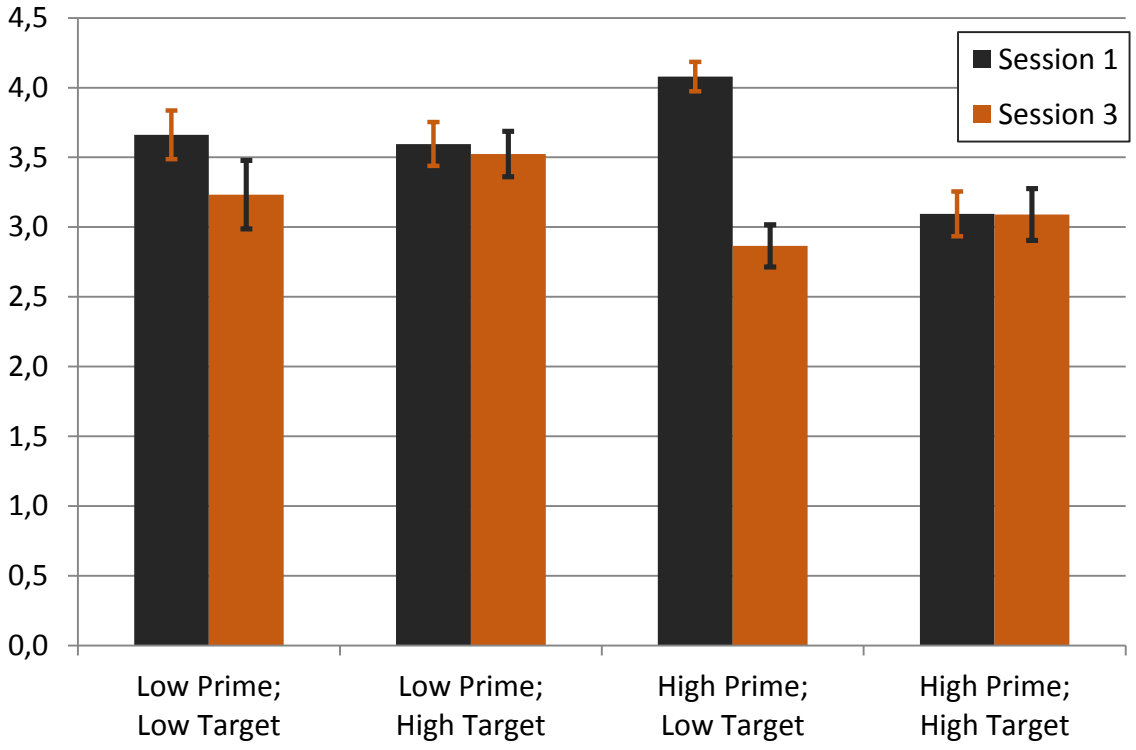
Source	Sig.	Sig.	Sig.	Sig.	Sig.	Before	Source
Intercept	.000	.000	.000	.000	.000	.000	Intercept
Session	.000	.000	.000	.000	.000	.000	Session
Hemisphere	.058	.072	.134	.279	.272	.000	Hemisphere
Prime	.121	.128	.126	.118	.159	.000	Prime
Target	.306	.319	.296	.238	.330	.000	Target
Session * Hemisphere	.606	.518	.478	.265	.298	.107	Session * Hemisphere
Session * Prime	.065	.068	.064	.060	.125	.011	Session * Prime
Session * Target	.000	.000	.000	.000	.000	.000	Session * Target
Hemisphere * Prime	.003	.004	.007	.014	.011	.455	Hemisphere * Prime
Hemisphere * Target	.727	.725	.969	.654	.567	.048	Hemisphere * Target
Prime * Target	.017	.020	.020	.022	.016	.000	Prime * Target
Session * Hemisphere * Prime	.180	.196	.272				Session * Hemisphere * Prime
Session * Hemisphere * Target	.061	.087	.059	.070			Session * Hemisphere * Target
Session * Prime * Target	.034	.036	.031	.033	.034	.211	Session * Prime * Target
Hemisphere * Prime * Target	.110	.137					Hemisphere * Prime * Target
Session * Hemisphere * Prime * Target	.238						Session * Hemisphere * Prime * Target
Visual_Response	.000	.000	.000	.000	.000		Visual_Response
Hemisphere * Visual_Response	.002	.002	.005	.010	.008		Hemisphere * Visual_Response

Estimated Marginal Means

Values of the **Numeric Response**

IF

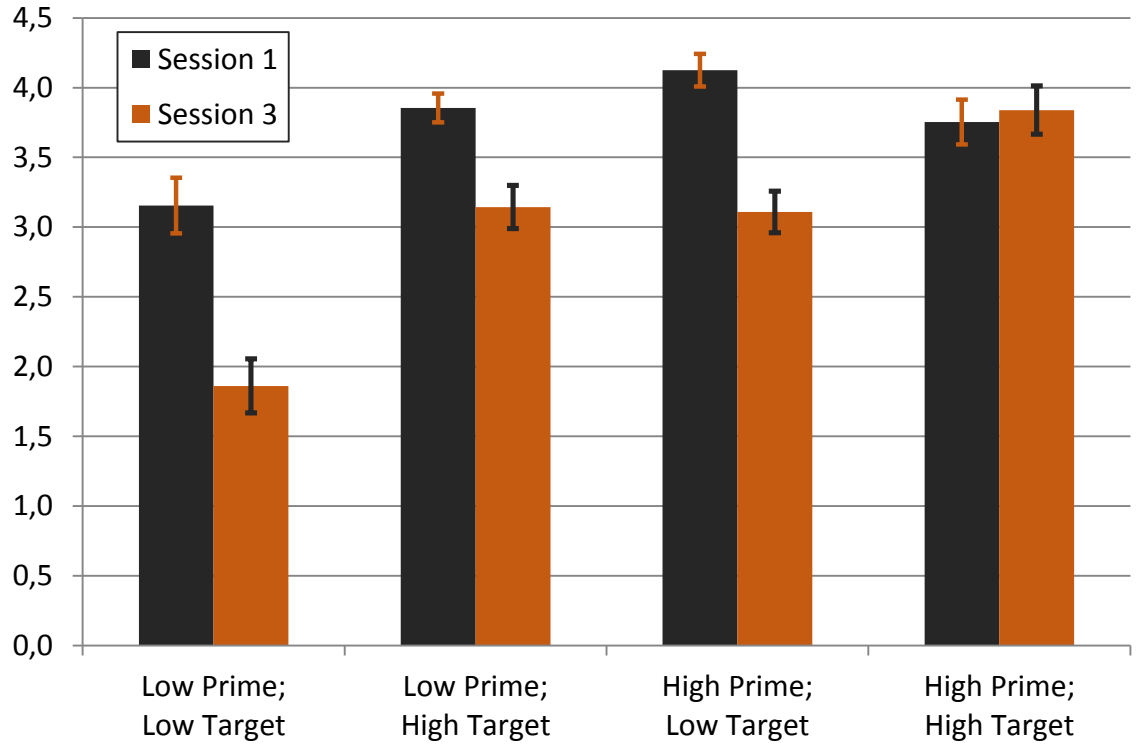
The **Visual Response** is -3.455



Values of the **Numeric Response**

IF

The **Visual Response** is not constant



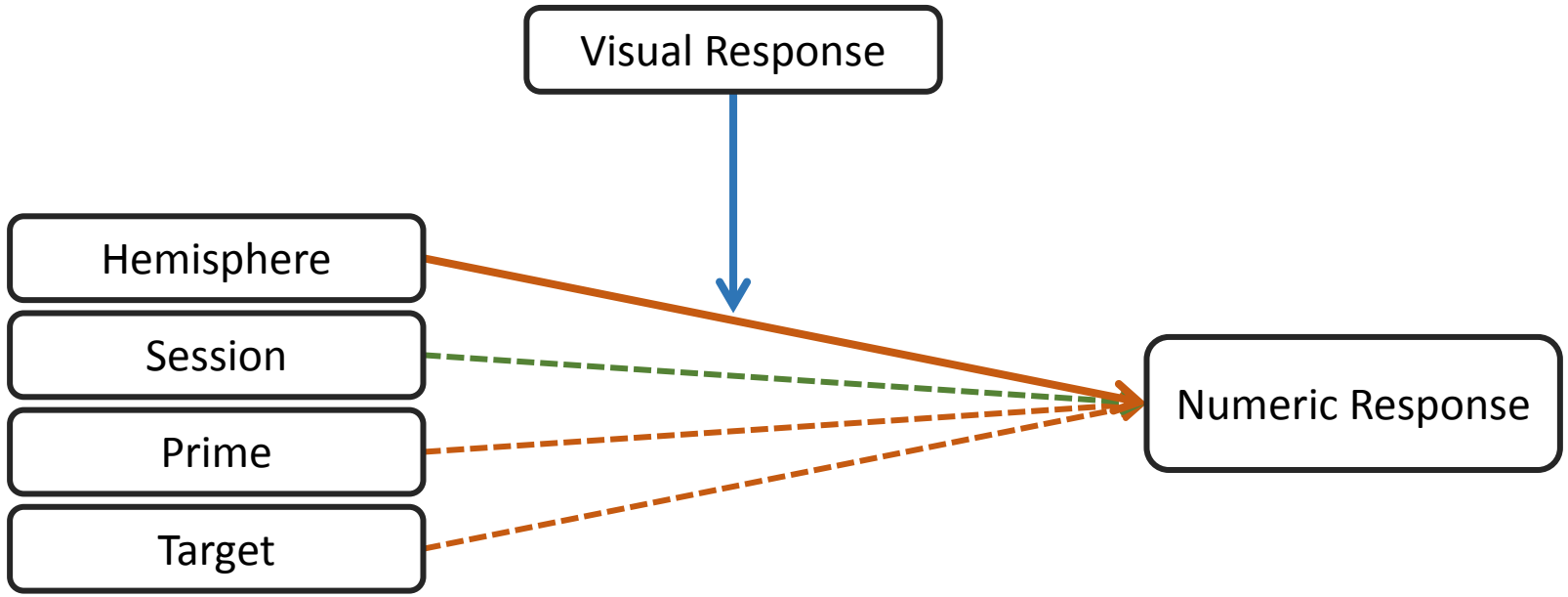
…What about that Moderation?…

Moderation

A Moderator is just a Fancy Interaction

Moderation means that the relationship between a **dependent** and **independent** is affected by a **third variable**

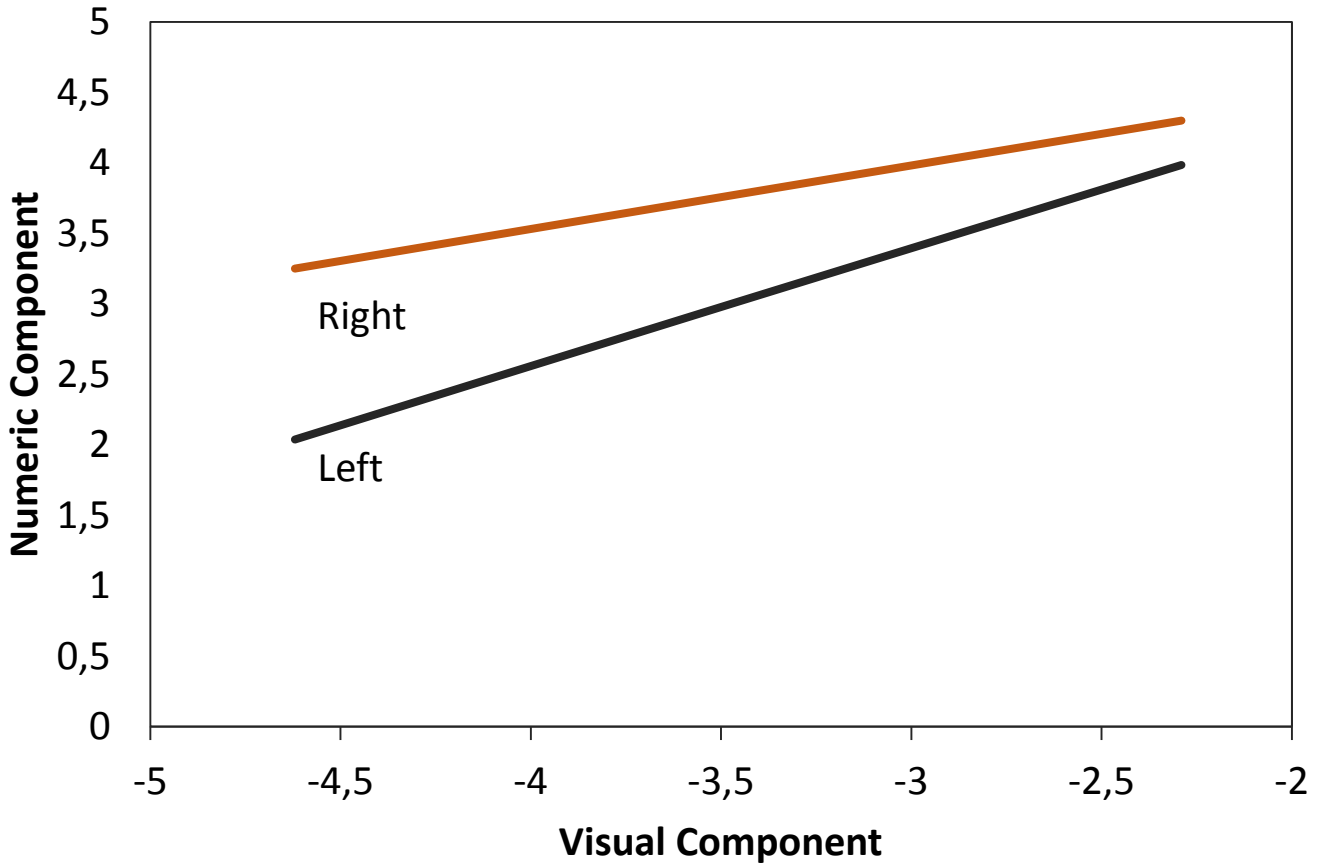
The **Hemisphere*Visual Response** interaction was significant (*p*=.008).
Which means that the effect of **Hemisphere** changes based on the value of **Visual Response**



We want to know what the differences between Left and Right hemisphere is for a
Low (-1SD)-Average-High (+1SD) Visual Response (M=-3.455; SD=1.168)

Estimated Marginal Means

```
MIXED Numeric_Response BY Session Hemisphere Prime Target WITH Visual_Response
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Session Hemisphere Prime Target Session*Hemisphere Session*Prime Session*Target
    Hemisphere*Prime Hemisphere*Target Prime*Target Session*Prime*Target
    Visual_Response Hemisphere*Visual_Response | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION
  /REPEATED=Session*Hemisphere*Prime*Target | SUBJECT(PP) COVTYPE(CSH)
  /EMMEANS=TABLES(Hemisphere*Prime) COMPARE(Hemisphere) ADJ(SIDAK)
  /EMMEANS=TABLES(Hemisphere*Prime) COMPARE(Prime) ADJ(SIDAK)
  /EMMEANS=TABLES(Session*Prime*Target) COMPARE(Session) ADJ(SIDAK)
  /EMMEANS=TABLES(Hemisphere) WITH(Visual_Response=-4.623352) COMPARE ADJ(SIDAK)
  /EMMEANS=TABLES(Hemisphere) WITH(Visual_Response=-3.455150) COMPARE ADJ(SIDAK)
  /EMMEANS=TABLES(Hemisphere) WITH(Visual_Response=-2.286948) COMPARE ADJ(SIDAK).
```



Estimates 1SD Below

Hemisphere	Mean	Std. Error	df
Left	2,037	,136	156,210
Right	3,250	,171	196,271

Visual_Response = -4.62

Estimates Mean

Hemisphere	Mean	Std. Error	df
Left	3,011	,082	68,360
Right	3,775	,082	63,750

Visual_Response = -3.46

Estimates 1SD Above

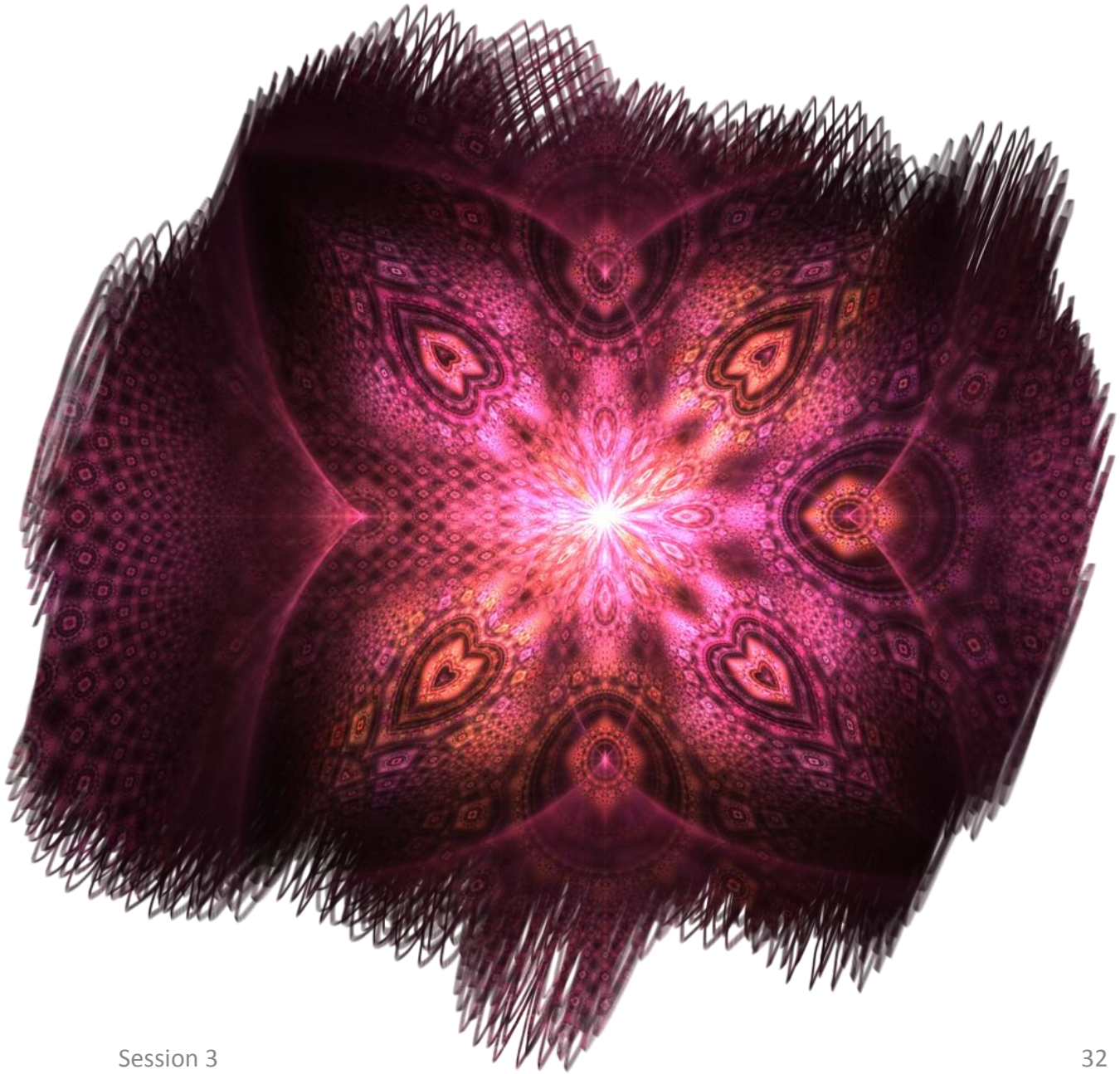
Hemisphere	Mean	Std. Error	df
Left	3,985	,181	179,276
Right	4,300	,133	144,265

Visual_Response = -2.29

Short Break

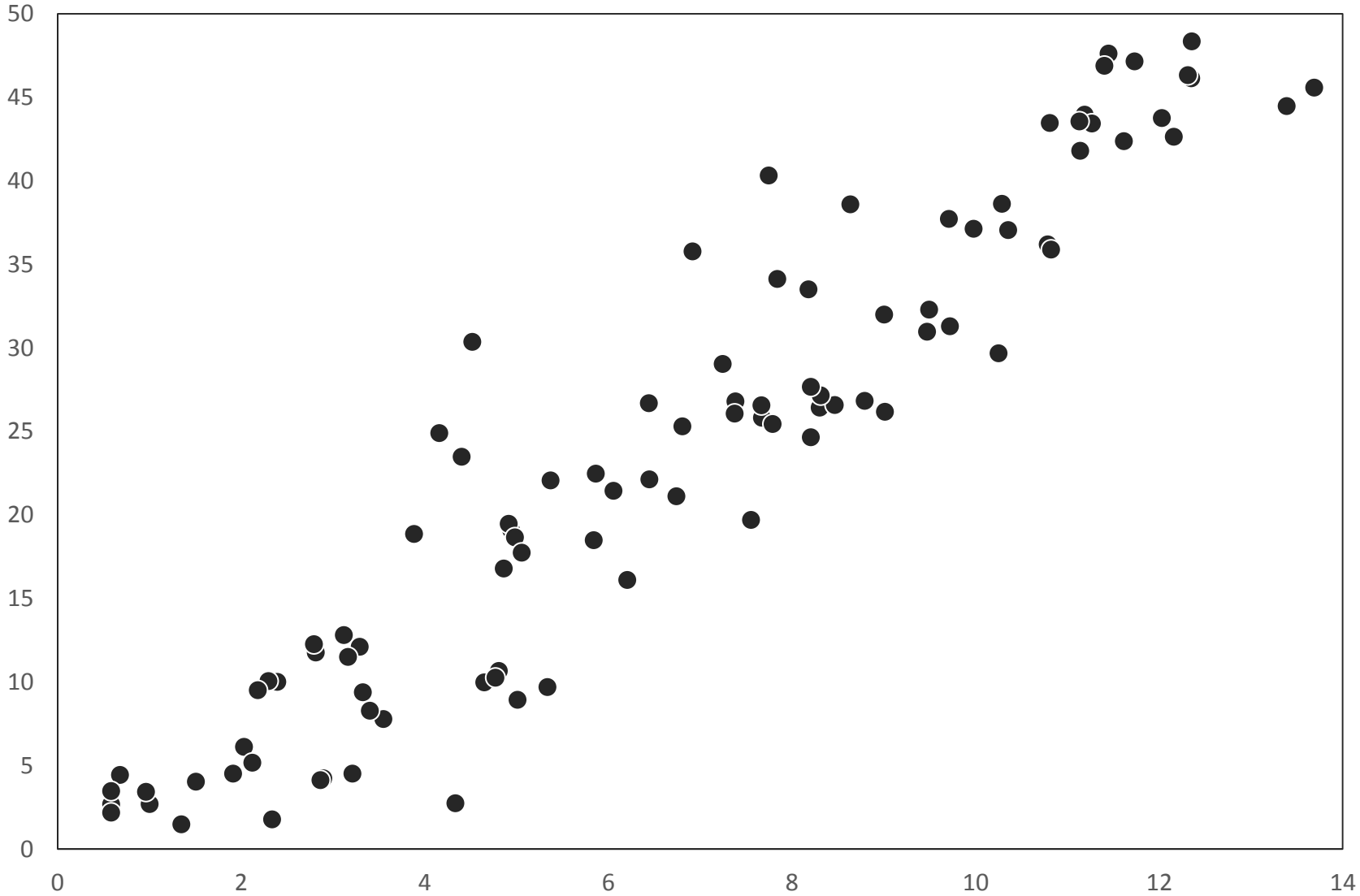
01

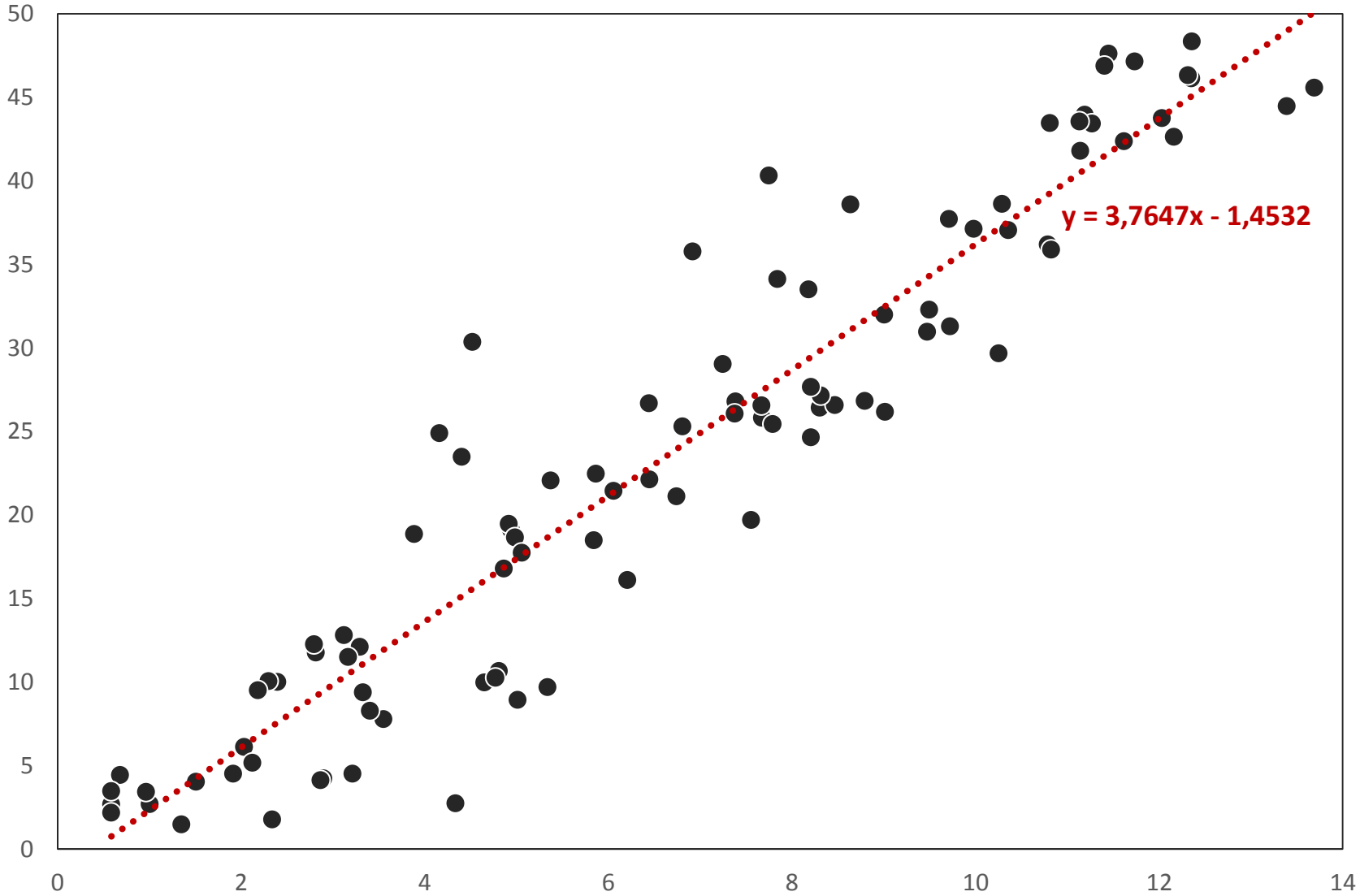
Random Effects



Model 1: Fixed Effects

Keeping everything fixed


50
45
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14


y = 3,7647x - 1,4532
0
5
10
15
20
25
30
35
40
45
50
0
2
4
6
8
10
12
14

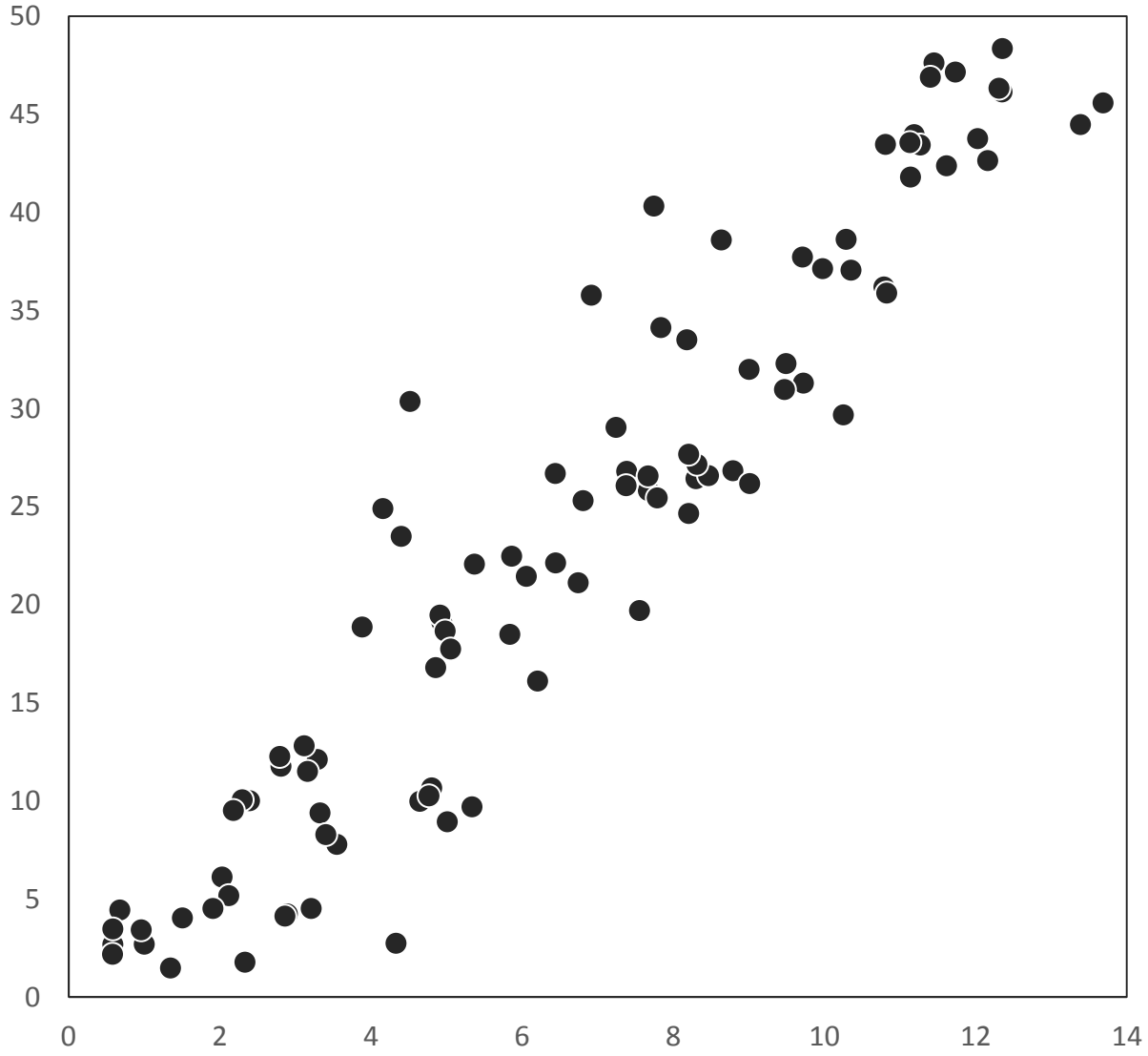
Your score on **Y** is
Intercept plus
your score on **X times Slope**

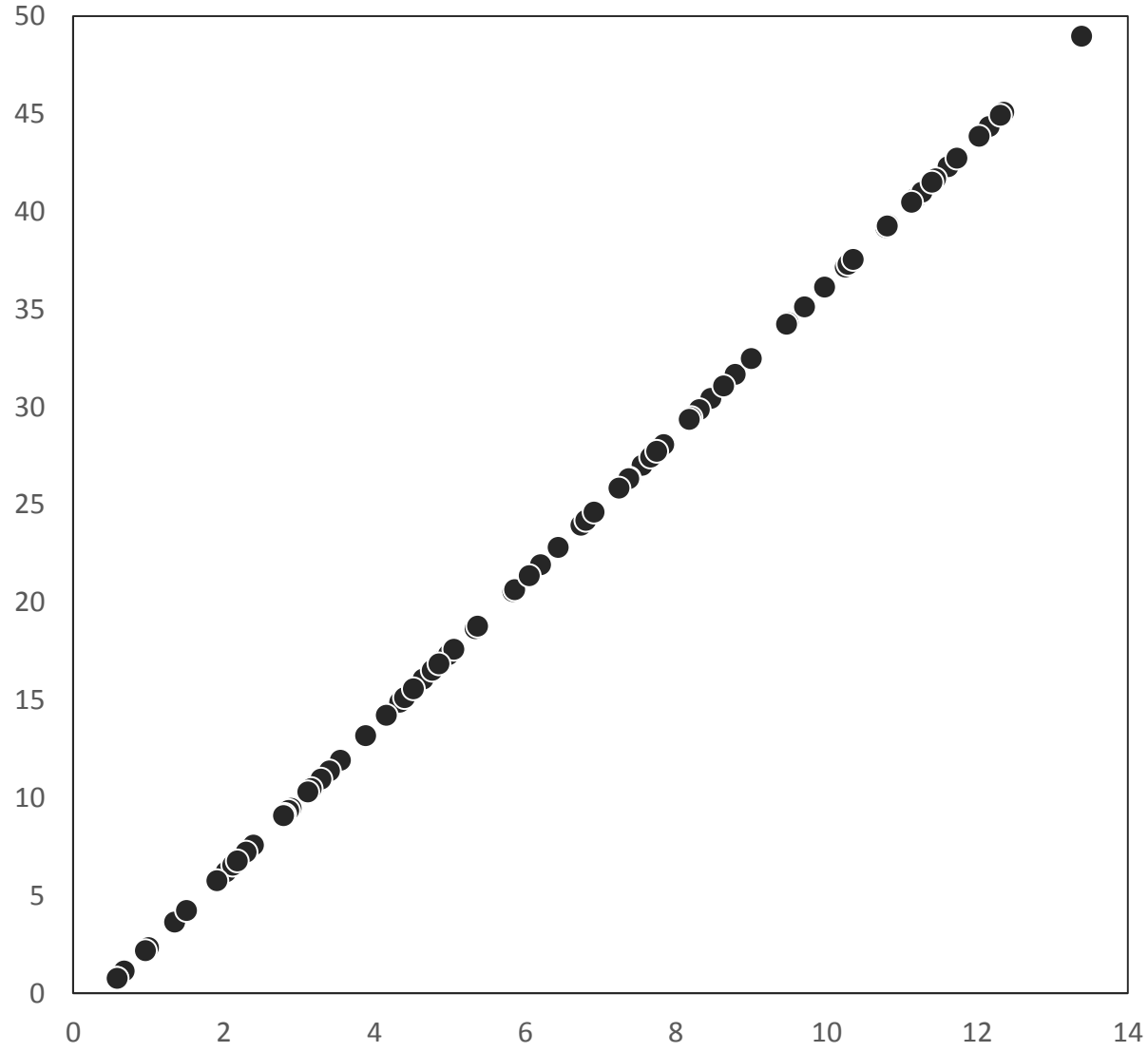
Both are Fixed

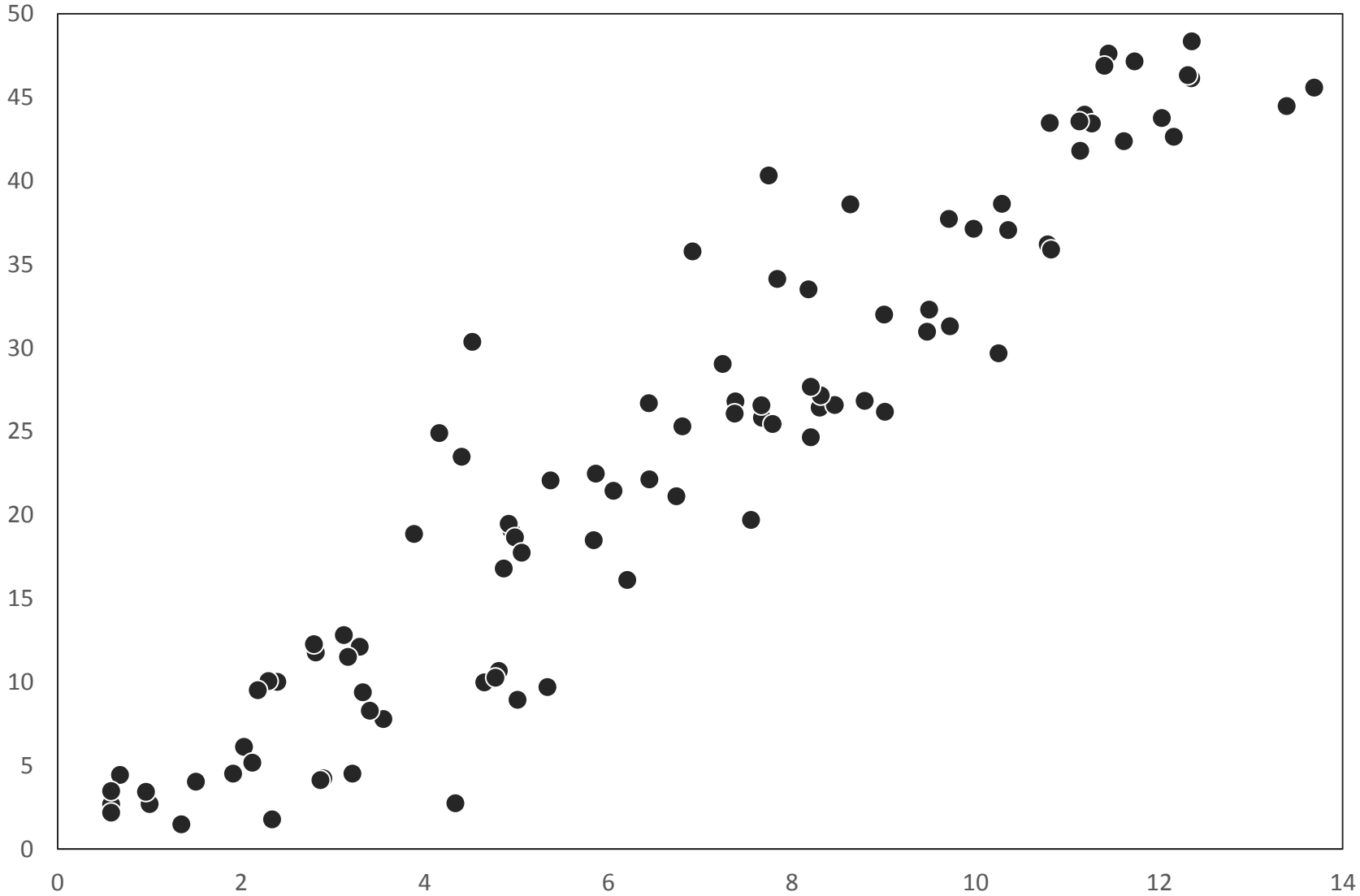
Observed Values

Fixed Model

Predicted Values






50
45
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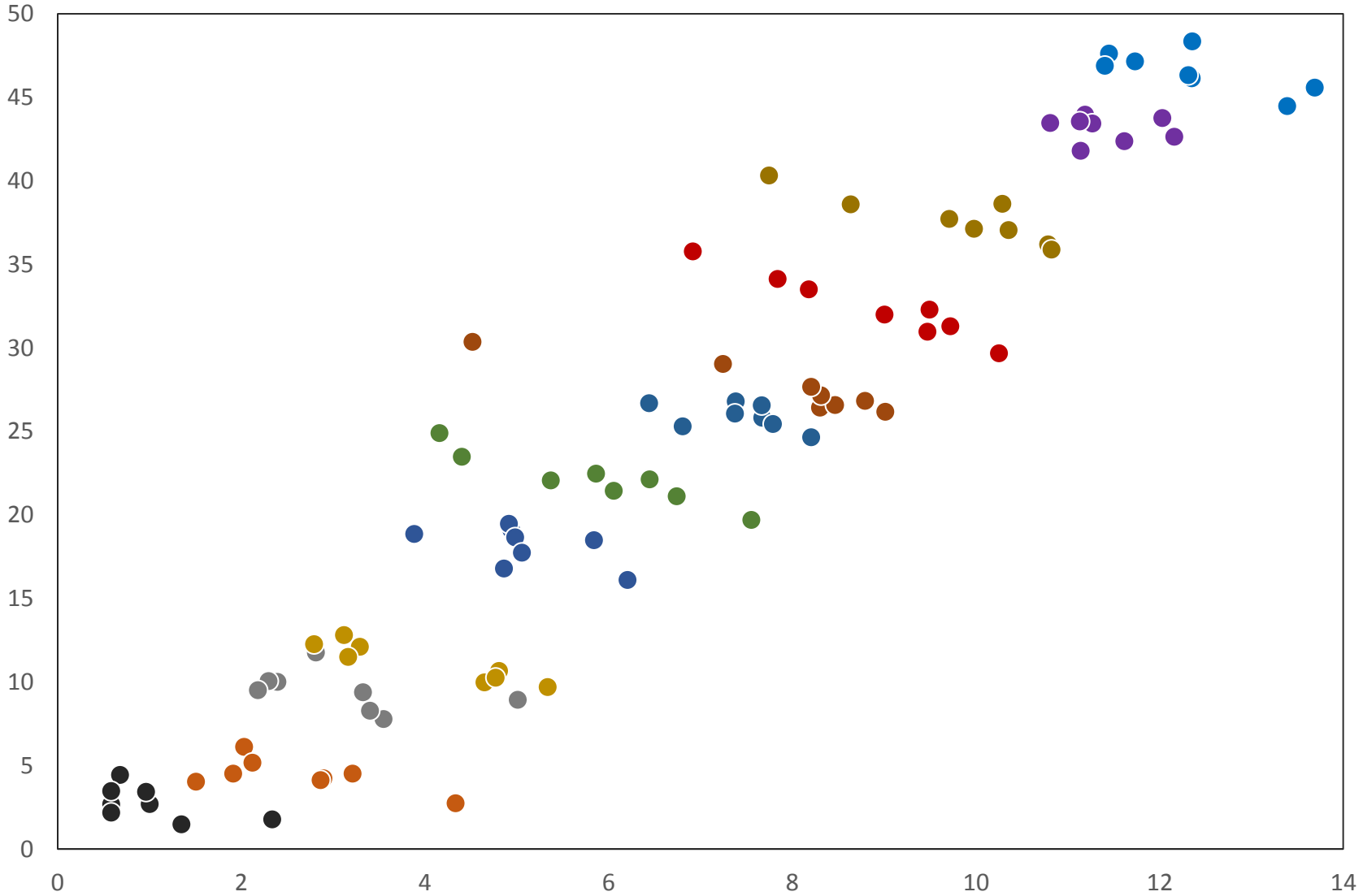
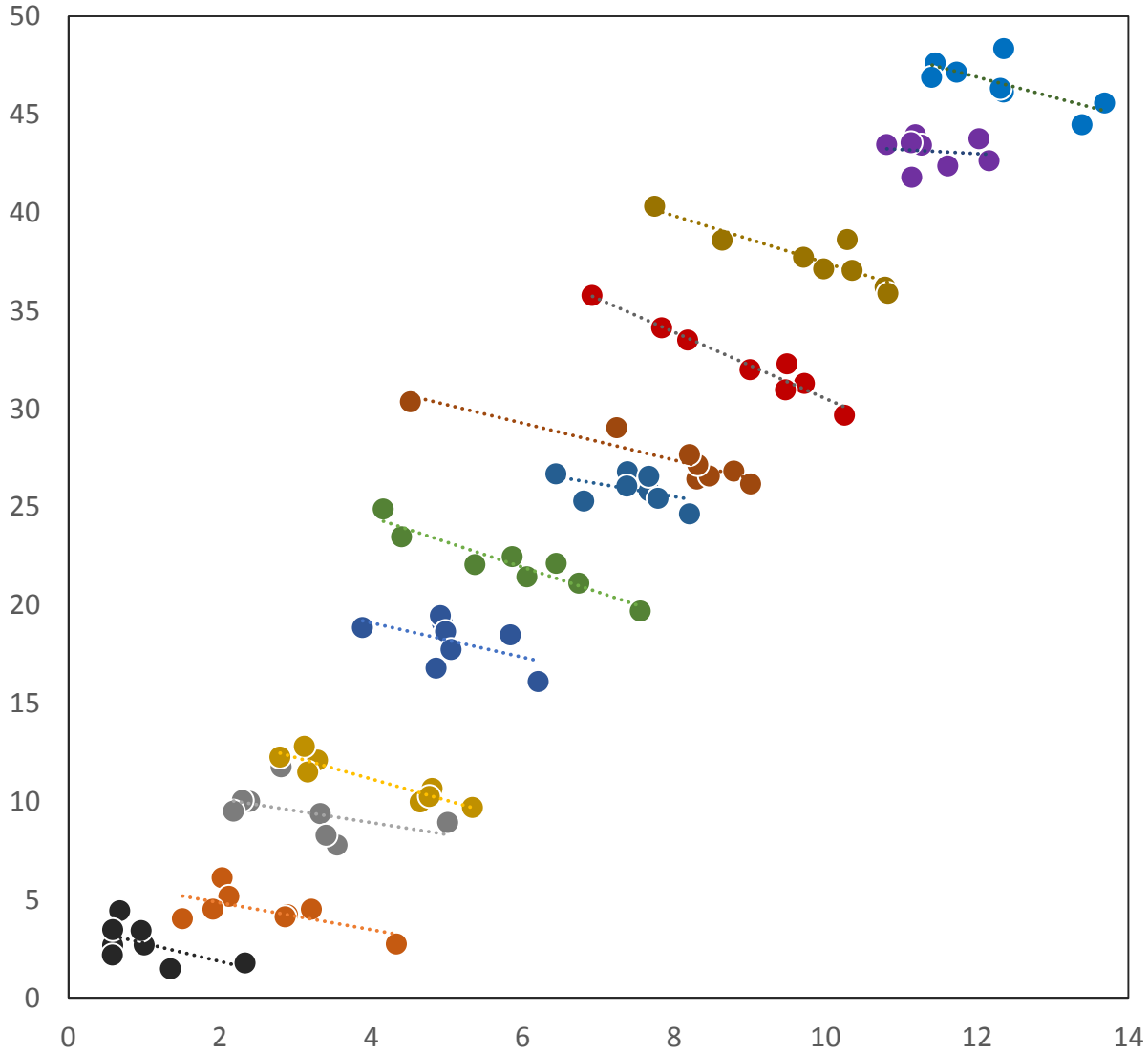
12
14

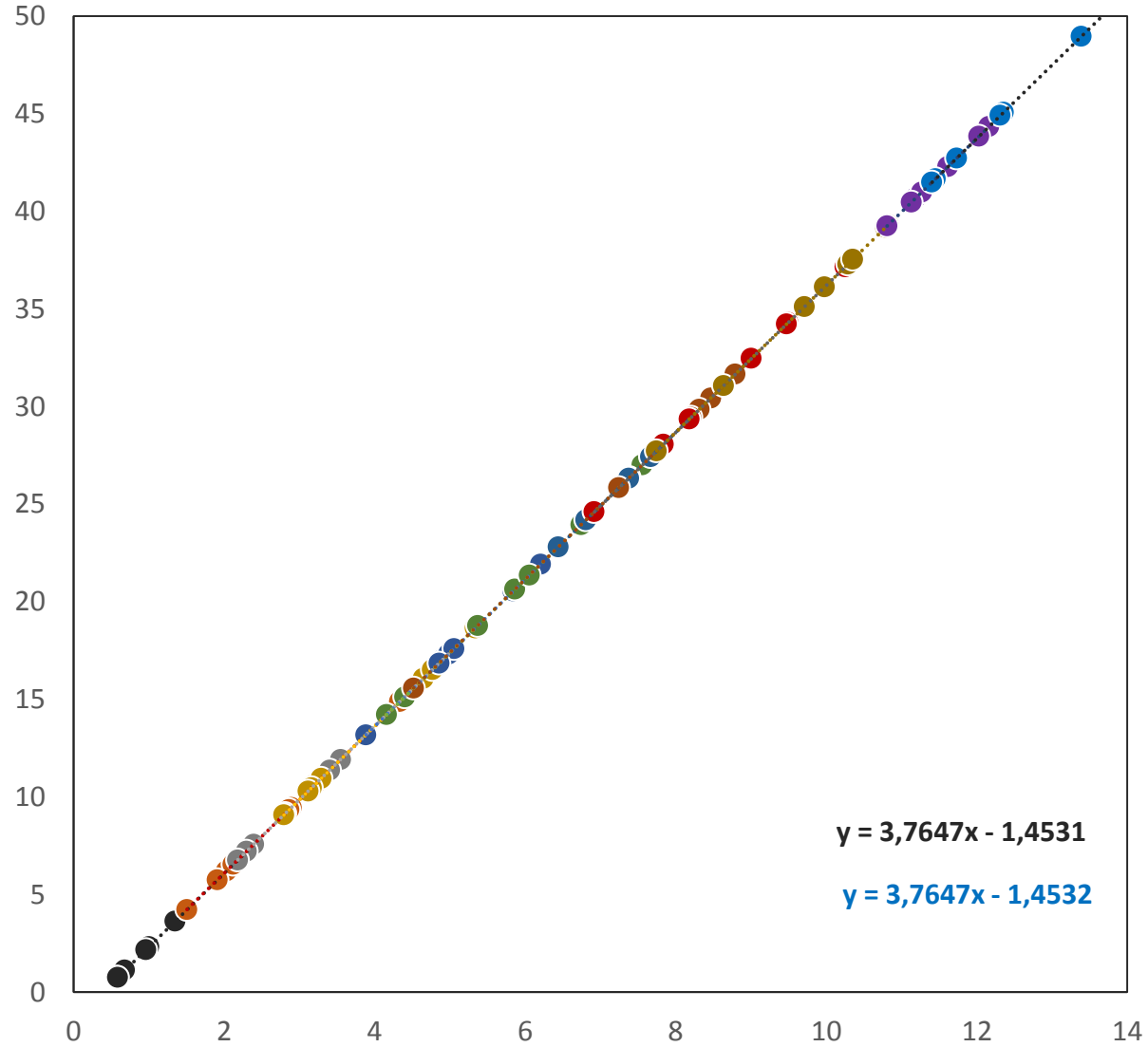

50
45
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14

Observed Values

Fixed Model

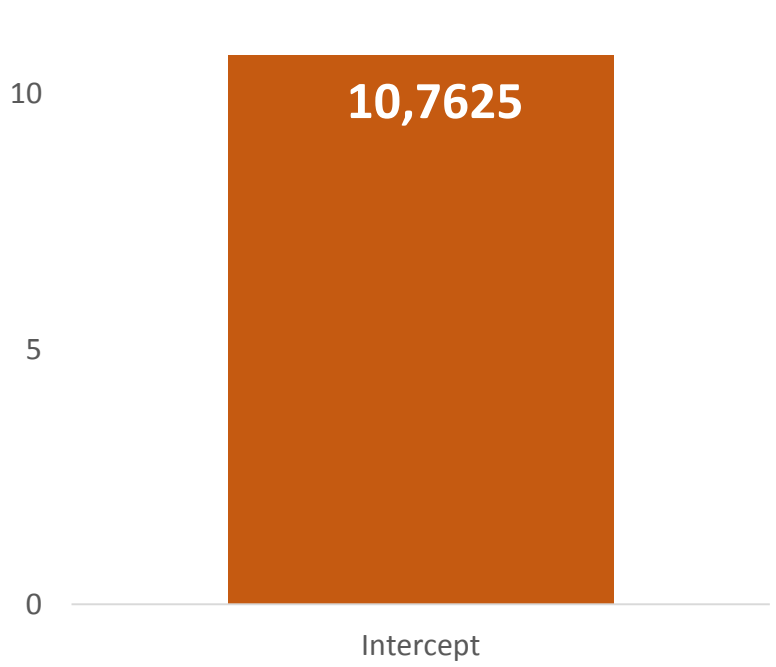
Predicted Values

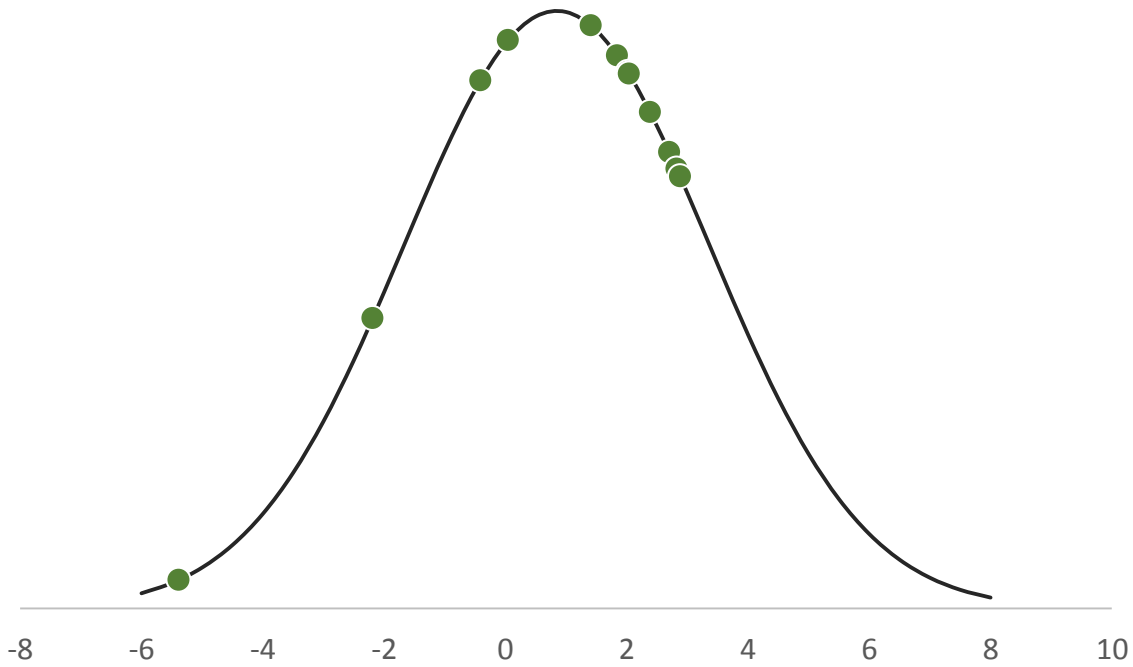




Model 2: Random Slope

Should we allow each group to have their own slope value?





	Intercept	Slope
1	10.7625	-5.3866
2	10.7625	-2.1863
3	10.7625	-0.4107
4	10.7625	0.0441
5	10.7625	1.4089
6	10.7625	1.8426
7	10.7625	2.0232
8	10.7625	2.0400
9	10.7625	2.3855
10	10.7625	2.7033
11	10.7625	2.8252
12	10.7625	2.8827

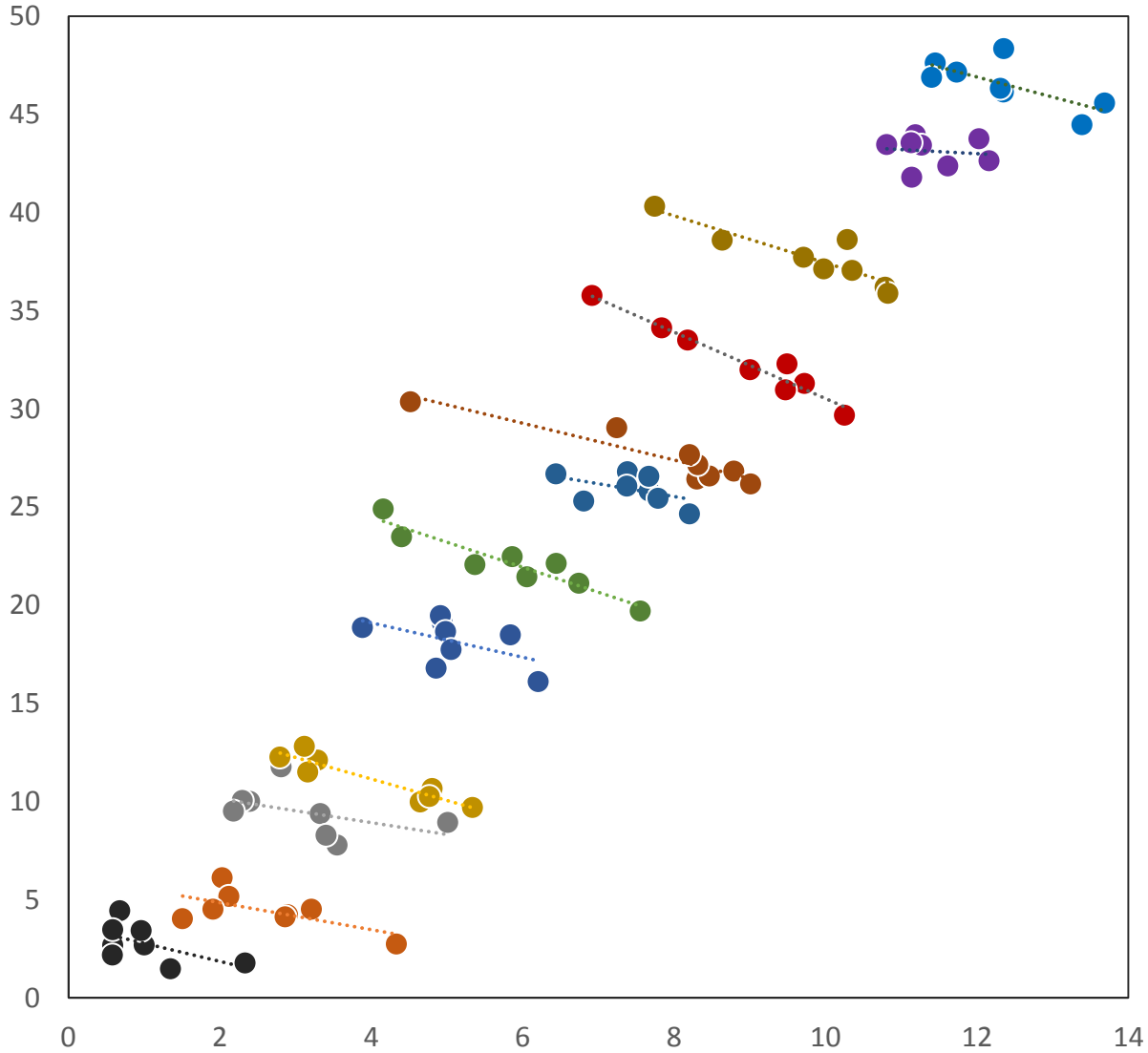
Your score on **Y** is
Intercept (10.7625) plus
your score on **X**
times a Slope that comes from a population with
Mean Slope 0.848 (SD=2.524)

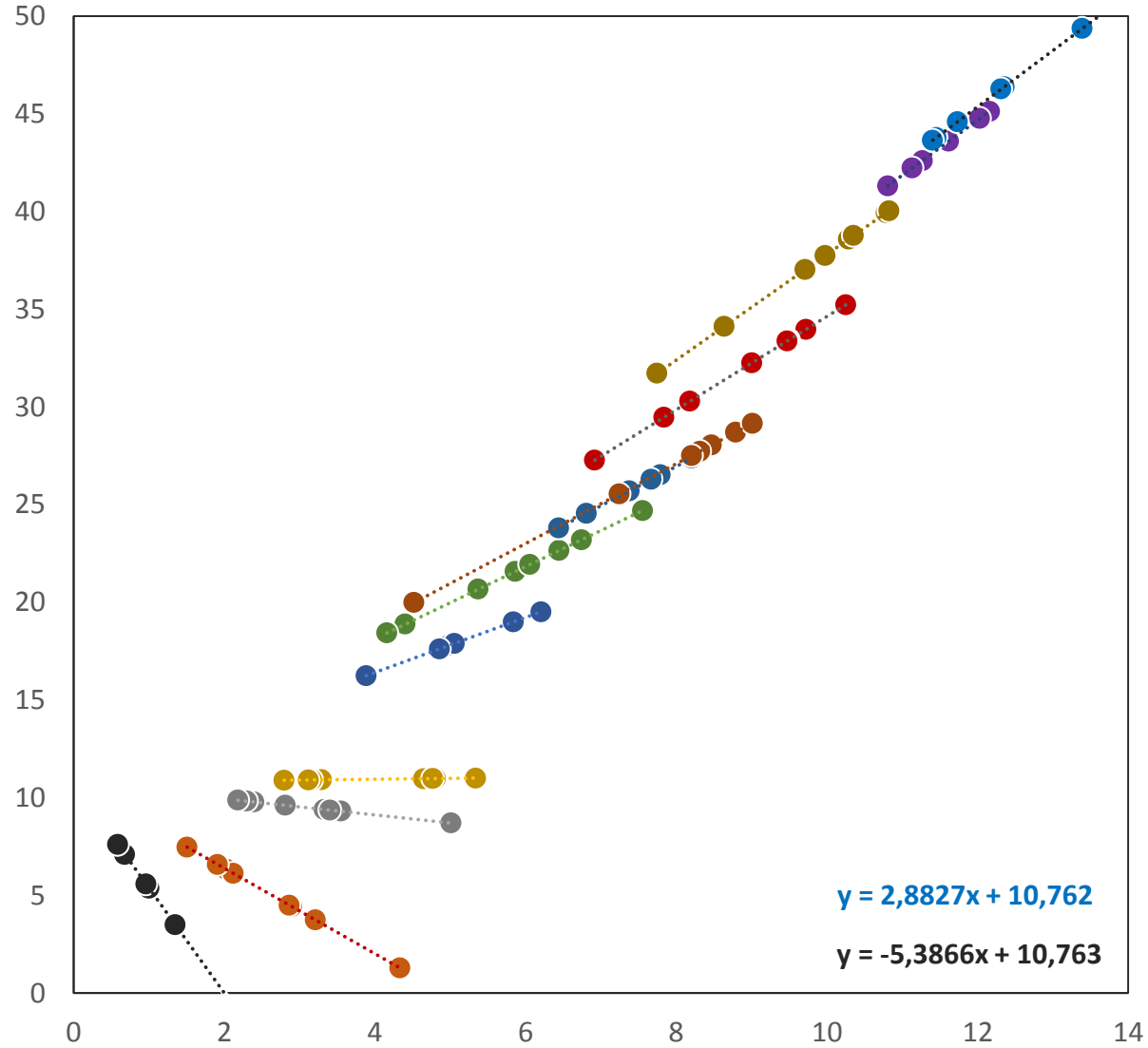
Intercept is Fixed, Slope is Random

Observed Values

Random Slope

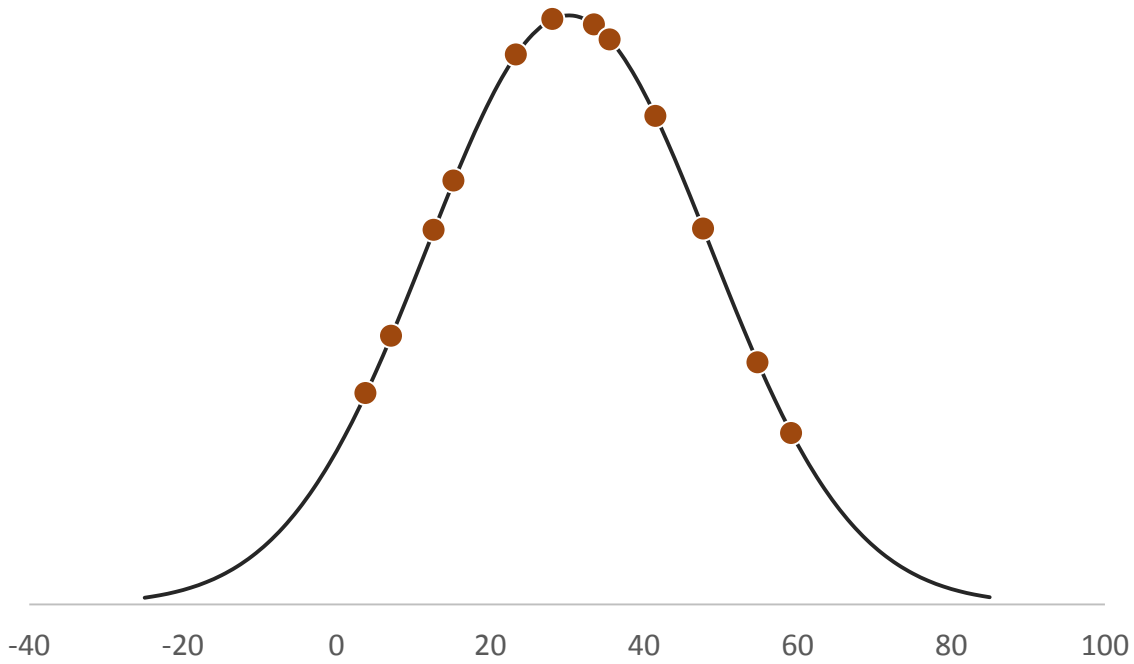
Predicted Values





Model 3: Random Intercept

What if we allow each group to have their own Intercept?



	Intercept	Slope
1	3,8020	-1,0265
2	7,1060	-1,0265
3	12,6626	-1,0265
4	15,2485	-1,0265
5	23,3656	-1,0265
6	28,1317	-1,0265
7	33,5212	-1,0265
8	35,5822	-1,0265
9	41,5343	-1,0265
10	47,7254	-1,0265
11	54,8262	-1,0265
12	59,2099	-1,0265

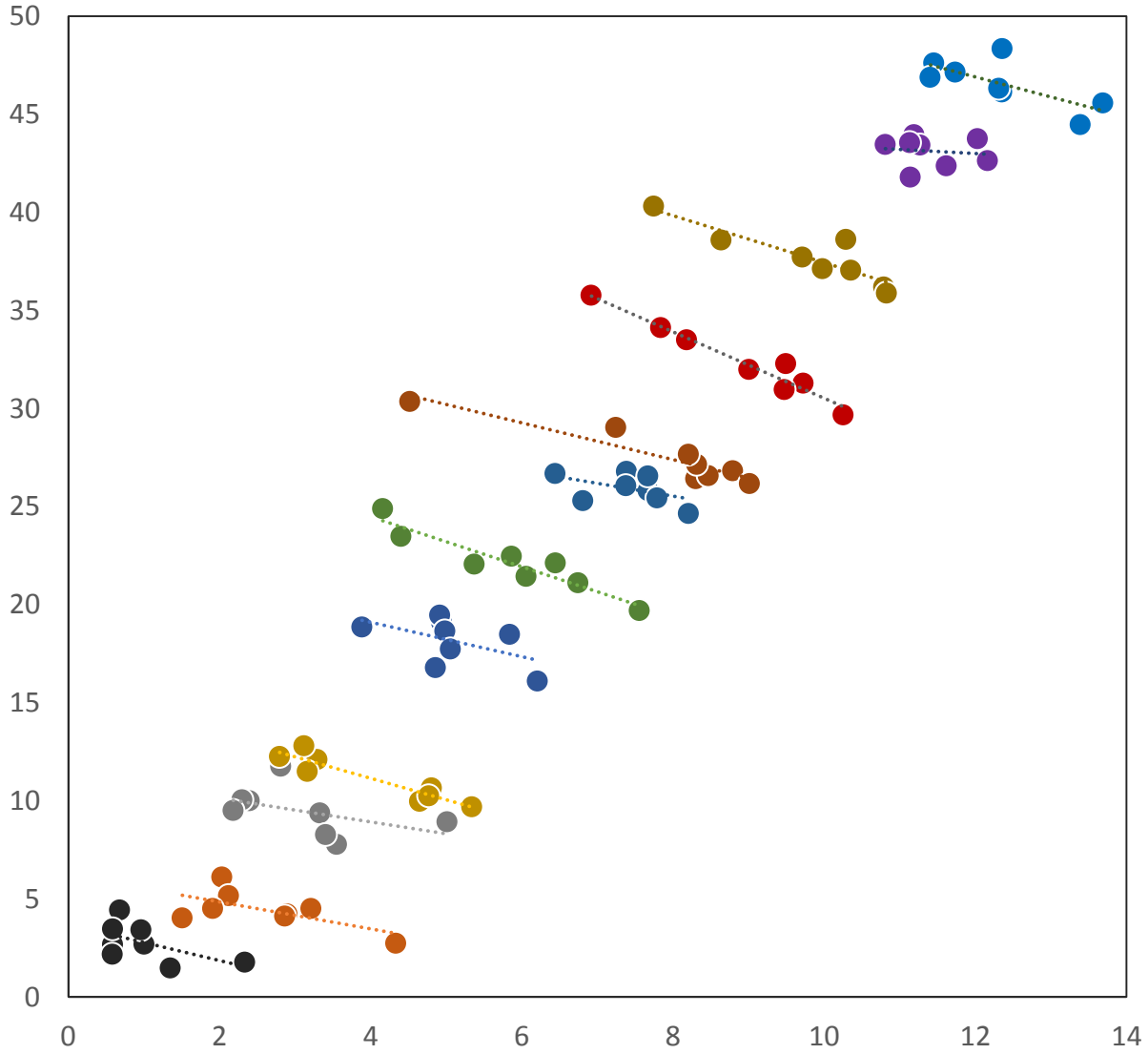
Your score on **Y** is
A variable Intercept with Mean 30.226 (SD=18.434)
plus your score on **X** **times the Slope (-1.0265)**

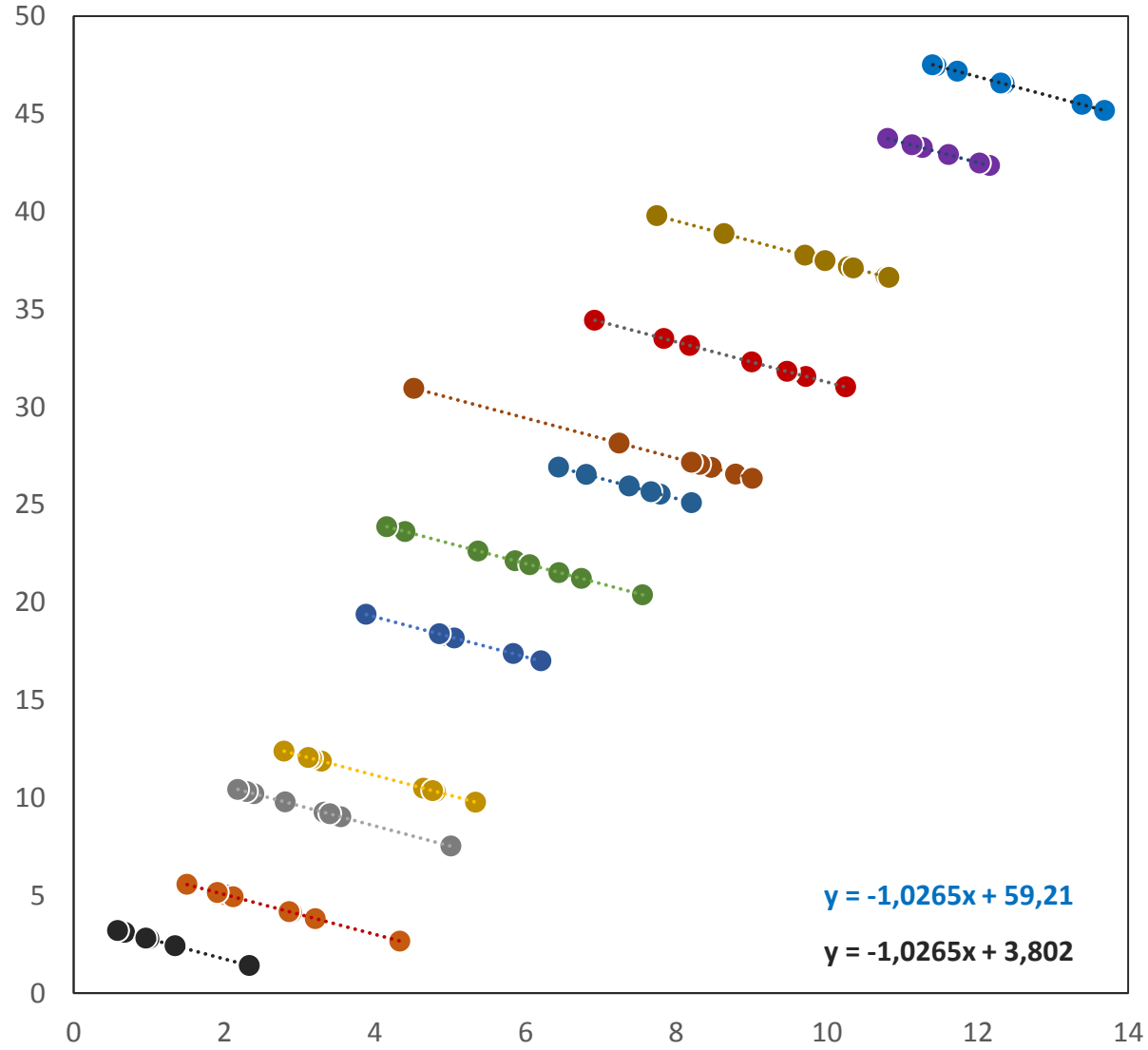
Intercept is Random, Slope is Fixed

Observed Values

Random Intercept

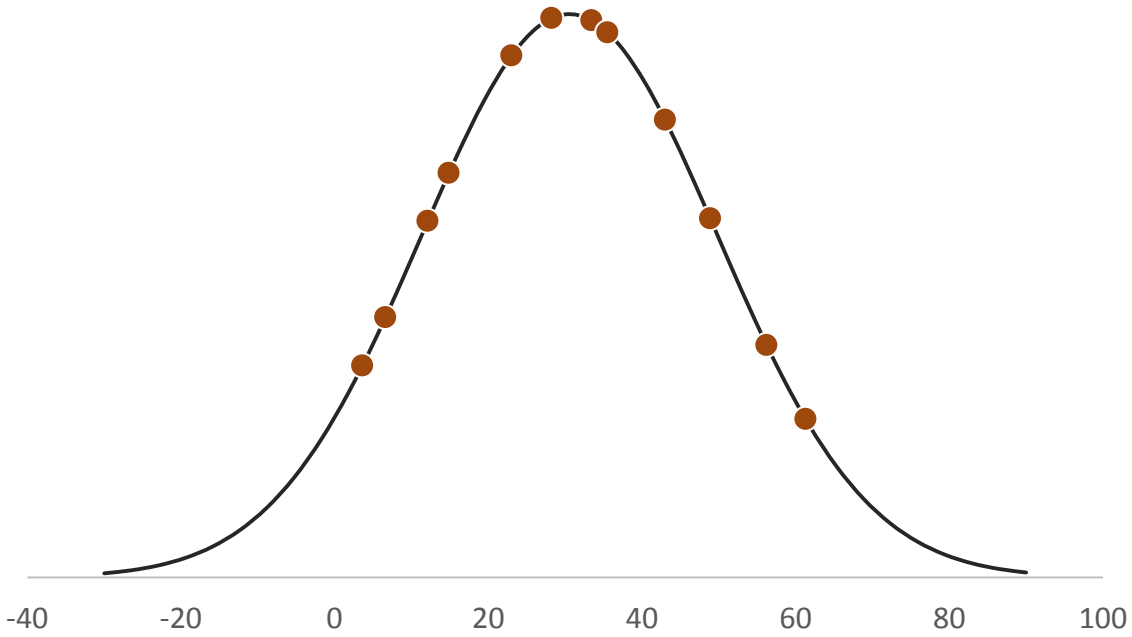
Predicted Values

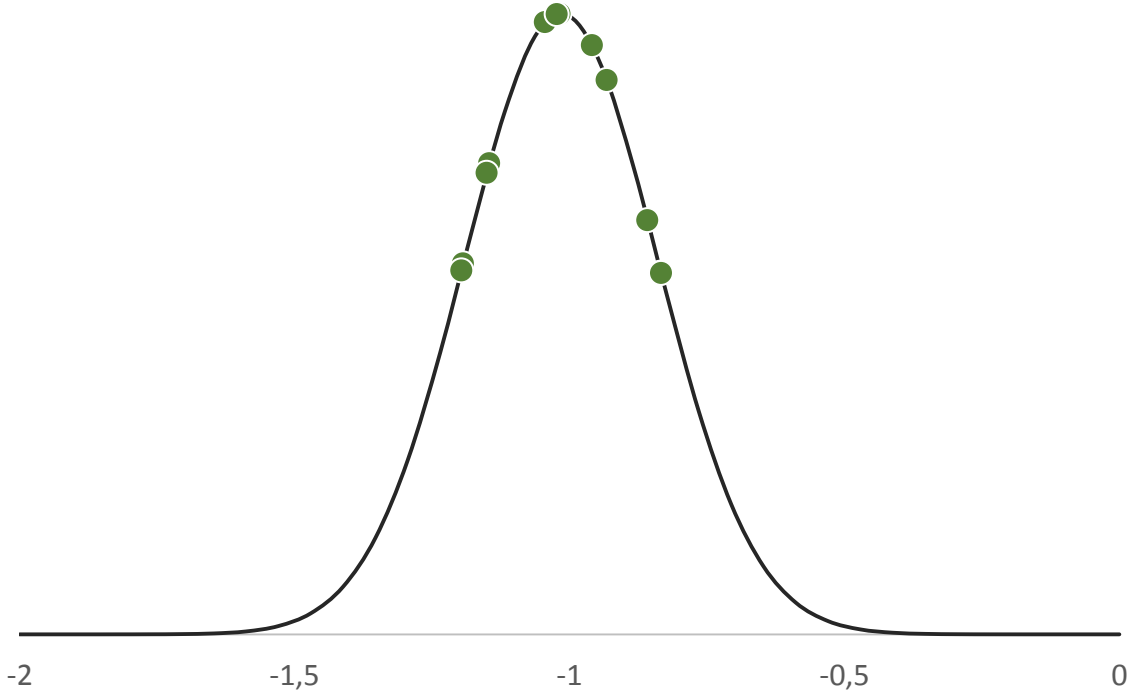




Model 4: Random Intercept & Slope

What if we allow both the Intercept and Slope to vary?





	Intercept	Slope
1	3,6061	-0,8333
2	6,5999	-0,8331
3	12,1338	-0,8577
4	14,8721	-0,9320
5	23,0201	-0,9586
6	28,2375	-1,0443
7	33,4508	-1,0171
8	35,5497	-1,0225
9	43,0132	-1,1929
10	48,8892	-1,1453
11	56,2343	-1,1499
12	61,3012	-1,1961

Your score on **Y** is

A variable Intercept with Mean 30.576 (SD=19.275)

plus your score on **X**

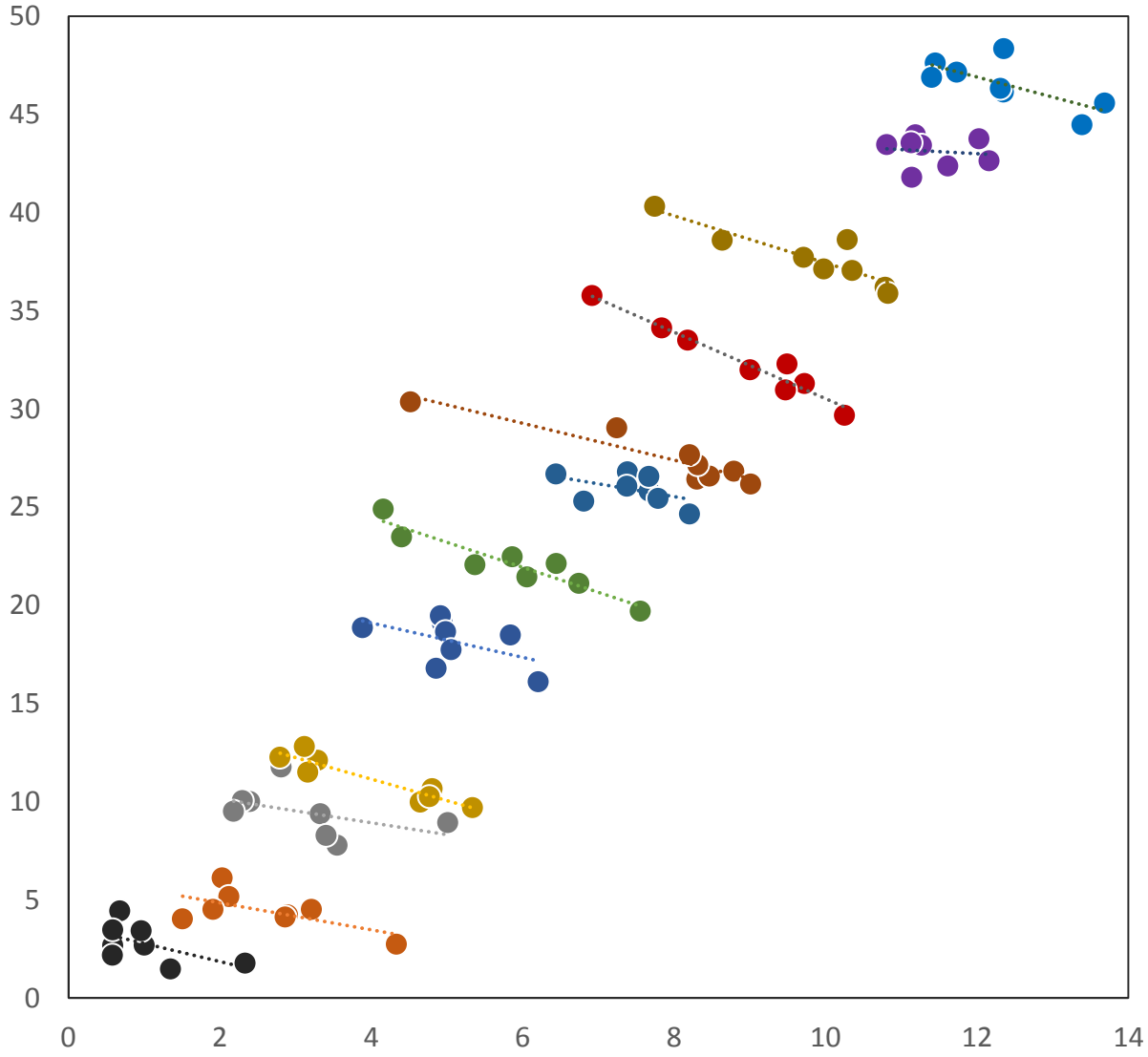
times the variable Slope with Mean -1.015 (SD=0.175)

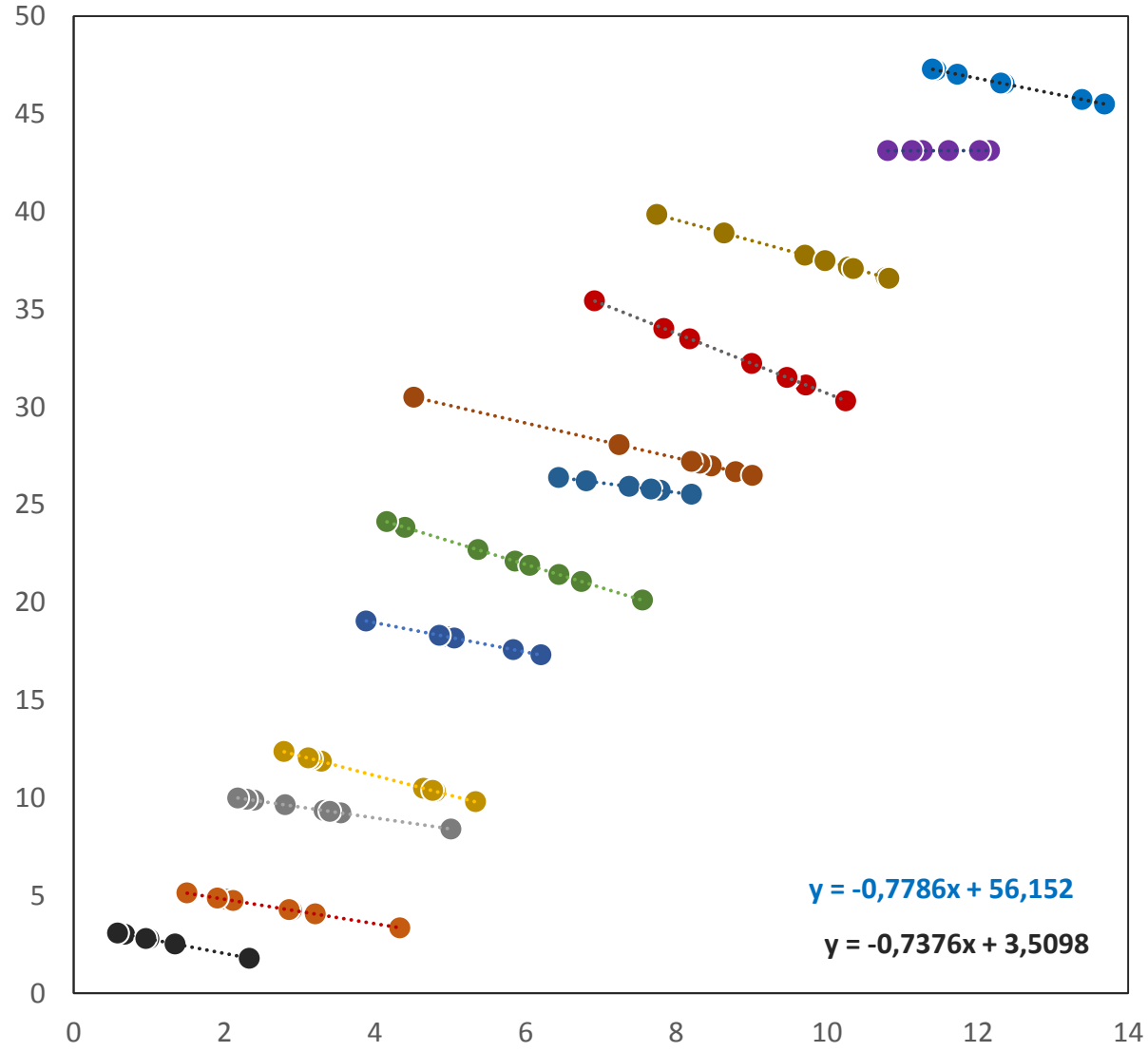
Intercept is Random and Slope is Random

Observed Values

Random Intercept & Slope

Predicted Values





Selection: Which Model is better

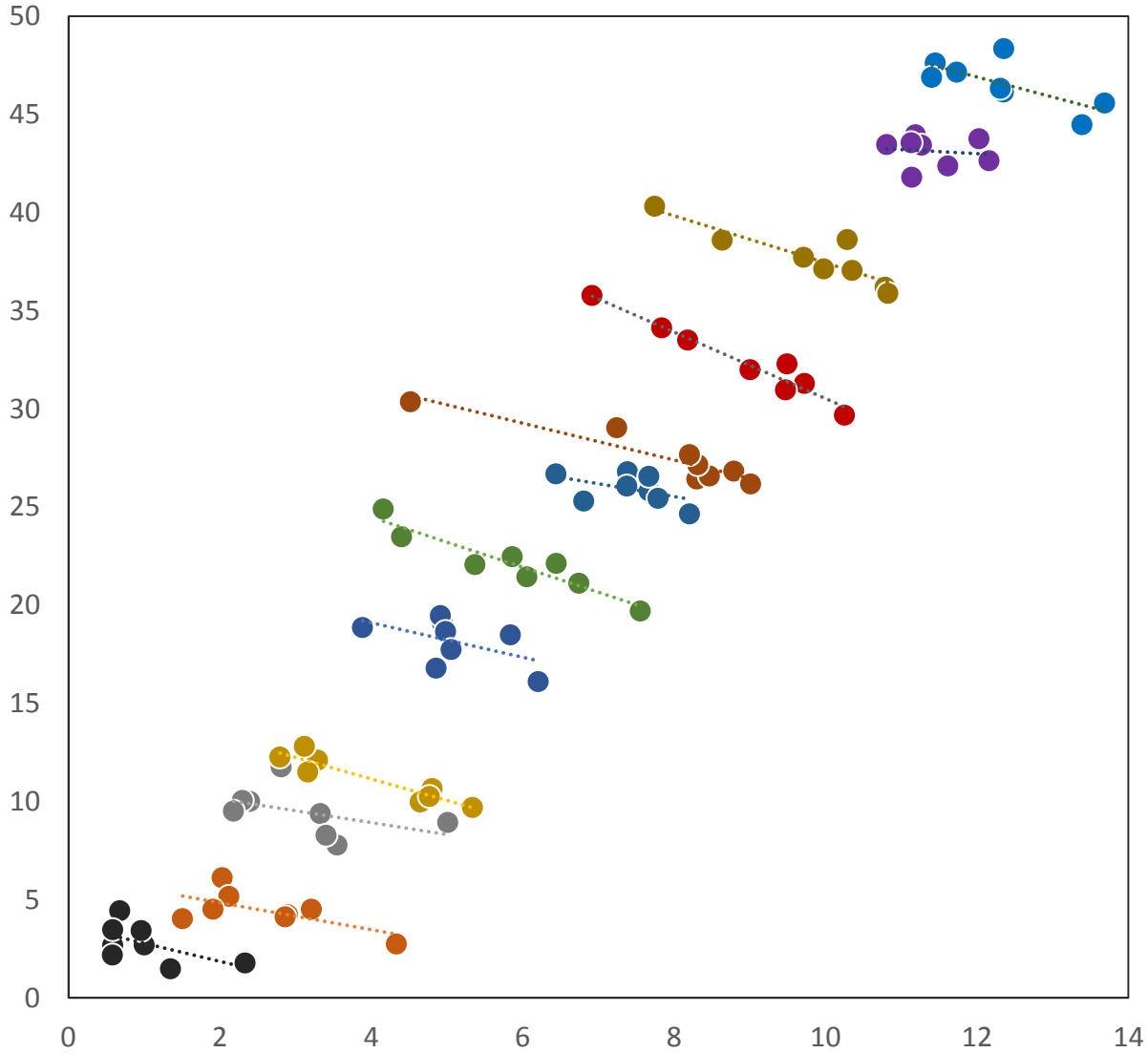
Of the four models, which fits the data best?

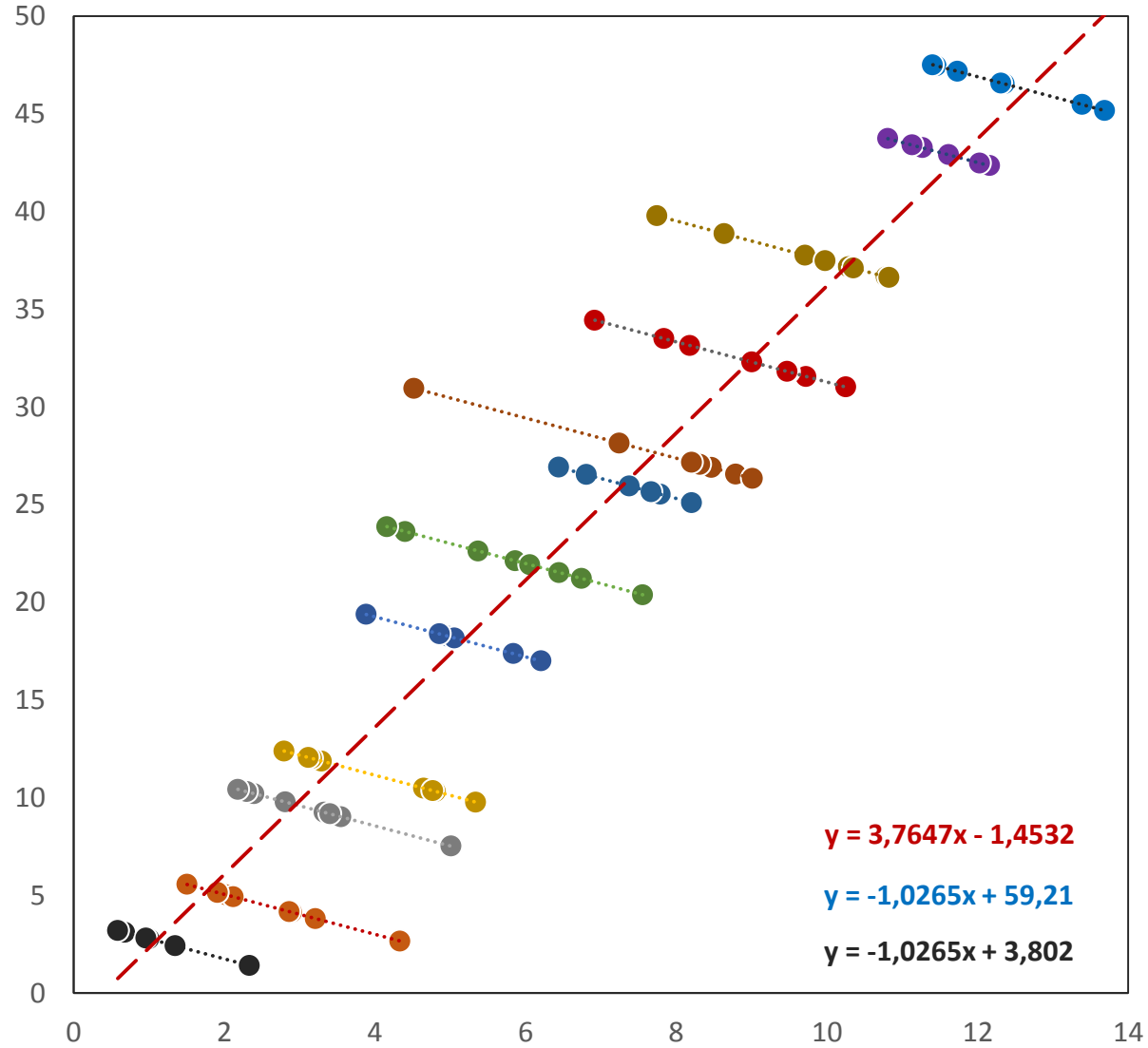
	Parameters	-2LL	AIC	BIC
Fixed Model	3	568.714	570.714	573.258
Random Slope	4	545.484	549.484	554.571
Random Intercept	4	326.096	330.096	335.183
Random Intercept+Slope	6	324.455	332.455	342.628

Observed Values

Random Intercept

Predicted Values



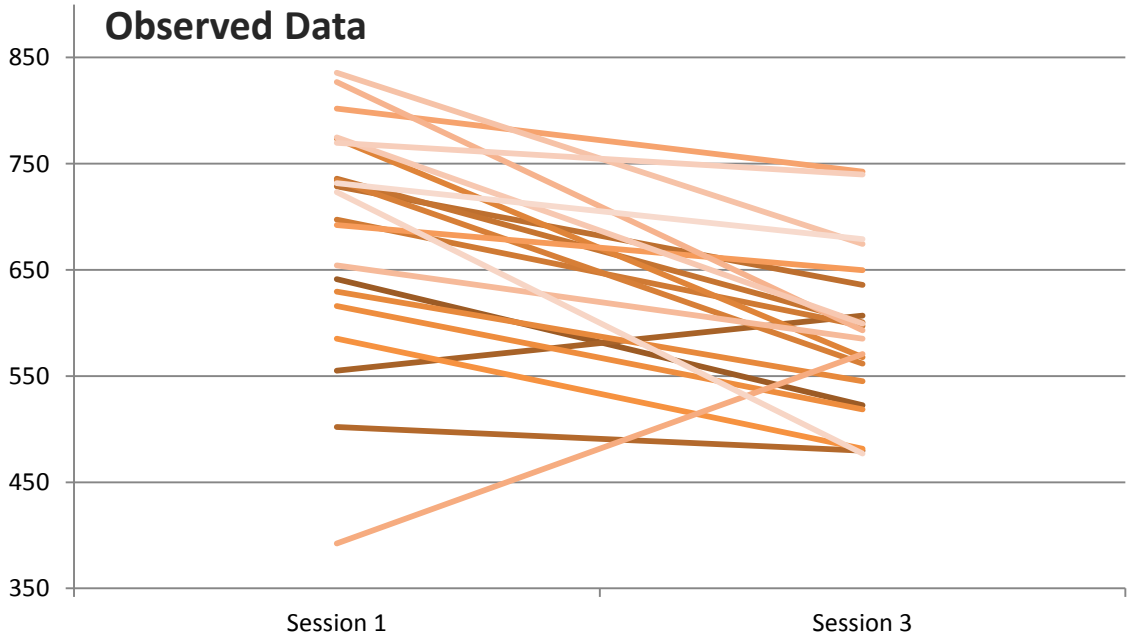


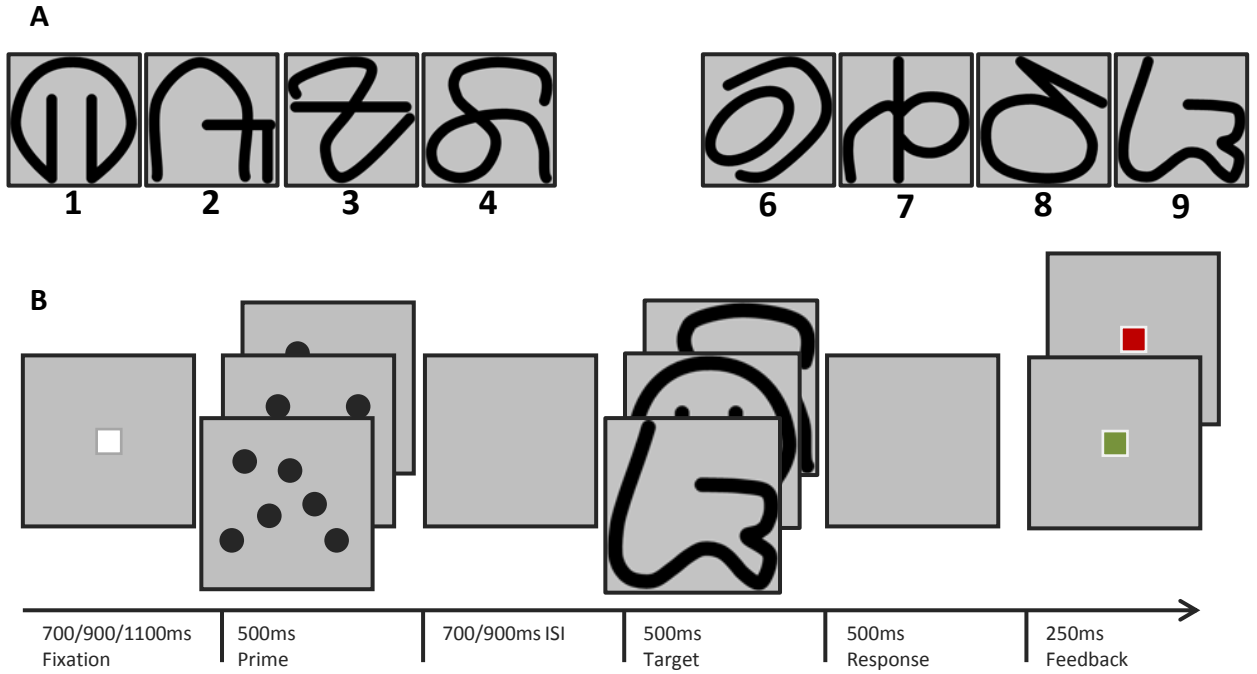
Realistic Example

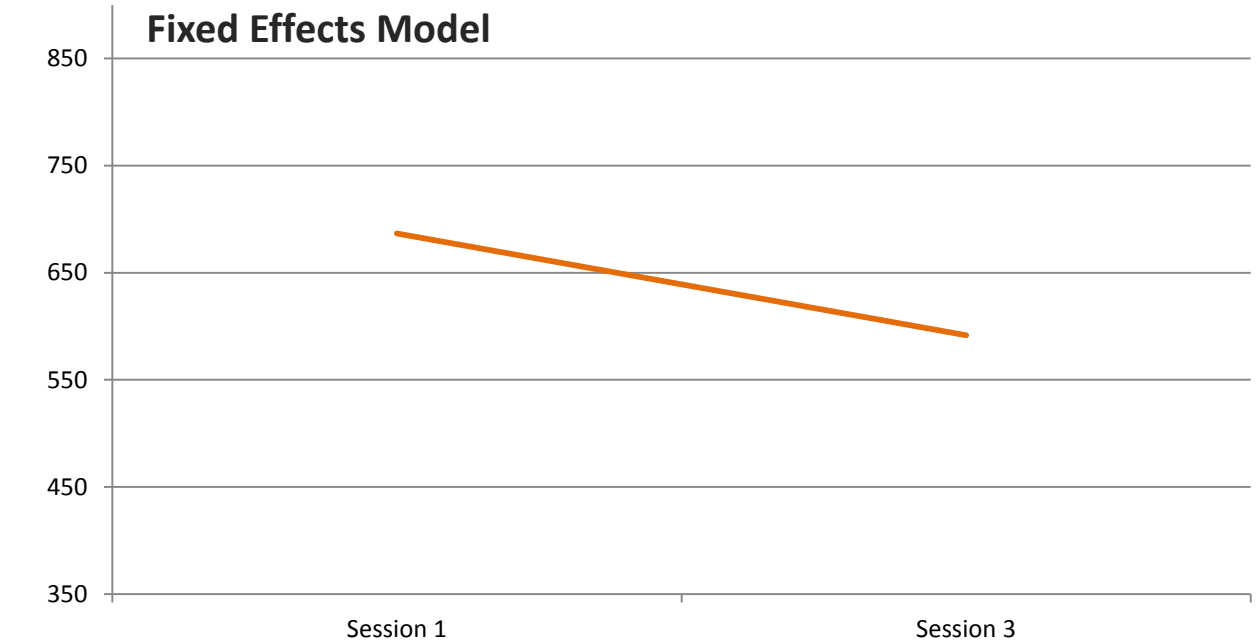
More of the same, but on a more realistic example

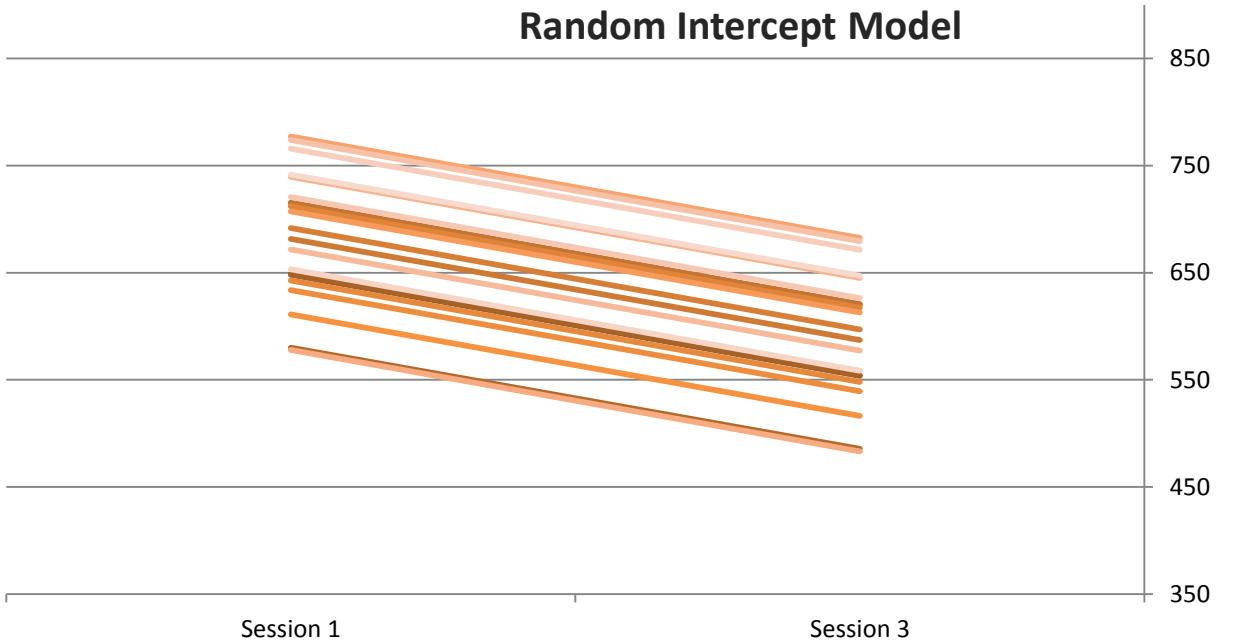
The data comes from the same experiment we saw before, except this time is regular old behavioral data (Reaction Times) in Same trials (dots and symbols show the same quantity).

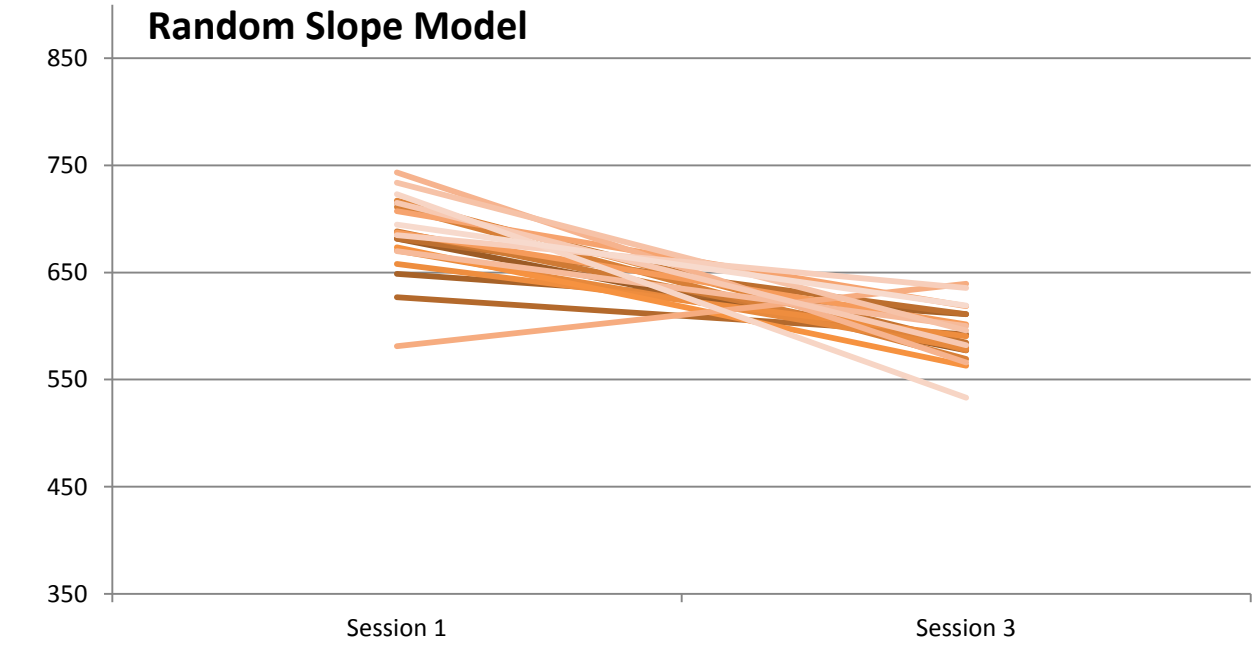
The model only has session and symbol in it (because Dots is redundant). The observed data sure looks like a nice candidate for random effects; all participants have a different start- and end-point, some even show an increase in reaction time over time.

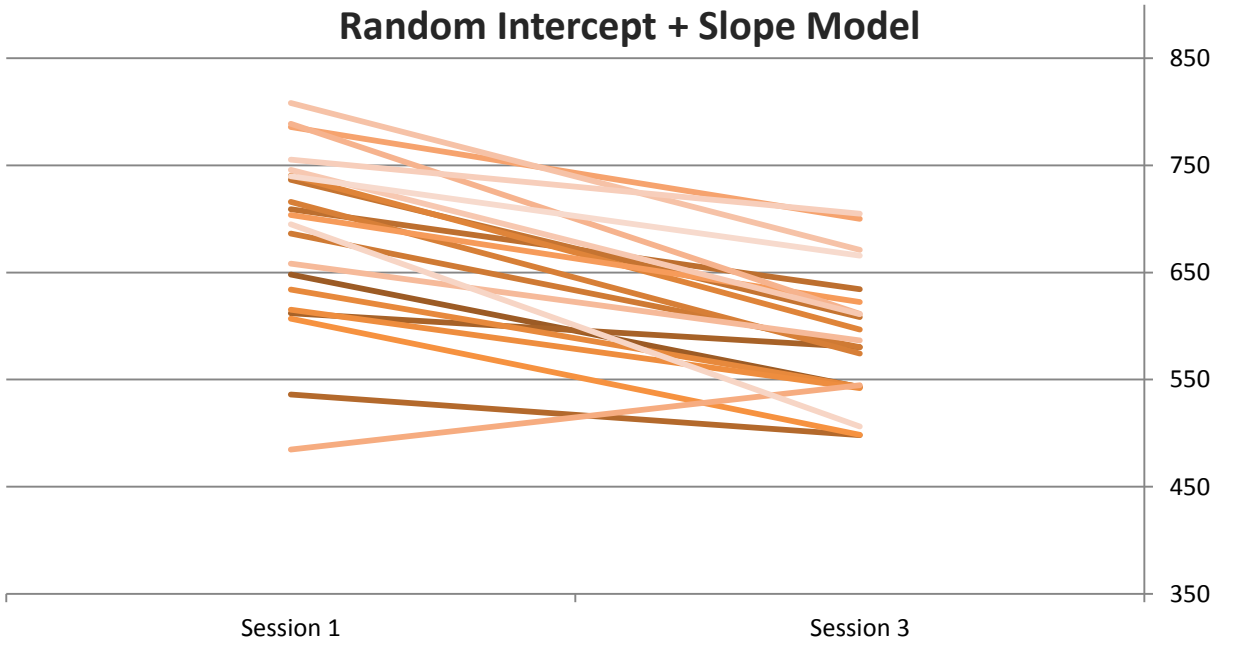





Fixed Effects Model
850
750
650
550
450
350
Session 1
Session 3


Random Intercept Model
850
750
650
550
450
350
Session 1
Session 3


Random Slope Model
850
750
650
550
450
350
Session 1
Session 3


Random Intercept + Slope Model
850
750
650
550
450
350
Session 1
Session 3

Structure	Parameters	-2LL	AIC	BIC
Fixed	**7**	**952.447**	**958.447**	**965.667**
Intercept	8	949.861	957.861	967.487
Slope	**8**	**947.084**	**955.084**	**964.711**
Both	9	945.060	955.060	967.094

Type III Tests of Fixed Effects

Source	Fixed	Intercept	**Slope**	Both
Intercept	.000	.000	**.000**	.000
Session	.000	.000	**.000**	.000
Symbol	.000	.000	**.000**	.000
Session * Symbol	.120	.176	**.059**	.087

Adding a random slope to the model improves the fit significantly, while the addition of a random intercept didn't do so much. Striking is how the interaction effect changes (the session effect too, but you can't see it).

It changes from p=.120 to p=.059. While in this case the conclusion didn't change, you can imagine situations where random effects can make a difference.

This Session

- What are Estimated Marginal Means
- What are covariates
- Using EMMs and Covariates to check for moderation
- Dealing with Random Slopes and Intercepts

The Next Session

~~How to build Models and decide on covariance structures~~

~~(plus talk about what covariance structures are)~~

~~Adding covariates, random intercepts, and random slopes~~

~~(Making the Mixed Models truly Mixed)~~

Adding Planned and Polynomial Contrasts

(Thinking ahead like a good data scientist)

Session Evaluation