

Intensive Data Analysis II

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1 Reading the Data

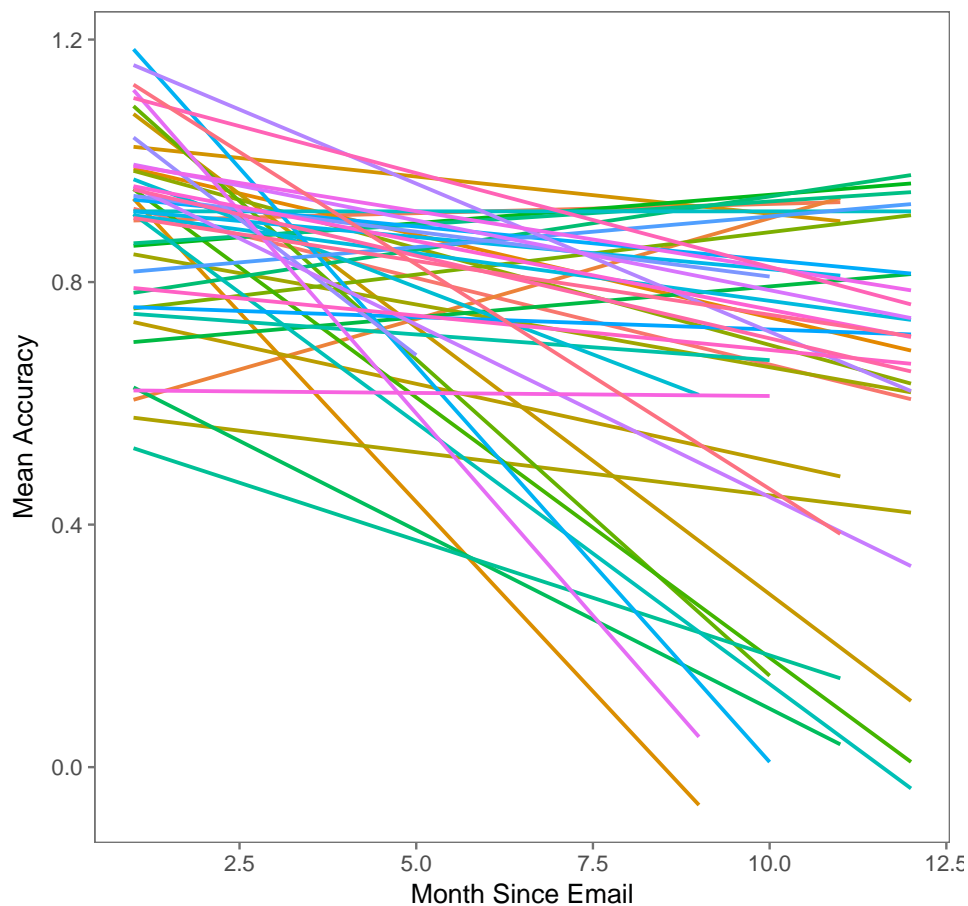
```
> cell_demo = read.csv("cell_demo.csv", header = TRUE, sep = ",")  
> cell = read.csv("cell_withitems_complete.csv", header = TRUE, sep = ",")  
> cell = merge(cell, cell_demo, by = "ID")  
> cell$ID = as.factor(as.character(cell$ID))
```

2 Eyeballing the Data

Accuracy for Name Retrieval

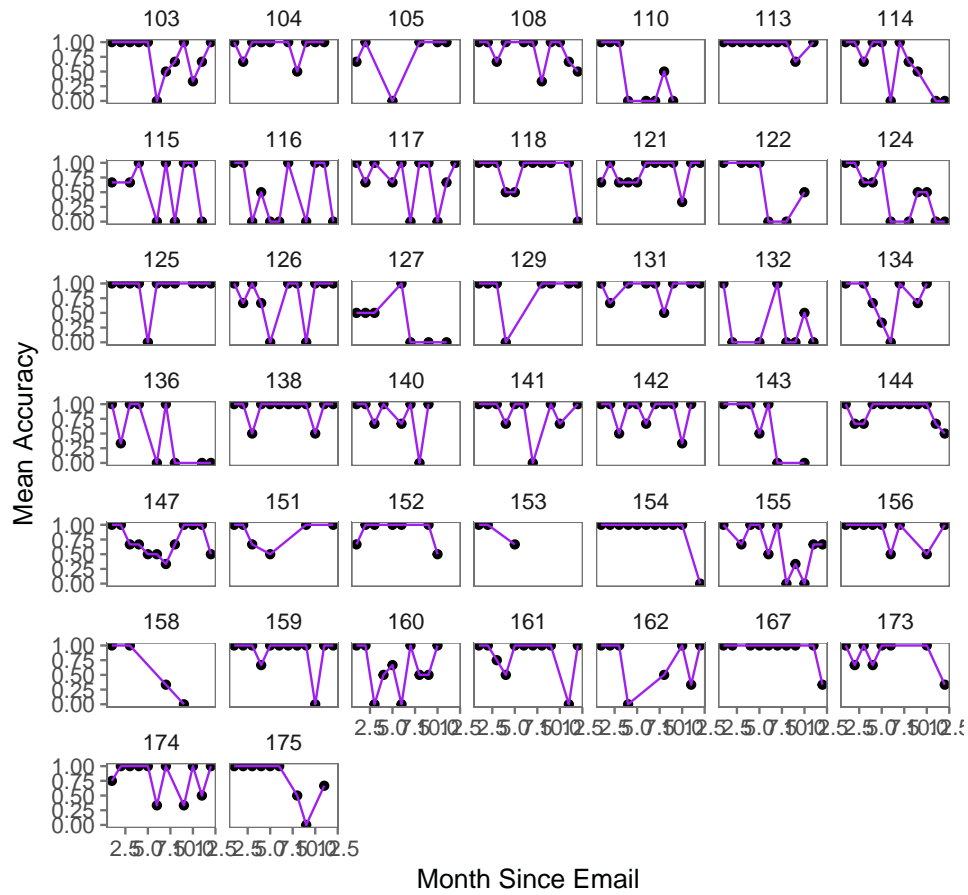
First, we get an average accuracy estimate for each month, per subject to visually examine the data:

Name Retrieval Accuracy Across Time

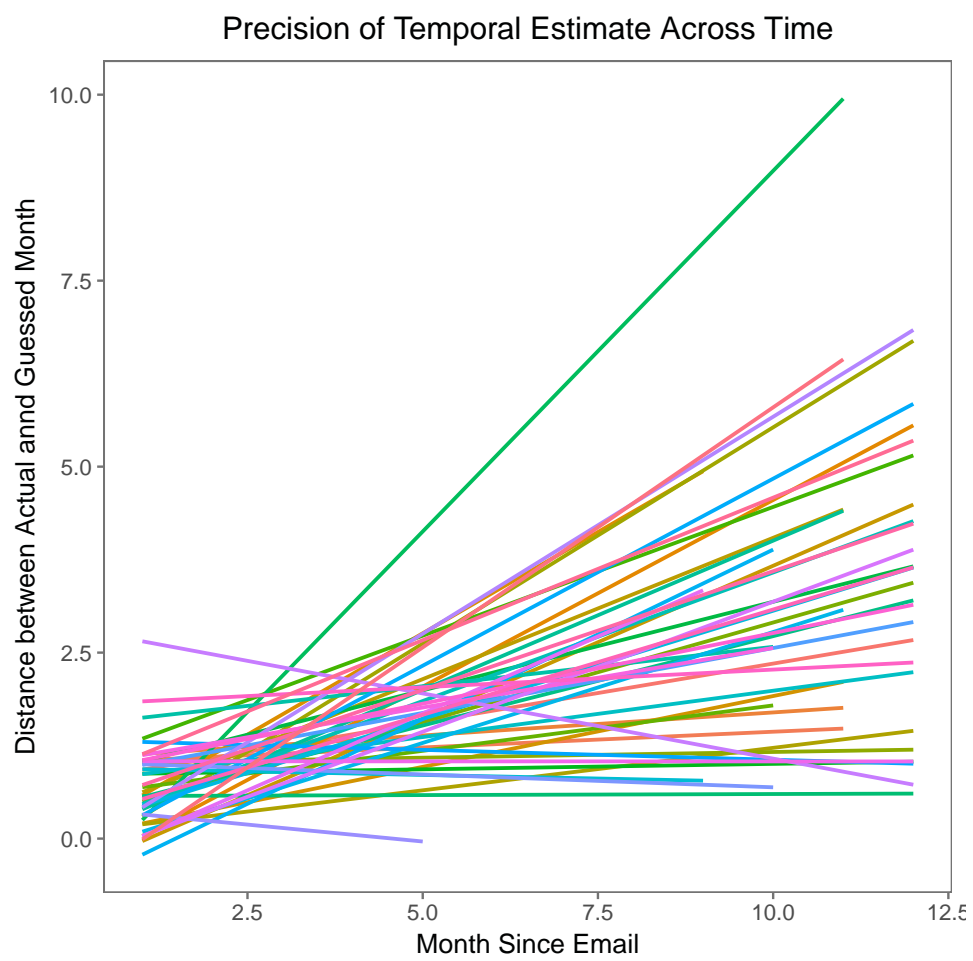


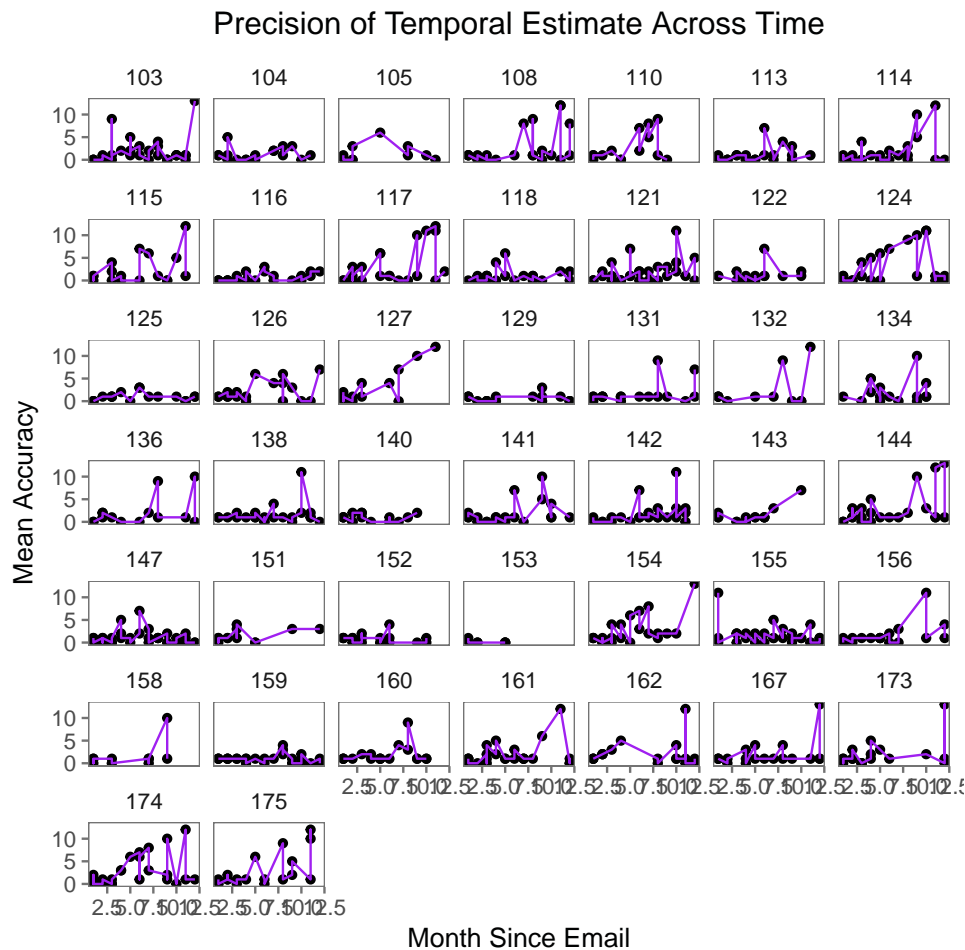
We also look at this at the subject level:

Name Retrieval Accuracy Across Time



Distance of Temporal Estimate





3 Model 1: Fixed Slope of Time

Name Retrieval Accuracy

```
> library(lme4)
> acc_model_1 = glmer(data = cell, Accuracy ~ Month + (1|ID), family = "binomial")
> summary(acc_model_1)
```

```
Generalized linear mixed model fit by maximum likelihood
(Laplace Approximation) [glmerMod]
Family: binomial ( logit )
Formula: Accuracy ~ Month + (1 | ID)
Data: cell
```

AIC	BIC	logLik	deviance	df.resid
867.3	881.6	-430.7	861.3	844

Scaled residuals:

Min	1Q	Median	3Q	Max
-3.2297	0.2825	0.4001	0.5530	1.0383

Random effects:

Groups	Name	Variance	Std.Dev.
ID	(Intercept)	0.3423	0.5851

Number of obs: 847, groups: ID, 44

```

Fixed effects:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  2.25612     0.20798  10.848 < 2e-16 ***
Month        -0.16585     0.02515  -6.594 4.29e-11 ***
---
Signif. codes:
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
      (Intr)
Month -0.796

```

Here, the coefficient b1 for Month, is the predicted change in the logit for a 1-unit change in Month. Thus, these are the odds that Accuracy changes by exp (b1) for a 1-unit change in Month. We can also convert odds to probabilities:

```

> odds = exp(-0.16585)
> prob = odds/(1+odds)
> prob

```

```
[1] 0.4586323
```

Thus, for every 1-unit change in Month, the odds of Accuracy decrease by 16 percent, and the accuracy changes by 0.45.

We can also look at the ICC for this model:

```

> reghelper::ICC(acc_model_1) ## why is this 1?

```

```
[1] 1
```

Temporal Distance

```

> time_model_1 = lmer(data = cell, TimeJudgmentDistance ~ Month + (1|ID))
> summary(time_model_1)

```

```

Linear mixed model fit by REML ['lmerMod']
Formula: TimeJudgmentDistance ~ Month + (1 | ID)
Data: cell

```

```
REML criterion at convergence: 3993
```

Scaled residuals:

```

      Min       1Q   Median       3Q      Max
-1.5249 -0.5710 -0.2568  0.1874  4.1881

```

Random effects:

```

Groups   Name             Variance Std.Dev.
ID       (Intercept)  0.1932   0.4395
Residual                    6.3308   2.5161
Number of obs: 847, groups: ID, 44

```

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	0.47150	0.17671	2.668
Month	0.24104	0.02484	9.704

Correlation of Fixed Effects:
 (Intr)
 Month -0.783

We see a main effect of Month, for every 1-unit change in Month, the temporal distance increase by 0.24 units.

```
> reghelper::ICC(time_model_1)
```

```
[1] 0.02961433
```

4 Model 2: Adding Random Slope for Time

Name Retrieval Accuracy

```
> library(lme4)
> acc_model_2 = glmer(data = cell, Accuracy ~ Month + (Month|ID), family = "binomial")
> summary(acc_model_2)
```

Generalized linear mixed model fit by maximum likelihood
 (Laplace Approximation) [glmerMod]
 Family: binomial (logit)
 Formula: Accuracy ~ Month + (Month | ID)
 Data: cell

AIC	BIC	logLik	deviance	df.resid
868.6	892.3	-429.3	858.6	842

Scaled residuals:

Min	1Q	Median	3Q	Max
-2.9522	0.3237	0.4052	0.5279	1.2395

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
ID	(Intercept)	0.058688	0.24226	
	Month	0.003532	0.05943	1.00

Number of obs: 847, groups: ID, 44

Fixed effects:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	2.19914	0.19064	11.54	< 2e-16 ***
Month	-0.15994	0.02734	-5.85	4.92e-09 ***

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
 (Intr)
 Month -0.747

```
> anova(acc_model_1, acc_model_2)
```

```
Data: cell
Models:
acc_model_1: Accuracy ~ Month + (1 | ID)
acc_model_2: Accuracy ~ Month + (Month | ID)
```

	Df	AIC	BIC	logLik	deviance	Chisq	Chi	Df
acc_model_1	3	867.33	881.55	-430.66	861.33			
acc_model_2	5	868.56	892.27	-429.28	858.56	2.7648		2

```
Pr(>Chisq)
acc_model_1
acc_model_2      0.251
```

```
>
> ## model with random slope is NOT better
```

Temporal Distance

```
> # time_model_2 = lmer(data = cell, TimeJudgmentDistance ~ Month + (Month|ID))
> # summary(time_model_2)
> ## does not converge!
```

5 Model 3: Examining Polynomial Trend

Name Retrieval Accuracy

```
> cell$Month.c = as.numeric(scale(cell$Month, center = TRUE, scale = FALSE))
> #acc_model_3 = glmer(data = cell, Accuracy ~ Month.c + I((Month.c)^2) (1|ID), family = "binomial")
> #summary(acc_model_3)
>
> ## not sure
```

Temporal Distance

```
> time_model_3 = lmer(data = cell, TimeJudgmentDistance ~ Month.c + I((Month.c)^2) + (1|ID))
> summary(time_model_3)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula:
TimeJudgmentDistance ~ Month.c + I((Month.c)^2) + (1 | ID)
Data: cell
```

```
REML criterion at convergence: 4000
```

```
Scaled residuals:
    Min       1Q   Median       3Q      Max
-1.4669 -0.5841 -0.2450  0.1944  4.2282
```

```
Random effects:
Groups   Name              Variance Std.Dev.
ID       (Intercept) 0.1967    0.4435
```

```

Residual          6.3306   2.5161
Number of obs: 847, groups: ID, 44

```

Fixed effects:

```

          Estimate Std. Error t value
(Intercept)  1.913343   0.150168  12.741
Month.c       0.248562   0.026304   9.449
I((Month.c)^2) -0.007160   0.008262  -0.867

```

Correlation of Fixed Effects:

```

          (Intr) Mnth.c
Month.c      0.230
I((Mnt.)^2) -0.678 -0.329

```

```

> # quadratic term not significant!

```

6 Centering the Data

Centering Time

We first make the 0 for the time variable (Month) meaningful, and see if any of the models change before we add any new predictors.

```

> ## make the 0 for month meaningful
> cell$Month_0 = cell$Month - 1
> acc_model_4 = glmer(data = cell, Accuracy ~ Month_0 + (1|ID), family = "binomial")
> summary(acc_model_4)

```

Generalized linear mixed model fit by maximum likelihood

```

(Laplace Approximation) [glmerMod]
Family: binomial ( logit )
Formula: Accuracy ~ Month_0 + (1 | ID)
Data: cell

```

```

      AIC      BIC   logLik deviance df.resid
867.3    881.6   -430.7    861.3     844

```

Scaled residuals:

```

      Min      1Q  Median      3Q      Max
-3.2297  0.2825  0.4001  0.5530  1.0383

```

Random effects:

```

Groups Name      Variance Std.Dev.
ID      (Intercept) 0.3423   0.5851
Number of obs: 847, groups: ID, 44

```

Fixed effects:

```

          Estimate Std. Error z value Pr(>|z|)
(Intercept)  2.09028    0.18857  11.085 < 2e-16 ***
Month_0      -0.16585    0.02515  -6.594 4.29e-11 ***
---

```

Signif. codes:

```

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Correlation of Fixed Effects:

(Intr)
Month_0 -0.745

```
> ## model with random slope of Month_0 does not converge. acc_model_4 is the final model.  
>  
> time_model_4 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 + (1|ID))  
> summary(time_model_4)
```

Linear mixed model fit by REML ['lmerMod']
Formula: TimeJudgmentDistance ~ Month_0 + (1 | ID)
Data: cell

REML criterion at convergence: 3993

Scaled residuals:

Min	1Q	Median	3Q	Max
-1.5249	-0.5710	-0.2568	0.1874	4.1881

Random effects:

Groups	Name	Variance	Std.Dev.
ID	(Intercept)	0.1932	0.4395
Residual		6.3308	2.5161

Number of obs: 847, groups: ID, 44

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	0.71254	0.15802	4.509
Month_0	0.24104	0.02484	9.704

Correlation of Fixed Effects:

(Intr)
Month_0 -0.718

```
> time_model_5 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 + (Month_0|ID))  
> summary(time_model_5)
```

Linear mixed model fit by REML ['lmerMod']
Formula: TimeJudgmentDistance ~ Month_0 + (Month_0 | ID)
Data: cell

REML criterion at convergence: 3957.1

Scaled residuals:

Min	1Q	Median	3Q	Max
-2.2200	-0.5532	-0.2003	0.1879	4.1901

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
ID	(Intercept)	0.03442	0.1855	
	Month_0	0.02867	0.1693	-1.00
Residual		5.85977	2.4207	

Number of obs: 847, groups: ID, 44

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	0.70430	0.14134	4.983
Month_0	0.24967	0.03581	6.973

Correlation of Fixed Effects:

(Intr)
Month_0 -0.679

```
> anova(time_model_4, time_model_5)
```

Data: cell

Models:

time_model_4: TimeJudgmentDistance ~ Month_0 + (1 | ID)

time_model_5: TimeJudgmentDistance ~ Month_0 + (Month_0 | ID)

	Df	AIC	BIC	logLik	deviance	Chisq
time_model_4	4	3992.8	4011.8	-1992.4	3984.8	
time_model_5	6	3961.6	3990.0	-1974.8	3949.6	35.256

Chi Df Pr(>Chisq)

time_model_4

time_model_5 2 2.209e-08 ***

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```
> ##model 5 with random slope is better.
```

6.1 Adding New Predictors

We have 2 predictors that could potentially influence our DVs. The number of messages sent to the recipient over the year (a level-1 predictor), and the vividness for the email conversation (level 1 predictor). We will now try to include these variables.

Uncentered Messages

```
> acc_pred_1 = glmer(data = cell, Accuracy ~ Month_0 + Messages + (1|ID), family = "binomial")
> summary(acc_pred_1)
```

Generalized linear mixed model fit by maximum likelihood

(Laplace Approximation) [glmerMod]

Family: binomial (logit)

Formula: Accuracy ~ Month_0 + Messages + (1 | ID)

Data: cell

AIC	BIC	logLik	deviance	df.resid
846.6	865.6	-419.3	838.6	843

Scaled residuals:

Min	1Q	Median	3Q	Max
-7.3552	0.0430	0.4053	0.5598	1.2609

Random effects:

Groups	Name	Variance	Std.Dev.
ID	(Intercept)	0.3533	0.5944

Number of obs: 847, groups: ID, 44

Fixed effects:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	1.51985	0.22530	6.746	1.52e-11 ***
Month_0	-0.13782	0.02610	-5.281	1.29e-07 ***
Messages	0.06158	0.01692	3.640	0.000273 ***

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:

	(Intr) Mnth_0
Month_0	-0.706
Messages	-0.517 0.135

```
> anova(acc_model_4, acc_pred_1) ## this is a better model
```

Data: cell

Models:

acc_model_4: Accuracy ~ Month_0 + (1 | ID)

acc_pred_1: Accuracy ~ Month_0 + Messages + (1 | ID)

	Df	AIC	BIC	logLik	deviance	Chisq	Chi	Df
acc_model_4	3	867.33	881.55	-430.66	861.33			
acc_pred_1	4	846.64	865.61	-419.32	838.64	22.687		1

Pr(>Chisq)

acc_model_4

acc_pred_1 1.907e-06 ***

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```
> time_pred_1 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 + Messages + (Month_0|ID))
> summary(time_pred_1)
```

Linear mixed model fit by REML ['lmerMod']

Formula:

TimeJudgmentDistance ~ Month_0 + Messages + (Month_0 | ID)

Data: cell

REML criterion at convergence: 3966.4

Scaled residuals:

	Min	1Q	Median	3Q	Max
	-2.2178	-0.5530	-0.2001	0.1877	4.1876

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
ID	(Intercept)	0.03454	0.1859	
	Month_0	0.02868	0.1693	-1.00
Residual		5.86701	2.4222	

Number of obs: 847, groups: ID, 44

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	0.7064800	0.1569244	4.502
Month_0	0.2494711	0.0363674	6.860
Messages	-0.0001207	0.0037629	-0.032

Correlation of Fixed Effects:

	(Intr)	Mnth_0
Month_0	-0.678	
Messages	-0.433	0.173

```
> anova(time_model_5, time_pred_1) ## not a better model
```

Data: cell

Models:

time_model_5: TimeJudgmentDistance ~ Month_0 + (Month_0 | ID)

time_pred_1: TimeJudgmentDistance ~ Month_0 + Messages + (Month_0 | ID)

	Df	AIC	BIC	logLik	deviance	Chisq	Chi	Df
--	----	-----	-----	--------	----------	-------	-----	----

time_model_5	6	3961.6	3990.0	-1974.8	3949.6			
--------------	---	--------	--------	---------	--------	--	--	--

time_pred_1	7	3963.6	3996.8	-1974.8	3949.6	9e-04	1	
-------------	---	--------	--------	---------	--------	-------	---	--

Pr(>Chisq)

time_model_5

time_pred_1 0.9756

Uncentered Vividness

```
> # acc_pred_2 = glmer(data = cell, Accuracy ~ Month_0 + Vividness + (1|ID), family = "binomial")
> # summary(acc_pred_2) ## does not converge
> #
> # time_pred_2 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 + Vividness + (Month_0|ID))
> # summary(time_pred_2) ## does not converge
```

Within-Person and Grand Mean Centering

```
> library(dplyr)
> ## aggregate per subject all IVs and DVs
> cell_agg = cell %>% group_by(ID) %>%
+   summarize(acc_mean = mean(Accuracy, na.rm = TRUE),
+             time_mean = mean(TimeJudgmentDistance, na.rm = TRUE),
+             messages_mean = mean(Messages, na.rm = TRUE),
+             vividness_mean = mean(Vividness, na.rm = TRUE))
> head(cell_agg)
```

A tibble: 6 x 5

	ID	acc_mean	time_mean	messages_mean	vividness_mean
<fctr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
1	103	0.7666667	1.7666667	5.633333	8.000000
2	104	0.8823529	1.2352941	7.941176	8.000000
3	105	0.8181818	1.3636364	5.181818	6.545455
4	108	0.7727273	2.7727273	9.681818	7.000000
5	110	0.4285714	2.6428571	37.928571	6.142857
6	113	0.9565217	0.9565217	7.652174	8.130435

```

> ## merge aggregate info with long data
> cell = merge(cell, cell_agg, by = "ID", all.x = T)
> ## person and grand-mean centered scores using original and aggregate
> library(dplyr)
> cell = cell %>% mutate(acc_pc = Accuracy - acc_mean,
+                         time_pc = TimeJudgmentDistance - time_mean,
+                         messages_pc = Messages - messages_mean,
+                         vividness_pc = Vividness - vividness_mean)

```

7 Centered Multiple Predictors

Time and Messages

```

> acc_pred_3 = glmer(data = cell, Accuracy ~ Month_0 + messages_mean +
+                  messages_pc + (1|ID), family = "binomial")
> summary(acc_pred_3)

```

```

Generalized linear mixed model fit by maximum likelihood
(Laplace Approximation) [glmerMod]
Family: binomial ( logit )
Formula:
Accuracy ~ Month_0 + messages_mean + messages_pc + (1 | ID)
Data: cell

```

AIC	BIC	logLik	deviance	df.resid
846.3	870.0	-418.2	836.3	842

Scaled residuals:

Min	1Q	Median	3Q	Max
-7.4906	0.0416	0.4054	0.5648	1.3510

Random effects:

Groups	Name	Variance	Std.Dev.
ID	(Intercept)	0.3116	0.5582

Number of obs: 847, groups: ID, 44

Fixed effects:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	1.78568	0.28474	6.271	3.58e-10 ***
Month_0	-0.13781	0.02610	-5.280	1.29e-07 ***
messages_mean	0.03696	0.02297	1.609	0.107566
messages_pc	0.06331	0.01692	3.741	0.000184 ***

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:

	(Intr)	Mnth_0	mssgs_m
Month_0		-0.576	
messages_mn	-0.721	0.117	
messages_pc	-0.359	0.132	0.680

```

> ## Accuracy increases if the number of sent messages is over and above the person's sending
> ## behaviour in general. IMPORTANT!
>

```

```
> time_pred_3 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 + messages_mean +
+                               messages_pc + (Month_0|ID))
> summary(time_pred_3)
```

Linear mixed model fit by REML ['lmerMod']

Formula:

TimeJudgmentDistance ~ Month_0 + messages_mean + messages_pc +
(Month_0 | ID)

Data: cell

REML criterion at convergence: 3972.6

Scaled residuals:

Min	1Q	Median	3Q	Max
-2.2124	-0.5531	-0.2050	0.1772	4.1834

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
ID	(Intercept)	0.03383	0.1839	
	Month_0	0.02855	0.1690	-1.00
Residual		5.87189	2.4232	

Number of obs: 847, groups: ID, 44

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	0.620365	0.210361	2.949
Month_0	0.248359	0.036375	6.828
messages_mean	0.008254	0.014131	0.584
messages_pc	-0.001029	0.004044	-0.255

Correlation of Fixed Effects:

	(Intr)	Mnth_0	mssgs_m
Month_0	-0.472		
messages_mn	-0.728	-0.001	
messages_pc	-0.058	0.179	-0.104

```
>
> ## Still no effect of messages
```

Time and Vividness

```
> # acc_pred_4 = glmer(data = cell, Accuracy ~ Month_0 + vividness_mean +
> #                               vividness_pc + (1|ID), family = "binomial")
> # summary(acc_pred_4) ## does not converge
> #
> # time_pred_4 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 + vividness_mean +
> #                               vividness_pc + (Month_0|ID))
> # summary(time_pred_4) ## does not converge
```

Time and Messages Interaction

```
> # acc_pred_5 = glmer(data = cell, Accuracy ~ Month_0 + messages_mean +
> #                               messages_pc + Month_0*messages_pc +
> #                               (1|ID), family = "binomial")
```

```

> # summary(acc_pred_5) ## does not converge
>
> # time_pred_5 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 + messages_mean +
> #                                     messages_pc + Month_0*messages_pc +
> #                                     (Month_0|ID))
> # summary(time_pred_5) ## no effect
>

```

8 Graphing the Models

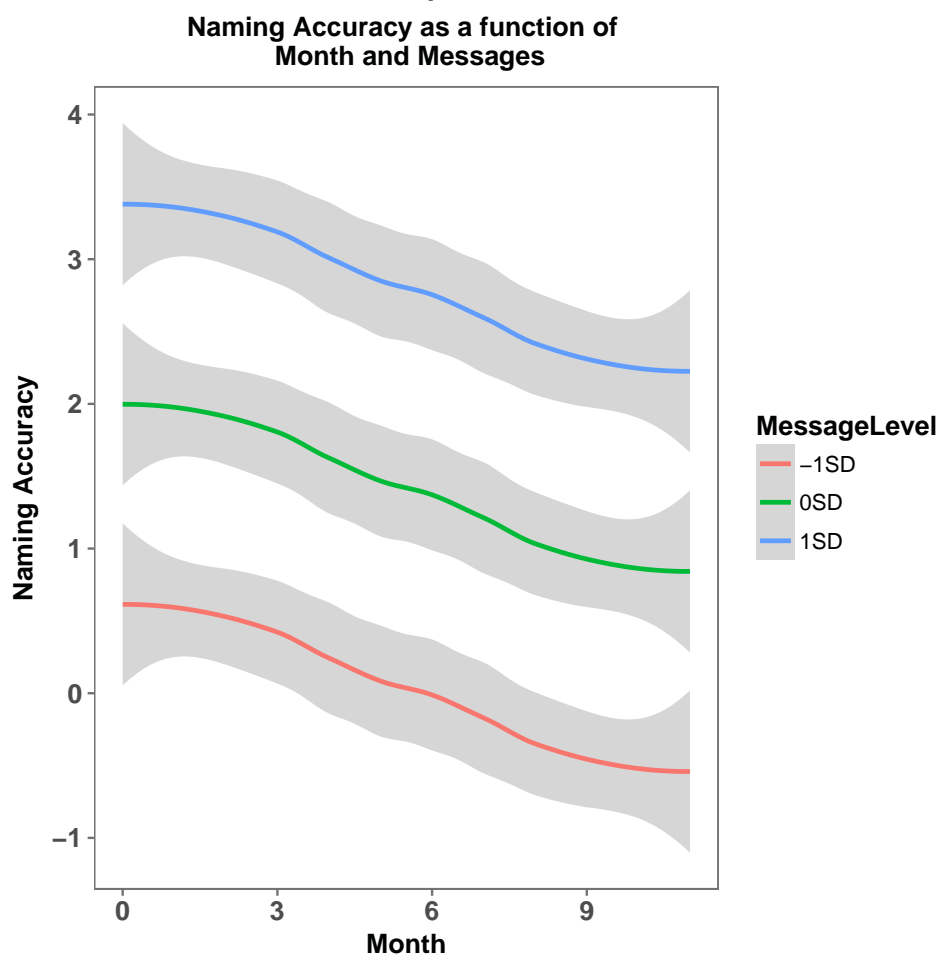
Naming Accuracy

```

> sjPlot::sjp.glmer(acc_pred_3, type = "eff", vars = c("Month_0", "messages_pc"))

```

The final model for accuracy is acc_{pred_3} , with time and messages. We are going to try and plot the fitted values from this model.



9 Regression Table

Storing Table into a Dataframe

Making the Table

10 Naming Accuracy as a Factor

```

> ##creatng a factor term for naming accuracy
> cell$acc_fac = as.factor(as.character(cell$Accuracy))
> time_model_6 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 +
+                      acc_fac + (Month_0|ID))
> summary(time_model_6)

```

Linear mixed model fit by REML ['lmerMod']

Formula:

TimeJudgmentDistance ~ Month_0 + acc_fac + (Month_0 | ID)

Data: cell

REML criterion at convergence: 3884.4

Scaled residuals:

Min	1Q	Median	3Q	Max
-2.7857	-0.4778	-0.2026	0.2238	4.6923

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
ID	(Intercept)	0.03674	0.1917	
	Month_0	0.02397	0.1548	-1.00
Residual		5.39870	2.3235	

Number of obs: 847, groups: ID, 44

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	2.30899	0.22743	10.153
Month_0	0.19567	0.03406	5.745
acc_fac1	-1.78491	0.20269	-8.806

Correlation of Fixed Effects:

	(Intr)	Mnth_0
Month_0	-0.554	
acc_fac1	-0.801	0.180

```

> ## adding interaction term
> time_model_7 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 +
+                      acc_fac + Month_0*acc_fac + (Month_0|ID))
> summary(time_model_7)

```

Linear mixed model fit by REML ['lmerMod']

Formula:

TimeJudgmentDistance ~ Month_0 + acc_fac + Month_0 * acc_fac +
(Month_0 | ID)

Data: cell

REML criterion at convergence: 3871.9

Scaled residuals:

Min	1Q	Median	3Q	Max
-3.1481	-0.4549	-0.1793	0.1818	4.8774

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
ID	(Intercept)	0.02999	0.1732	


```

      Month_0      0.02183  0.1478  -1.00
Residual          5.31142  2.3047
Number of obs: 847, groups: ID, 44

```

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	1.18163	0.35765	3.304
Month_0	0.38789	0.05781	6.710
acc_fac1	-0.45771	0.38400	-1.192
Month_0:acc_fac1	-0.24345	0.05996	-4.060

Correlation of Fixed Effects:

	(Intr)	Mnth_0	acc_f1
Month_0		-0.836	
acc_fac1	-0.926	0.753	
Mnth_0:cc_1	0.777	-0.819	-0.852

```
> anova(time_model_5, time_model_6)
```

Data: cell

Models:

time_model_5: TimeJudgmentDistance ~ Month_0 + (Month_0 | ID)

time_model_6: TimeJudgmentDistance ~ Month_0 + acc_fac + (Month_0 | ID)

	Df	AIC	BIC	logLik	deviance	Chisq
time_model_5	6	3961.6	3990.0	-1974.8	3949.6	
time_model_6	7	3889.2	3922.4	-1937.6	3875.2	74.347

	Chi	Df	Pr(>Chisq)
time_model_5			
time_model_6	1		< 2.2e-16 ***

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```
> anova(time_model_6, time_model_7)
```

Data: cell

Models:

time_model_6: TimeJudgmentDistance ~ Month_0 + acc_fac + (Month_0 | ID)

time_model_7: TimeJudgmentDistance ~ Month_0 + acc_fac + Month_0 * acc_fac +

time_model_7: (Month_0 | ID)

	Df	AIC	BIC	logLik	deviance	Chisq
time_model_6	7	3889.2	3922.4	-1937.6	3875.2	
time_model_7	8	3874.8	3912.8	-1929.4	3858.8	16.401

	Chi	Df	Pr(>Chisq)
time_model_6			
time_model_7	1		5.126e-05 ***

Signif. codes:

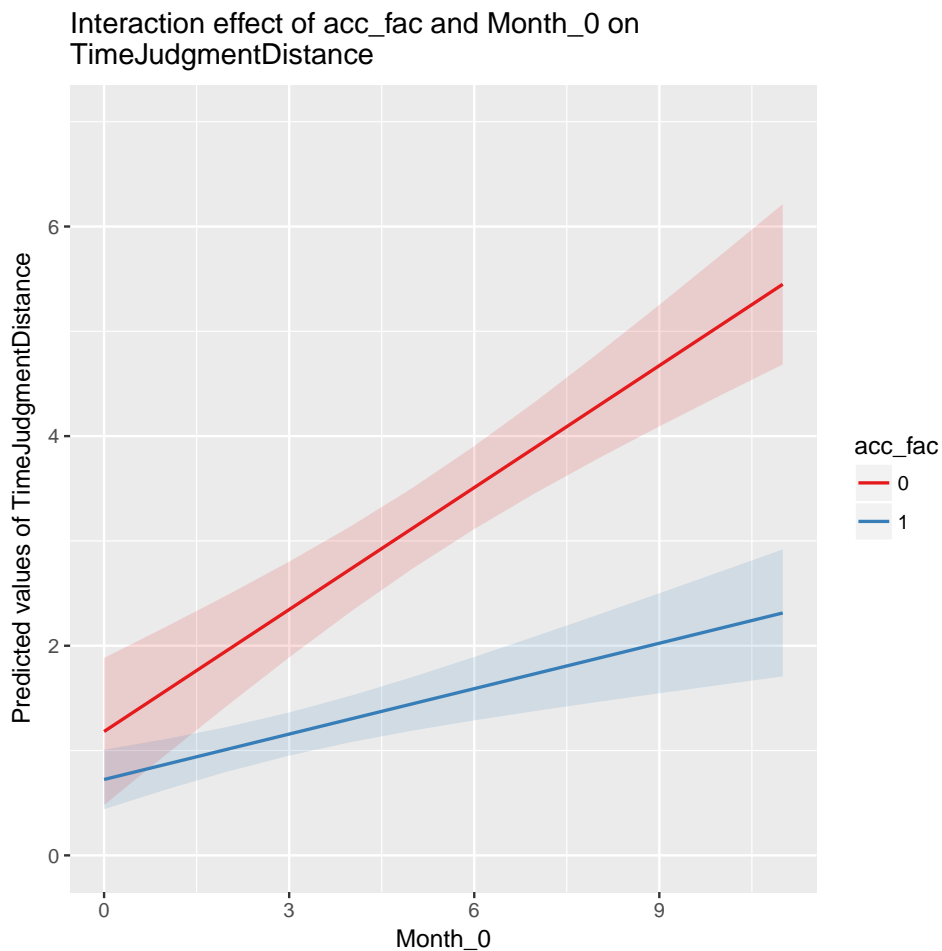
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```
>
```

```
> ## thus, time_model_7 is a better model
```

Plotting The Temporal Distance Model

Using sjPlot



Using predict()

11 Naming Accuracy and Vividness as IVs

```
> time_model_8 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 +  
+                               acc_fac + Month_0*acc_fac +  
+                               Vividness +  
+                               (Month_0|ID))  
> summary(time_model_8)
```

Linear mixed model fit by REML ['lmerMod']

Formula:

TimeJudgmentDistance ~ Month_0 + acc_fac + Month_0 * acc_fac +
Vividness + (Month_0 | ID)
Data: cell

REML criterion at convergence: 3806.3

Scaled residuals:

Min	1Q	Median	3Q	Max
-2.7998	-0.5159	-0.1245	0.2745	4.7145

```
Random effects:
Groups   Name             Variance Std.Dev. Corr
ID       (Intercept) 0.01803  0.1343
        Month_0      0.02755  0.1660  -1.00
Residual                4.81913  2.1953
Number of obs: 847, groups: ID, 44
```

```
Fixed effects:
              Estimate Std. Error t value
(Intercept)    2.68530    0.38191   7.031
Month_0         0.33148    0.05720   5.795
acc_fac1        0.61168    0.38683   1.581
Vividness      -0.28266    0.03253  -8.689
Month_0:acc_fac1 -0.23567    0.05739  -4.107
```

```
Correlation of Fixed Effects:
      (Intr) Mnth_0 acc_f1 Vvdnss
Month_0    -0.770
acc_fac1   -0.640  0.654
Vividness  -0.451  0.108 -0.321
Mnth_0:cc_1 0.697 -0.793 -0.802 -0.010
```

```
> anova(time_model_7, time_model_8)
```

```
Data: cell
```

```
Models:
```

```
time_model_7: TimeJudgmentDistance ~ Month_0 + acc_fac + Month_0 * acc_fac +
time_model_7:      (Month_0 | ID)
time_model_8: TimeJudgmentDistance ~ Month_0 + acc_fac + Month_0 * acc_fac +
time_model_8:      Vividness + (Month_0 | ID)

      Df    AIC    BIC logLik deviance Chisq
time_model_7  8 3874.8 3912.8 -1929.4   3858.8
time_model_8  9 3806.2 3848.8 -1894.1   3788.2 70.678
      Chi Df Pr(>Chisq)
```

```
time_model_7
time_model_8      1 < 2.2e-16 ***
```

```
---
```

```
Signif. codes:
```

```
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
> #3-way interaction
```

```
>
```

```
> time_model_9 = lmer(data = cell, TimeJudgmentDistance ~ Month_0 +
+                      acc_fac + Month_0*acc_fac +
+                      Vividness + Month_0*acc_fac*Vividness +
+                      (Month_0|ID))
> summary(time_model_9)
```

```
Linear mixed model fit by REML ['lmerMod']
```

```
Formula:
```

```
TimeJudgmentDistance ~ Month_0 + acc_fac + Month_0 * acc_fac +
  Vividness + Month_0 * acc_fac * Vividness + (Month_0 | ID)
Data: cell
```

REML criterion at convergence: 3760.7

Scaled residuals:

Min	1Q	Median	3Q	Max
-3.3588	-0.4816	-0.0740	0.3379	4.6726

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
ID	(Intercept)	0.06673	0.2583	
	Month_0	0.03680	0.1918	-1.00
Residual		4.45260	2.1101	

Number of obs: 847, groups: ID, 44

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	1.85695	0.54652	3.398
Month_0	0.63136	0.08526	7.405
acc_fac1	-1.00127	0.80033	-1.251
Vividness	-0.06419	0.09082	-0.707
Month_0:acc_fac1	-0.25510	0.12330	-2.069
Month_0:Vividness	-0.08284	0.01509	-5.490
acc_fac1:Vividness	0.05574	0.11130	0.501
Month_0:acc_fac1:Vividness	0.05171	0.01855	2.787

Correlation of Fixed Effects:

	(Intr)	Mnth_0	acc_f1	Vvdsn	Mn_0:_1	Mn_0:V
Month_0		-0.852				
acc_fac1		-0.679	0.566			
Vividness		-0.795	0.680	0.542		
Mnth_0:cc_1		0.565	-0.601	-0.842	-0.464	
Mnth_0:Vvsn		0.639	-0.732	-0.437	-0.844	0.497
acc_fc1:Vvd		0.648	-0.555	-0.855	-0.815	0.732
Mnth_0:_1:V		-0.516	0.588	0.678	0.682	-0.836
ac_1:V						
Month_0						
acc_fac1						
Vividness						
Mnth_0:cc_1						
Mnth_0:Vvsn						
acc_fc1:Vvd						
Mnth_0:_1:V						-0.825

```
> anova(time_model_8, time_model_9)
```

Data: cell

Models:

```
time_model_8: TimeJudgmentDistance ~ Month_0 + acc_fac + Month_0 * acc_fac +
```

```
time_model_8: Vividness + (Month_0 | ID)
```

```
time_model_9: TimeJudgmentDistance ~ Month_0 + acc_fac + Month_0 * acc_fac +
```

```
time_model_9: Vividness + Month_0 * acc_fac * Vividness + (Month_0 | ID)
```

	Df	AIC	BIC	logLik	deviance	Chisq
--	----	-----	-----	--------	----------	-------

time_model_8	9	3806.2	3848.8	-1894.1	3788.2	
--------------	---	--------	--------	---------	--------	--

time_model_9	12	3748.9	3805.8	-1862.5	3724.9	63.234
--------------	----	--------	--------	---------	--------	--------

	Chi	Df	Pr(>Chisq)
--	-----	----	------------

time_model_8			
--------------	--	--	--

time_model_9	3	1.197e-13	***
--------------	---	-----------	-----

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

>

> ## Thus the 3-way model is better. This is the final model for Temporal Distance.

12 Plotting Final Temporal Model

