

Generalized Linear Mixed Models

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Read in the individual data (or a pairwise dataset)

```
library(tidyr)
library(dplyr)

#install.packages("lme4")
library(lme4)

acitelli_ind <- read.csv("/Users/randigarcia/Desktop/Three-day-workshop/R Workshop/Data/
```

Convert individual data to pairwise. I also create a `simhobs` variable that will be our binary response, two dummy variables that will be useful for estimating separate random intercepts for men and women, and a count variable `cigarettes`.

```
tempA <- acitelli_ind %>%
  mutate(genderE = gender, partnum = 1) %>%
  mutate(gender = ifelse(gender == 1, "A", "P")) %>%
  gather(variable, value, self_pos:genderE) %>%
  unite(var_gender, variable, gender) %>%
  spread(var_gender, value)

tempB <- acitelli_ind %>%
  mutate(genderE = gender, partnum = 2) %>%
  mutate(gender = ifelse(gender == 1, "P", "A")) %>%
  gather(variable, value, self_pos:genderE) %>%
  unite(var_gender, variable, gender) %>%
  spread(var_gender, value)
```

```

acitelli_pair <- bind_rows(tempA, tempB) %>%
  arrange(cuplid) %>%
  mutate(gender_A = ifelse(genderE_A == 1, "hus", "wife"),
         gender_A = as.factor(gender_A),
         simhob_bin_A = ifelse(simhob_A == 1, 1, 0), #forced binary variable
         man = ifelse(genderE_A == 1, 1, 0),
         woman = ifelse(genderE_A == 1, 0, 1),
         cigarettes_A = rpois(296, 0.7)) %>%
  group_by(cuplid) %>%
  mutate(cupcig = rpois(1, 0.7)) %>%
  ungroup(cuplid) %>%
  mutate(cigarettes_A = cigarettes_A + cupcig)

rm(tempA, tempB)

```

Logistic Multilevel Modeling (Binary variables)

To account for the nonindependence, we can make use of the `glmer()` function from the `lme4` package. Note that we are asking for the variance of intercepts across dyads, that is the random intercept in traditional multilevel modeling. The `gls()` function in the `nlme` package does not have an option for specifying a link function (i.e., there is no `family =` option). The syntax of `glmer()` differs a bit from `gls()` in that the random effects are specified within the formula: `+ (1/cuplid)`.

Indistinguishable Dyads

```

apim_bin <- glmer(simhob_bin_A ~ other_pos_A + other_pos_P
                  + (1|cuplid),
                  data = acitelli_pair,
                  family = binomial,
                  na.action = na.omit)

summary(apim_bin)

```

```

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: binomial ( logit )
## Formula: simhob_bin_A ~ other_pos_A + other_pos_P + (1 | cuplid)
##   Data: acitelli_pair
##
##           AIC           BIC    logLik deviance df.resid

```

```
##      322.5      337.3     -157.3      314.5          292
##
## Scaled residuals:
##      Min        1Q      Median        3Q        Max
## -0.90316 -0.44848 -0.33245  0.02569  2.03565
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   cuplid (Intercept) 1.659      1.288
## Number of obs: 296, groups:  cuplid, 148
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -8.3310      2.4903  -3.345 0.000821 ***
## other_pos_A    0.9195      0.3894   2.361 0.018217 *
## other_pos_P    0.6723      0.3756   1.790 0.073481 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) oth__A
## other_pos_A -0.738
## other_pos_P -0.708  0.058
```

Distinguishable Dyads

Interaction approach.

```
apim_bin_di <- glmer(simhob_bin_A ~ other_pos_A + other_pos_P + genderE_A
  + other_pos_A*genderE_A + other_pos_P*genderE_A
  + (man + woman - 1|cuplid),
  data = acitelli_pair,
  family = binomial,
  na.action = na.omit)

summary(apim_bin_di)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: binomial ( logit )
##   Formula:
##   simhob_bin_A ~ other_pos_A + other_pos_P + genderE_A + other_pos_A *
##     genderE_A + other_pos_P * genderE_A + (man + woman - 1 | cuplid)
##   Data: acitelli_pair
```

```
##
##      AIC      BIC   logLik deviance df.resid
##    314.7    347.9   -148.4    296.7      287
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.09016 -0.48698 -0.00949  0.03293  2.52186
##
## Random effects:
##   Groups Name   Variance Std.Dev. Corr
##   cuplid man    183.8755 13.5601
##        woman    0.1908  0.4368  1.00
## Number of obs: 296, groups:  cuplid, 148
##
## Fixed effects:
##
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      -38.413      15.095  -2.545   0.0109 *
## other_pos_A         6.104       2.453   2.489   0.0128 *
## other_pos_P         1.433       2.551   0.562   0.5744
## genderE_A        -30.611      14.859  -2.060   0.0394 *
## other_pos_A:genderE_A  5.014       2.462   2.037   0.0417 *
## other_pos_P:genderE_A  0.937       2.559   0.366   0.7142
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) oth__A oth__P gndE_A o__A:E
## other_pos_A -0.656
## other_pos_P -0.683 -0.098
## genderE_A    0.988 -0.647 -0.675
## othr__A:E_A -0.635  0.985 -0.113 -0.643
## othr__P:E_A -0.662 -0.114  0.986 -0.670 -0.134
## convergence code: 0
## unable to evaluate scaled gradient
## Model failed to converge: degenerate Hessian with 2 negative eigenvalues
```

Two-intercept model.

#does not converge

```
apim_bin_di_two <- glmer(simhob_bin_A ~ gender_A + other_pos_A:gender_A + other_pos_P:gender_A
+ (man + woman - 1|cuplid),
  data = acitelli_pair,
  family = binomial,
  na.action = na.omit)

apim_bin_di_two <- glmer(simhob_bin_A ~ gender_A + other_pos_A:gender_A + other_pos_P:gender_A
```

```

+ (1|cuplid),
data = acitelli_pair,
family = binomial,
na.action = na.omit)

apim_bin_di_two <- glmer(simhob_bin_A ~ gender_A + other_pos_A:gender_A + other_pos_P:gender_A +
+ (man + woman - 1|cuplid),
data = acitelli_pair,
family = binomial,
na.action = na.omit,
nAGQ = 0) #Adaptive Gauss-Hermite Quadrature

summary(apim_bin_di_two)

```

```

## Generalized linear mixed model fit by maximum likelihood (Adaptive
##   Gauss-Hermite Quadrature, nAGQ = 0) [glmerMod]
## Family: binomial ( logit )
## Formula:
## simhob_bin_A ~ gender_A + other_pos_A:gender_A + other_pos_P:gender_A +
##   1 + (man + woman - 1 | cuplid)
## Data: acitelli_pair
##
##      AIC      BIC   logLik deviance df.resid
##  330.4    363.6  -156.2    312.4      287
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -0.97710 -0.52321 -0.39856  0.00841  1.90671
##
## Random effects:
##   Groups Name   Variance Std.Dev. Corr
##   cuplid man    1.257     1.121
##          woman 1.038     1.019    1.00
## Number of obs: 296, groups:  cuplid, 148
##
## Fixed effects:
##
##              Estimate Std. Error z value Pr(>|z|)
## gender_Ahus      -7.1637     2.7924  -2.566   0.0103 *
## gender_Awife     -6.0917     2.4851  -2.451   0.0142 *
## gender_Ahus:other_pos_A    0.4259     0.5214   0.817   0.4141
## gender_Awife:other_pos_A   1.0173     0.4539   2.241   0.0250 *
## gender_Ahus:other_pos_P    0.9160     0.5003   1.831   0.0671 .
## gender_Awife:other_pos_P   0.1722     0.4655   0.370   0.7114
## ---

```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          gndr_Ah gndr_Aw gndr_Ah:__A gndr_Aw:__A gndr_Ah:__P
## gender_Awif  0.153
## gndr_Ah:__A -0.641  -0.103
## gndr_Aw:__A -0.087  -0.611  -0.037
## gndr_Ah:__P -0.605  -0.090  -0.218    0.153
## gndr_Aw:__P -0.104  -0.629   0.164   -0.226   -0.036
```

Log-Linear Multilevel Modeling (Count variables)

Indistinguishable Dyads

```
apim_poi <- glmer(cigarettes_A ~ other_pos_A + other_pos_P
                  + (1|cuplid),
                  data = acitelli_pair,
                  family = poisson,
                  na.action = na.omit)
```

```
summary(apim_poi)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
## Formula: cigarettes_A ~ other_pos_A + other_pos_P + (1 | cuplid)
##   Data: acitelli_pair
##
##      AIC      BIC   logLik deviance df.resid
##   889.5    904.3   -440.8    881.5      292
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.2675 -0.4623 -0.1371  0.4359  2.1573
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   cuplid (Intercept) 0.1776    0.4215
## Number of obs: 296, groups:  cuplid, 148
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
```

```
## (Intercept)  0.16159    0.66097    0.244    0.807
## other_pos_A  0.10373    0.10972    0.945    0.344
## other_pos_P -0.07413    0.10762   -0.689    0.491
##
## Correlation of Fixed Effects:
##              (Intr) oth__A
## other_pos_A -0.715
## other_pos_P -0.696  0.006
## convergence code: 0
## Model failed to converge with max|grad| = 0.00120471 (tol = 0.001, component 1)
```

Distinguishable Dyads

Interaction approach.

```
apim_poi_di <- glmer(cigarettes_A ~ other_pos_A + other_pos_P + genderE_A
  + other_pos_A*genderE_A + other_pos_P*genderE_A
  + (man + woman - 1|cuplid),
  data = acitelli_pair,
  family = poisson,
  na.action = na.omit)

summary(apim_poi_di)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
##   Formula:
## cigarettes_A ~ other_pos_A + other_pos_P + genderE_A + other_pos_A *
##   genderE_A + other_pos_P * genderE_A + (man + woman - 1 | cuplid)
##   Data: acitelli_pair
##
##           AIC          BIC    logLik deviance df.resid
##      898.1       931.3   -440.1    880.1      287
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.2346 -0.4408 -0.1400  0.4723  2.2872
##
## Random effects:
##   Groups Name   Variance Std.Dev. Corr
##   cuplid man    0.1651   0.4063
##          woman 0.1828   0.4275   1.00
## Number of obs: 296, groups:  cuplid, 148
```

```
##
## Fixed effects:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)      0.09390    0.66378   0.142   0.888
## other_pos_A       0.10208    0.11035   0.925   0.355
## other_pos_P      -0.05726    0.10877  -0.526   0.599
## genderE_A         0.49516    0.53704   0.922   0.357
## other_pos_A:genderE_A 0.01354    0.11607   0.117   0.907
## other_pos_P:genderE_A -0.12865    0.11448  -1.124   0.261
##
## Correlation of Fixed Effects:
##              (Intr) oth__A oth__P gndE_A o__A:E
## other_pos_A -0.710
## other_pos_P -0.695 -0.003
## genderE_A   -0.026 -0.083  0.117
## othr__A:E_A -0.092  0.096  0.029 -0.552
## othr__P:E_A  0.119 -0.010 -0.150 -0.527 -0.411
## convergence code: 0
## Model failed to converge with max|grad| = 0.0342649 (tol = 0.001, component 1)

Two-intercept model.

apim_poi_di_two <- glmer(cigarettes_A ~ gender_A + other_pos_A:gender_A + other_pos_P:gender_A +
  + (man + woman - 1|cuplid),
  data = acitelli_pair,
  family = poisson,
  na.action = na.omit)

summary(apim_poi_di_two)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula:
## cigarettes_A ~ gender_A + other_pos_A:gender_A + other_pos_P:gender_A +
## 1 + (man + woman - 1 | cuplid)
## Data: acitelli_pair
##
##      AIC      BIC  logLik deviance df.resid
##  898.1    931.3  -440.1    880.1     287
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.2355 -0.4398 -0.1403  0.4725  2.2843
##
## Random effects:
```



```
## Groups Name Variance Std.Dev. Corr
## cuplid man 0.1654 0.4067
## woman 0.1837 0.4286 1.00
## Number of obs: 296, groups: cuplid, 148
##
## Fixed effects:
##
## Estimate Std. Error z value Pr(>|z|)
## gender_Ahus 0.58286 0.84298 0.691 0.489
## gender_Awife -0.39262 0.86511 -0.454 0.650
## gender_Ahus:other_pos_A 0.11710 0.16773 0.698 0.485
## gender_Awife:other_pos_A 0.08651 0.15230 0.568 0.570
## gender_Ahus:other_pos_P -0.18596 0.14563 -1.277 0.202
## gender_Awife:other_pos_P 0.07131 0.16943 0.421 0.674
##
## Correlation of Fixed Effects:
## gndr_Ah gndr_Aw gndr_Ah:__A gndr_Aw:__A gndr_Ah:__P
## gender_Awif 0.209
## gndr_Ah:__A -0.696 -0.137
## gndr_Aw:__A -0.120 -0.565 -0.051
## gndr_Ah:__P -0.544 -0.124 -0.216 0.223
## gndr_Aw:__P -0.140 -0.673 0.209 -0.223 -0.052
## convergence code: 0
## Model failed to converge with max|grad| = 0.00401621 (tol = 0.001, component 1)
```

Generalized Estimating Equations (GEE)

Indistinguishable Dyads

```
#install.packages("gee")
library(gee)

apim_gee <- gee(simhob_bin_A ~ other_pos_A + other_pos_P,
               id = cuplid,
               data = acitelli_pair,
               na.action = na.omit,
               family = binomial,
               corstr = "unstructured")

## (Intercept) other_pos_A other_pos_P
## -6.2582893 0.6956734 0.5017679

summary(apim_gee)
```

```

##
## GEE: GENERALIZED LINEAR MODELS FOR DEPENDENT DATA
## gee S-function, version 4.13 modified 98/01/27 (1998)
##
## Model:
## Link:                      Logit
## Variance to Mean Relation: Binomial
## Correlation Structure:     Unstructured
##
## Call:
## gee(formula = simhob_bin_A ~ other_pos_A + other_pos_P, id = cuplid,
##      data = acitelli_pair, na.action = na.omit, family = binomial,
##      corstr = "unstructured")
##
## Summary of Residuals:
##      Min      1Q      Median      3Q      Max
## -0.43310561 -0.27624377 -0.19297150  0.07522507  0.86606888
##
##
## Coefficients:
##              Estimate Naive S.E.   Naive z Robust S.E.  Robust z
## (Intercept) -6.2729871  1.8140043 -3.458088   1.7415077 -3.602044
## other_pos_A  0.6982148  0.2901570  2.406334   0.2851282  2.448775
## other_pos_P  0.5025443  0.2840654  1.769115   0.2605414  1.928846
##
## Estimated Scale Parameter:  0.9978716
## Number of Iterations:  2
##
## Working Correlation
##      [,1]      [,2]
## [1,] 1.0000000 0.2703261
## [2,] 0.2703261 1.0000000

```