```r
setwd("~/Dropbox/Classes/Longitudinal Data Analysis")
wgt <- read.table("weightslong.csv", sep = ",", header = TRUE)
dems <- read.table("agegender.csv", sep = ",", header = TRUE)
library(tidyr)
```

```
## Warning: package 'tidyr' was built under R version 3.3.2
```

```r
library(dplyr)
```

```
## Warning: package 'dplyr' was built under R version 3.3.2
##
## Attaching package: 'dplyr'
## The following objects are masked from 'package:stats':
##
##     filter, lag
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
library(plyr)
```

```
## ------------------------------------------------------------------------------
## You have loaded plyr after dplyr - this is likely to cause problems.
## If you need functions from both plyr and dplyr, please load plyr first, then dplyr:
## library(plyr); library(dplyr)
## ------------------------------------------------------------------------------
##
## Attaching package: 'plyr'
## The following objects are masked from 'package:dplyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize
```

```r
library(lubridate)
```

```
##
## Attaching package: 'lubridate'
## The following object is masked from 'package:plyr':
##
##     here
## The following object is masked from 'package:base':
##
##     date
```

```r
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.3.2
```

```r
library(lme4)
```

```
## Loading required package: Matrix
##
## Attaching package: 'Matrix'
## The following object is masked from 'package:tidyr':
##
##     expand
```

1 Question 1

Run a series of models using a time-invariant nominal covariate. a) where the covariate only predicts the intercept b) predicts both intercept and slope c) is rescaled eg centering. For all models, how does your model change from model to model. What is your final model?

```
data <- merge(wgt, dems, by = "ID")
data$gender[data$gender == 1] <- 0
data$gender[data$gender == 2] <- 1
# a) covariate predicts only intercept
mod1a <- lmer(weight ~ wave + gender + gender * wave + (1 | ID), data = data)
summary(mod1a)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: weight ~ wave + gender + gender * wave + (1 | ID)
##    Data: data
##
## REML criterion at convergence: 26094.5
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2485 -0.5532 -0.1273  0.4530  5.9103
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 2383.55  48.822
##  Residual               36.19   6.015
## Number of obs: 3900, groups:  ID, 139
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept) 253.77918   12.61661   20.11
## wave         -0.81286    0.02481  -32.77
## gender      -21.36674   13.35799   -1.60
## wave:gender   0.20348    0.02641    7.71
##
## Correlation of Fixed Effects:
##             (Intr) wave   gender
## wave        -0.035
## gender      -0.944  0.033
## wave:gender  0.032 -0.939 -0.034
```

```
# Fixed effects Intercept: baseline male weight: 253.78 wave: for every
# additional week, decrease in weight by .81 for men gender: Females have a
# baseline weight of 253-21 wavebygender: differences in slopes between
# males and females across time

# b) covariate predicts intercept and slope
mod1b <- lmer(weight ~ wave + gender + gender * wave + (wave | ID), data = data)
summary(mod1b)
```

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

```
## Formula: weight ~ wave + gender + gender * wave + (wave | ID)
##    Data: data
##
## REML criterion at convergence: 23120.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.6273 -0.5696 -0.0630  0.4844  5.2610
##
## Random effects:
##  Groups   Name        Variance  Std.Dev. Corr
##  ID       (Intercept) 2512.2950 50.1228
##           wave           0.1655  0.4068  -0.20
##  Residual               14.4695  3.8039
## Number of obs: 3900, groups:  ID, 139
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept) 253.7208    12.9461  19.598
## wave         -0.8067     0.1064  -7.583
## gender      -21.6634    13.7068  -1.580
## wave:gender   0.2481     0.1130   2.195
##
## Correlation of Fixed Effects:
##             (Intr) wave   gender
## wave        -0.201
## gender      -0.944  0.190
## wave:gender  0.189 -0.941 -0.200
```

```
# fixed effects don't change much, but variance of the intercept of random
# effects increases and the residual decreases

# c) centering
dems$gender[dems$gender == 1] <- 0
dems$gender[dems$gender == 2] <- 1
mean(dems$age, na.rm = TRUE)
```

```
## [1] 49.09353
```

```
dems$age.c <- dems$age - 49.094
mean(dems$gender, na.rm = TRUE)
```

```
## [1] 0.8920863
```

```
dems$gender.c <- dems$gender - 0.892
data <- merge(wgt, dems, by = "ID")
mod1c <- lmer(weight ~ wave + gender.c + gender.c * wave + (wave | ID), data = data)
summary(mod1c)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: weight ~ wave + gender.c + gender.c * wave + (wave | ID)
##    Data: data
```

```
##
## REML criterion at convergence: 23120.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.6273 -0.5696 -0.0630  0.4844  5.2610
##
## Random effects:
##  Groups   Name        Variance  Std.Dev. Corr
##  ID       (Intercept) 2512.2931 50.1228
##           wave           0.1655  0.4068  -0.20
##  Residual               14.4695  3.8039
## Number of obs: 3900, groups:  ID, 139
##
## Fixed effects:
##                Estimate Std. Error t value
## (Intercept)   234.39711    4.25301   55.11
## wave           -0.58536    0.03595  -16.28
## gender.c      -21.66336   13.70683   -1.58
## wave:gender.c   0.24814    0.11304    2.20
##
## Correlation of Fixed Effects:
##             (Intr) wave   gndr.c
## wave        -0.197
## gender.c     0.000 -0.001
## wave:gndr.c -0.001  0.019 -0.200

# Random effects don't change at all. Intercept and wave are different
# because reference group is now the mean of the genders, not male or
# female. Gender and interaction don't change because those represent the
# differences between the groups, which is maintained by the centering.
```

From the intercept only to the intercept and slope model, the fixed effects change slightly and the intercept in the random effects SD increases a bit and the residual decreases. By centering the model, random effects don't change but the intercept and wave of the fixed effects does because it is no longer referencing a male group. Given the coefficients are a bit easier to interpret, I plan to keep the non-centered version.

2 Question 2

Introduce a time-invariant continuous covariate and run models a to c from 1

```
# a) intercept only
mod2a <- lmer(weight ~ wave + age + age * wave + (1 | ID), data = data)
summary(mod2a)

## Linear mixed model fit by REML ['lmerMod']
## Formula: weight ~ wave + age + age * wave + (1 | ID)
##    Data: data
```

```
##
## REML criterion at convergence: 26151.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2653 -0.5579 -0.1300  0.4722  5.9144
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 2343.36  48.408
##  Residual               36.62   6.052
## Number of obs: 3900, groups:  ID, 139
##
## Fixed effects:
##               Estimate Std. Error t value
## (Intercept)  2.731e+02  2.046e+01  13.347
## wave        -4.697e-01  4.495e-02 -10.450
## age         -7.820e-01  4.083e-01  -1.915
## wave:age    -3.255e-03  8.781e-04  -3.706
##
## Correlation of Fixed Effects:
##          (Intr) wave   age
## wave     -0.034
## age      -0.980  0.033
## wave:age  0.033 -0.982 -0.034
```

```
# Fixed effects Intercept: baseline weight of someone at age 0?: .0273 wave:
# for every additional week, decrease in weight by .47 for people at age 0?
# gender: ?? wavebygender: ??
mod2b <- lmer(weight ~ wave + age + age * wave + (wave | ID), data = data)
summary(mod2b)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: weight ~ wave + age + age * wave + (wave | ID)
##    Data: data
##
## REML criterion at convergence: 23131.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.6268 -0.5666 -0.0638  0.4828  5.2589
##
## Random effects:
##  Groups   Name        Variance  Std.Dev. Corr
##  ID       (Intercept) 2498.7012 49.9870
##           wave           0.1677  0.4095  -0.25
##  Residual               14.4677  3.8036
## Number of obs: 3900, groups:  ID, 139
##
## Fixed effects:
##               Estimate Std. Error t value
## (Intercept) 271.787912  21.116145  12.871
```

```
## wave         -0.249066   0.182288  -1.366
## age          -0.761723   0.421348  -1.808
## wave:age     -0.006835   0.003614  -1.891
##
## Correlation of Fixed Effects:
##          (Intr) wave   age
## wave     -0.247
## age      -0.980  0.242
## wave:age  0.243 -0.980 -0.248

# c) centered
mod2c <- lmer(weight ~ wave + age.c + age.c * wave + (wave | ID), data = data)
summary(mod2c)

## Linear mixed model fit by REML ['lmerMod']
## Formula: weight ~ wave + age.c + age.c * wave + (wave | ID)
##    Data: data
##
## REML criterion at convergence: 23131.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.6268 -0.5666 -0.0638  0.4828  5.2589
##
## Random effects:
##  Groups   Name        Variance  Std.Dev. Corr
##  ID       (Intercept) 2498.7452 49.9875
##           wave           0.1677  0.4095  -0.25
##  Residual               14.4677  3.8036
## Number of obs: 3900, groups:  ID, 139
##
## Fixed effects:
##               Estimate Std. Error t value
## (Intercept) 234.391903   4.241540   55.26
## wave         -0.584635   0.036183  -16.16
## age.c        -0.761723   0.421352   -1.81
## wave:age.c   -0.006835   0.003614   -1.89
##
## Correlation of Fixed Effects:
##            (Intr) wave   age.c
## wave       -0.249
## age.c       0.000  0.001
## wave:age.c  0.001 -0.035 -0.248

# intercept of fixed effects changes quite a bit - now represents the
# baseline weight at the mean age of participants.
```

Will use the centered version with age because better interpretability.

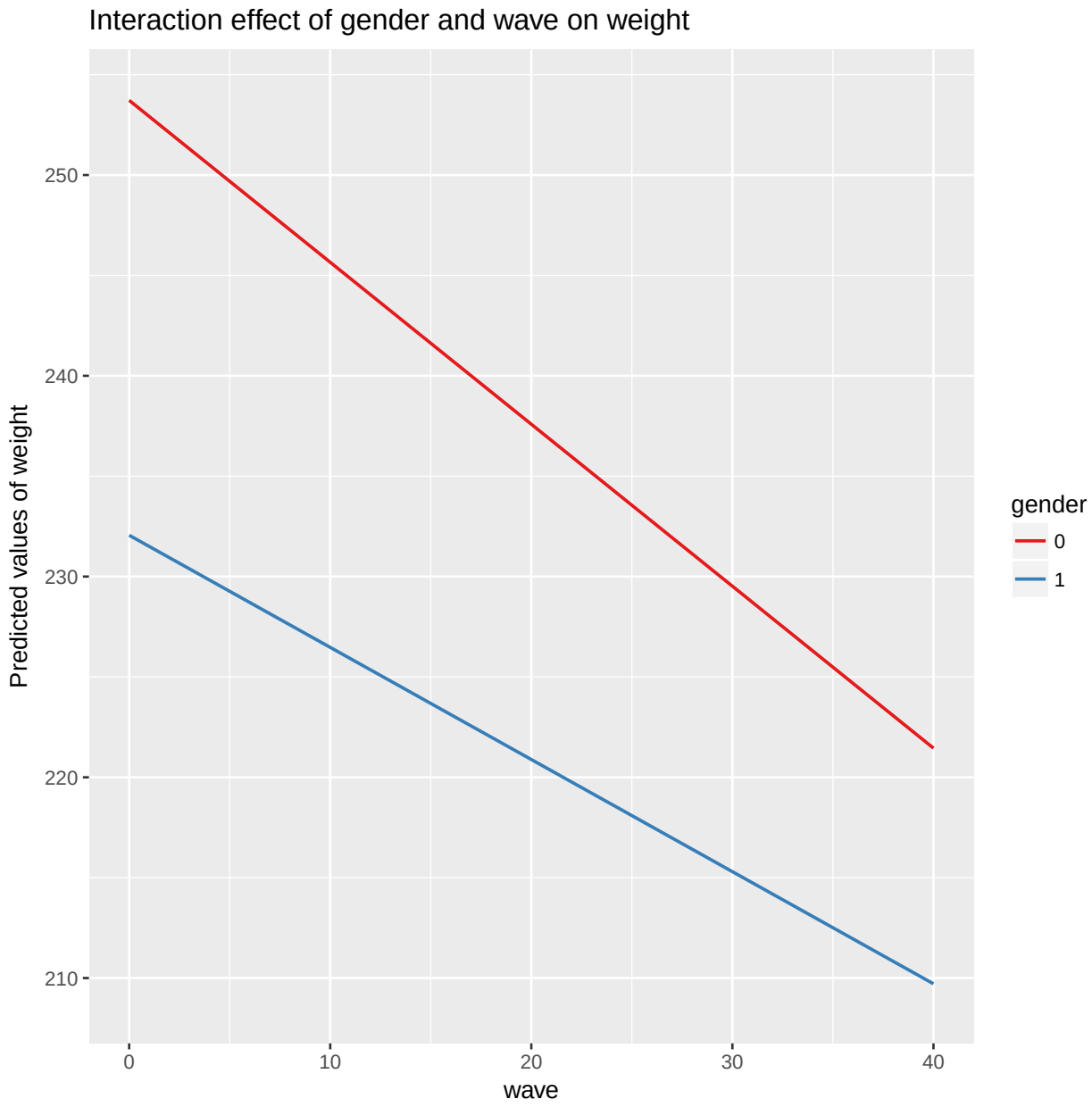
3 Question 3

Graph both of your final models for the continuous and nominal models above.

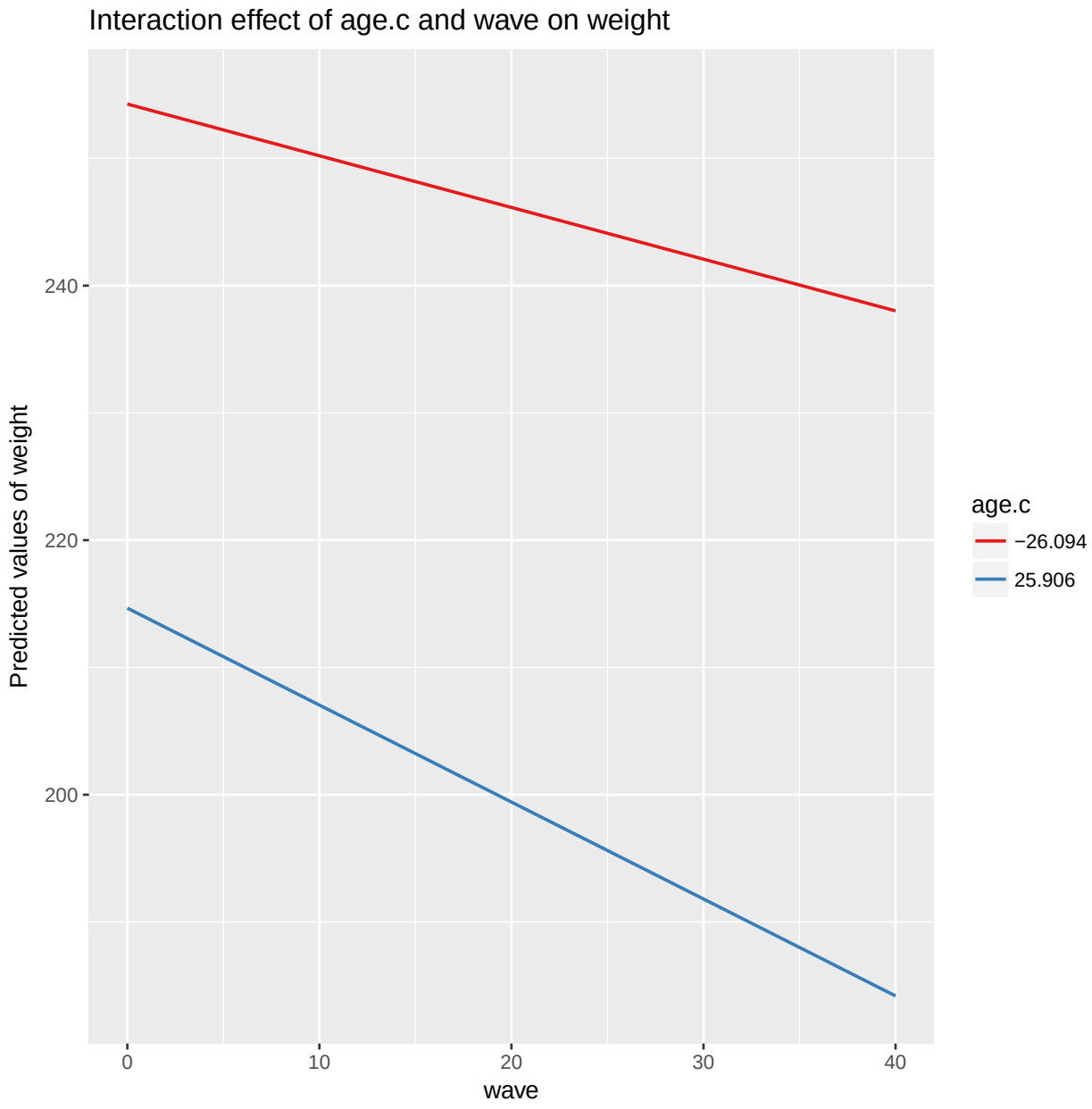
```
library(sjPlot)

## Warning:  package 'sjPlot' was built under R version 3.3.2
## Warning in checkMatrixPackageVersion():  Package version inconsistency detected.
## TMB was built with Matrix version 1.2.10
## Current Matrix version is 1.2.6
## Please re-install 'TMB' from source or restore original 'Matrix' package
## Install package "strengejacke" from GitHub (`devtools::install_github("strengejacke/strengejacke")`)
to load all sj-packages at once!

sjp.int(mod1b, type = "eff", p.kr = F, swap.pred = T)
```




```
sjp.int(mod2c, type = "eff", p.kr = F, swap.pred = T, mdrt.vaues = "meansd")
```



4 Question 4

Calculate confidence intervals around your estimates for your final models

```
confint.merMod(mod1b, method = "boot", nsim = 10)

## Computing bootstrap confidence intervals ...
## Warning in norm.inter(t, alpha):  extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha):  extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha):  extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha):  extreme order statistics used as endpoints
```

```
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
```

```
##                   2.5 %      97.5 %
## .sig01       45.5544700  55.4970510
## .sig02       -0.2664114  -0.0544817
## .sig03        0.3759279   0.4521886
## .sigma        3.6987492   3.8365939
## (Intercept) 238.8632942 280.1488989
## wave         -1.1135893  -0.6566492
## gender      -49.4377711  -3.2667193
## wave:gender   0.1032062   0.5070044
```

```
confint.merMod(mod2c, method = "boot", nsim = 10)
```

```
## Computing bootstrap confidence intervals ...
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model failed
to converge with max|grad| = 0.00338241 (tol = 0.002, component 1)
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model failed
to converge with max|grad| = 0.0125368 (tol = 0.002, component 1)
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, : Model failed
to converge with max|grad| = 0.0415263 (tol = 0.002, component 1)
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
## Warning in norm.inter(t, alpha): extreme order statistics used as endpoints
```

```
##                     2.5 %        97.5 %
## .sig01       46.02109055  51.111875588
## .sig02       -0.38992327  -0.174033131
## .sig03        0.36708803   0.445488600
## .sigma        3.73930581   3.874738506
## (Intercept) 227.78943561 237.280744212
## wave         -0.63799594  -0.578036127
## age.c        -1.67315162  -0.215860394
## wave:age.c   -0.01263621   0.001568964
```

```
# did 500 because taking too long- would do 5000 if doing for real
```

5 Question 5

Include both types of covariates in a single model. How does your interpretation of parameters change?

```
mod3a <- lmer(weight ~ wave + age.c + gender + age.c * wave + gender * wave +
    age.c * gender + (wave | ID), data = data)
summary(mod3a)

## Linear mixed model fit by REML ['lmerMod']
## Formula: weight ~ wave + age.c + gender + age.c * wave + gender * wave +
##     age.c * gender + (wave | ID)
##    Data: data
##
## REML criterion at convergence: 23118.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.6276 -0.5677 -0.0633  0.4827  5.2615
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  ID       (Intercept) 2473.112 49.730
##           wave           0.164  0.405   -0.23
##  Residual               14.466  3.803
## Number of obs: 3900, groups:  ID, 139
##
## Fixed effects:
##                Estimate Std. Error t value
## (Intercept)  254.851674  13.295580  19.168
## wave          -0.789901   0.106378  -7.425
## age.c         -0.418206   1.268495  -0.330
## gender       -23.091292  14.027390  -1.646
## wave:age.c    -0.006209   0.003590  -1.730
## wave:gender    0.231543   0.112954   2.050
## age.c:gender  -0.461571   1.336928  -0.345
##
## Correlation of Fixed Effects:
##             (Intr) wave   age.c  gender wv:g.c wv:gnd
## wave        -0.222
## age.c       -0.258  0.007
## gender      -0.948  0.211  0.245
## wave:age.c   0.020 -0.091 -0.079 -0.021
## wave:gender  0.209 -0.942 -0.007 -0.223  0.085
## age.c:gendr  0.244 -0.001 -0.943 -0.228  0.005  0.000
```

The coefficients now need to be interpreted for males at baseline at the mean age of the sample. For example, the fixed effects intercept shows males at the mean age have a weight of 254.9 at baseline. Males at the mean age will decrease by .79 pounds each week. Women at the mean age have a weight that is 23 pounds lower than men at the mean age at baseline. For men, as age increases each year from the mean, weight at baseline decreases by .42.