```
# ------------------------------------
#    Authors: Daniel Gustavson & Matt Panizzon
#
# Univariate Moderated Twin Analysis
# Moderator can differ between twins
# Sex differences
# ------------------------------------

# Loading Required Libraries
#
-------------------------------------------------------------------------
-
require(OpenMx)   #Loads OpenMx
require(psych)    #Loads Psych package
source("GenEpiHelperFunctions.R")

# Reading in Data
#
-------------------------------------------------------------------------
-
data <- read.csv("Fluency_GENETIC_data.csv",header=T)
names(data)

# scaled family age variable
describe(data$age_c)
data$zage_c <- scale(data$age_c)

# Defining Variables of Interest
twinvar <- c('zeduc', 'zfluency') #variable of interest
modvar <- c('zage_c','Country_x1','Country_x2') #moderator variable


# Split off A and B twins
twinA <- data[data$twin=="1",]
twinB <- data[data$twin=="2",]

# Merge into Single Data Set by Case
mergedata <- merge(twinA, twinB,
by=c("uniqueFamily","zygSex"),all=T,suffixes=c("_A","_B"))

# Defining Variables for OpenMx
nv <- 2
ntv <- nv*2
selvars <- paste(twinvar,c(rep("_A",nv),rep("_B",nv)),sep="")
modvars <- paste(modvar,c(rep("_A",3)),sep="")

# Create Separate Data Sets for MZ / DZ Twins by sex
MZMdata <- as.data.frame(subset(mergedata,
zygSex==1,c(selvars,modvars))) # MZ Male Twins
DZMdata <- as.data.frame(subset(mergedata,
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zygSex==2,c(selvars,modvars))) # DZ Male Twins
MZFdata <- as.data.frame(subset(mergedata,
zygSex==3,c(selvars,modvars))) # MZ Female Twins
DZFdata <- as.data.frame(subset(mergedata,
zygSex==4,c(selvars,modvars))) # DZ Female Twins
DZOdata <- as.data.frame(subset(mergedata,
zygSex==5,c(selvars,modvars))) # DZ Opp Sex Twins

# Removing Twins with Missing Moderator Values
# Age
MZMdata <- MZMdata[is.na(MZMdata[,modvars[1]])==0,]
DZMdata <- DZMdata[is.na(DZMdata[,modvars[1]])==0,]
MZFdata <- MZFdata[is.na(MZFdata[,modvars[1]])==0,]
DZFdata <- DZFdata[is.na(DZFdata[,modvars[1]])==0,]
DZOdata <- DZOdata[is.na(DZOdata[,modvars[1]])==0,]

# Education
MZMdata <- MZMdata[is.na(MZMdata[,selvars[3]])==0,]
MZMdata <- MZMdata[is.na(MZMdata[,selvars[1]])==0,]
DZMdata <- DZMdata[is.na(DZMdata[,selvars[3]])==0,]
DZMdata <- DZMdata[is.na(DZMdata[,selvars[1]])==0,]
MZFdata <- MZFdata[is.na(MZFdata[,selvars[3]])==0,]
MZFdata <- MZFdata[is.na(MZFdata[,selvars[1]])==0,]
DZFdata <- DZFdata[is.na(DZFdata[,selvars[3]])==0,]
DZFdata <- DZFdata[is.na(DZFdata[,selvars[1]])==0,]
DZOdata <- DZOdata[is.na(DZOdata[,selvars[3]])==0,]
DZOdata <- DZOdata[is.na(DZOdata[,selvars[1]])==0,]

# Print Descriptive Statistics
#
-----------------------------------------------------------------------
-
# Male Twins
colMeans(MZMdata,na.rm=TRUE)
colMeans(DZMdata,na.rm=TRUE)
cor(MZMdata,use="complete")
cor(DZMdata,use="complete")

# Female Twins
colMeans(MZFdata,na.rm=TRUE)
colMeans(DZFdata,na.rm=TRUE)
cor(MZFdata,use="complete")
cor(DZFdata,use="complete")

# OS Twins
colMeans(DZOdata,na.rm=TRUE)
cor(DZOdata,use="complete")


# Set default Mx optimizer to NPSOL
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mxOption(NULL, "Default optimizer", "NPSOL")


#
------------------------------------------------------------------------
-
# Fit ACE Model with Means and Variance Components moderation effects
#
------------------------------------------------------------------------
-
univModACEModel <- mxModel("univModACE",
mxModel("ACE",
     # Matrices a, c, and e to store a, c, and e path coefficients
     # Males
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=TRUE,
values=c(.7,.1,.2), name="aM", lbound=-20, ubound=20),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=TRUE,
values=c(.1,.3,.2), name="cM", lbound=-30, ubound=30),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=TRUE,
values=c(.7,.1,.6), name="eM", lbound=-20, ubound=20),
     # Females
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=TRUE,
values=c(.7,.1,.6), name="aF", lbound=-20, ubound=20),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=TRUE,
values=c(.1,.3,.2), name="cF", lbound=-20, ubound=20),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=TRUE,
values=c(.7,.1,.6), name="eF", lbound=-20, ubound=20),

     # Matrices a, c, and e to store moderated a, c, and e path
coefficients
     # Males
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(F,T,T),
values=c(0,.0,0), name="aIM1", lbound=-10, ubound=10 ),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(F,T,T),
values=c(0,.0,0), name="cIM1", lbound=-20, ubound=20 ),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(F,T,T),
values=c(0,.0,0), name="eIM1", lbound=-10, ubound=10 ),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(T,T,T),
values=c(0,.0,0), name="aIM2", lbound=-10, ubound=10 ),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(T,T,T),
values=c(0,.0,0), name="cIM2", lbound=-10, ubound=10 ),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(T,T,T),
values=c(0,.0,0), name="eIM2", lbound=-10, ubound=10 ),
     # Females
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(F,T,T),
values=c(0,.0,0), name="aIF1", lbound=-10, ubound=10 ),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(F,T,T),
values=c(0,.0,0), name="cIF1", lbound=-10, ubound=10 ),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(F,T,T),
values=c(0,.0,0), name="eIF1", lbound=-10, ubound=10 ),
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     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(T,T,T),
values=c(0,.0,0), name="aIF2", lbound=-10, ubound=10 ),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(T,T,T),
values=c(0,.0,0), name="cIF2", lbound=-10, ubound=10 ),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=c(T,T,T),
values=c(0,.0,0), name="eIF2", lbound=-10, ubound=10 ),

     # Matrix & Algebra for expected means vector (no effect of age on
mean so b1 is commented out)
     mxMatrix( type="Full", nrow=1, ncol=nv, free=c(T,T), values=
c(0,0), label=c("mean_M_ed","mean_M_flu"), name="muM", lbound=-20,
ubound=40  ),
   #  mxMatrix( type="Full", nrow=1, ncol=nv, free=c(F,F),
values=c(0,0), label=c("bM1_ed","bM1_flu"), name="bM1", lbound=-20,
ubound=20 ),
     mxMatrix( type="Full", nrow=1, ncol=nv, free=c(T,T),
values=c(0,0), label=c("bM2_ed","bM2_flu"), name="bM2", lbound=-20,
ubound=20 ),
     mxMatrix( type="Full", nrow=1, ncol=nv, free=c(T,T),
values=c(0,0), label=c("bM3_ed","bM3_flu"), name="bM3", lbound=-20,
ubound=20 ),
     mxMatrix( type="Full", nrow=1, ncol=nv, free=c(T,T),
values=c(0,0), label=c("bM4_ed","bM4_flu"), name="bM4", lbound=-20,
ubound=20 ),

     mxMatrix( type="Full", nrow=1, ncol=nv, free=c(T,T),
values=c(0,0), label=c("mean_F_ed","mean_F_flu"), name="muF" ,
lbound=-20, ubound=40 ),
   #  mxMatrix( type="Full", nrow=1, ncol=nv, free=c(F,F),
values=c(0,0), label=c("bF1_ed","bF1_flu"), name="bF1", lbound=-20,
ubound=20 ),
     mxMatrix( type="Full", nrow=1, ncol=nv, free=c(T,T),
values=c(0,0), label=c("bF2_ed","bF2_flu"), name="bF2", lbound=-20,
ubound=20 ),
     mxMatrix( type="Full", nrow=1, ncol=nv, free=c(T,T),
values=c(0,0), label=c("bF3_ed","bF3_flu"), name="bF3", lbound=-20,
ubound=20 ),
     mxMatrix( type="Full", nrow=1, ncol=nv, free=c(T,T),
values=c(0,0), label=c("bF4_ed","bF4_flu"), name="bF4", lbound=-20,
ubound=20 ),

     # Confidence interval statements - Run one line at a time due to
long runtime
     #   mxCI(c("bM2","bF2","bM3","bF3","bM4","bF4","bM5","bF5",
     #
"aIM1","cIM1","eIM1","aIM2","cIM2","eIM2","aIM3","cIM3","eIM3",
     #
"aIF1","cIF1","eIF1","aIF2","cIF2","eIF2","aIF3","cIF3","eIF3",
     #          "aM","cM","eM","aF","cF","eF","muM","muF")
     mxCI(c("aM","cM","eM","aF","cF","eF","muM","muF")
```

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     )),

#############
mxModel("MZM",
     # Matrix for Moderating Variable
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[1],sep=""), name="modA1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[3],sep=""), name="modB1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[1],sep=""), name="mod2"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[2],sep=""), name="mod3"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[3],sep=""), name="mod4"),

     # Matrices A, C, and E compute Moderated variance components
     mxAlgebra((ACE.aM + modA1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2) %*%
t(ACE.aM + modA1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2), name="AM1" ),
     mxAlgebra((ACE.cM + modA1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2) %*%
t(ACE.cM + modA1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2), name="CM1" ),
     mxAlgebra((ACE.eM + modA1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2) %*%
t(ACE.eM + modA1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2), name="EM1" ),

     mxAlgebra((ACE.aM + modB1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2) %*%
t(ACE.aM + modB1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2), name="AM2" ),
     mxAlgebra((ACE.cM + modB1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2) %*%
t(ACE.cM + modB1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2), name="CM2" ),
     mxAlgebra((ACE.eM + modB1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2) %*%
t(ACE.eM + modB1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2), name="EM2" ),

     mxAlgebra((ACE.aM + modA1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2) %*%
t(ACE.aM + modB1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2), name="AM12" ),
     mxAlgebra((ACE.cM + modA1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2) %*%
t(ACE.cM + modB1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2), name="CM12" ),

     # Algebra for expected variance/covariance matrix and expected
mean vector in MZ
     mxAlgebra(rbind ( cbind(AM1+CM1+EM1 , AM12+CM12),
                       cbind(AM12+CM12  , AM2+CM2+EM2)),
name="expCovMZM" ),

     mxAlgebra(ACE.muM + ACE.bM2 %*% mod2 + ACE.bM3 %*% mod3+ ACE.bM4
%*% mod4, name="meanAM"),
     mxAlgebra(ACE.muM + ACE.bM2 %*% mod2 + ACE.bM3 %*% mod3+ ACE.bM4
%*% mod4, name="meanBM"),
     mxAlgebra(cbind(meanAM,meanBM), name="expMeanM"),

     # Data & Objective
     mxData(observed=MZMdata, type="raw"),
```

```
     mxExpectationNormal( covariance="expCovMZM", means="expMeanM",
dimnames=selvars),
     mxFitFunctionML()
),


#############
mxModel("DZM",
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[1],sep=""), name="modA1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[3],sep=""), name="modB1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[1],sep=""), name="mod2"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[2],sep=""), name="mod3"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[3],sep=""), name="mod4"),

     # Matrices A, C, and E compute variance components
     mxAlgebra((ACE.aM + modA1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2) %*%
t(ACE.aM + modA1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2), name="AM1" ),
     mxAlgebra((ACE.cM + modA1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2) %*%
t(ACE.cM + modA1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2), name="CM1" ),
     mxAlgebra((ACE.eM + modA1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2) %*%
t(ACE.eM + modA1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2), name="EM1" ),

     mxAlgebra((ACE.aM + modB1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2) %*%
t(ACE.aM + modB1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2), name="AM2" ),
     mxAlgebra((ACE.cM + modB1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2) %*%
t(ACE.cM + modB1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2), name="CM2" ),
     mxAlgebra((ACE.eM + modB1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2) %*%
t(ACE.eM + modB1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2), name="EM2" ),

     mxAlgebra((ACE.aM + modA1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2) %*%
t(ACE.aM + modB1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2), name="AM12" ),
     mxAlgebra((ACE.cM + modA1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2) %*%
t(ACE.cM + modB1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2), name="CM12" ),

     # Algebra for expected variance/covariance matrix in DZ
     mxAlgebra(rbind ( cbind(AM1+CM1+EM1      , 0.5%x%AM12+CM12),
                       cbind(0.5%x%AM12+CM12 , AM2+CM2+EM2)),
name="expCovDZM" ),

     mxAlgebra(ACE.muM + ACE.bM2 %*% mod2 + ACE.bM3 %*% mod3+ ACE.bM4
%*% mod4, name="meanAM"),
     mxAlgebra(ACE.muM + ACE.bM2 %*% mod2 + ACE.bM3 %*% mod3+ ACE.bM4
%*% mod4, name="meanBM"),
     mxAlgebra(cbind(meanAM,meanBM), name="expMeanM"),
```

```
     # Data & Objective
     mxData(observed=DZMdata, type="raw"),
     mxExpectationNormal( covariance="expCovDZM", means="expMeanM",
dimnames=selvars),
     mxFitFunctionML()
),

#############
mxModel("MZF",
     # Matrix for Moderating Variable
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[1],sep=""), name="modA1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[3],sep=""), name="modB1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[1],sep=""), name="mod2"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[2],sep=""), name="mod3"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[3],sep=""), name="mod4"),

     # Matrices A, C, and E compute Moderated variance components
     mxAlgebra((ACE.aF + modA1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2) %*%
t(ACE.aF + modA1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2), name="AF1" ),
     mxAlgebra((ACE.cF + modA1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2) %*%
t(ACE.cF + modA1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2), name="CF1" ),
     mxAlgebra((ACE.eF + modA1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2) %*%
t(ACE.eF + modA1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2), name="EF1" ),

     mxAlgebra((ACE.aF + modB1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2) %*%
t(ACE.aF + modB1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2), name="AF2" ),
     mxAlgebra((ACE.cF + modB1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2) %*%
t(ACE.cF + modB1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2), name="CF2" ),
     mxAlgebra((ACE.eF + modB1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2) %*%
t(ACE.eF + modB1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2), name="EF2" ),

     mxAlgebra((ACE.aF + modA1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2) %*%
t(ACE.aF + modB1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2), name="AF12" ),
     mxAlgebra((ACE.cF + modA1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2) %*%
t(ACE.cF + modB1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2), name="CF12" ),

     # Algebra for expected variance/covariance matrix and expected
mean vector in MZ
     mxAlgebra(rbind ( cbind(AF1+CF1+EF1 , AF12+CF12),
                       cbind(AF12+CF12  , AF2+CF2+EF2)),
name="expCovMZF" ),

     mxAlgebra(ACE.muF + ACE.bF2 %*% mod2 + ACE.bF3 %*% mod3+ ACE.bF4
%*% mod4, name="meanAF"),
     mxAlgebra(ACE.muF + ACE.bF2 %*% mod2 + ACE.bF3 %*% mod3+ ACE.bF4
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%*% mod4, name="meanBF"),
     mxAlgebra(cbind(meanAF,meanBF), name="expMeanF"),

     # Data & Objective
     mxData(observed=MZFdata, type="raw"),
     mxExpectationNormal( covariance="expCovMZF", means="expMeanF",
dimnames=selvars),
     mxFitFunctionML()
),


#############
mxModel("DZF",
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[1],sep=""), name="modA1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[3],sep=""), name="modB1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[1],sep=""), name="mod2"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[2],sep=""), name="mod3"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[3],sep=""), name="mod4"),

     # Matrices A, C, and E compute variance components
     mxAlgebra((ACE.aF + modA1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2) %*%
t(ACE.aF + modA1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2), name="AF1" ),
     mxAlgebra((ACE.cF + modA1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2) %*%
t(ACE.cF + modA1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2), name="CF1" ),
     mxAlgebra((ACE.eF + modA1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2) %*%
t(ACE.eF + modA1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2), name="EF1" ),

     mxAlgebra((ACE.aF + modB1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2) %*%
t(ACE.aF + modB1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2), name="AF2" ),
     mxAlgebra((ACE.cF + modB1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2) %*%
t(ACE.cF + modB1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2), name="CF2" ),
     mxAlgebra((ACE.eF + modB1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2) %*%
t(ACE.eF + modB1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2), name="EF2" ),

     mxAlgebra((ACE.aF + modA1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2) %*%
t(ACE.aF + modB1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2), name="AF12" ),
     mxAlgebra((ACE.cF + modA1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2) %*%
t(ACE.cF + modB1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2), name="CF12" ),

     # Algebra for expected variance/covariance matrix in DZ
     mxAlgebra(rbind ( cbind(AF1+CF1+EF1      , 0.5%x%AF12+CF12),
                       cbind(0.5%x%AF12+CF12 , AF2+CF2+EF2)),
name="expCovDZF" ),

     mxAlgebra(ACE.muF + ACE.bF2 %*% mod2 + ACE.bF3 %*% mod3+ ACE.bF4
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%*% mod4, name="meanAF"),
     mxAlgebra(ACE.muF + ACE.bF2 %*% mod2 + ACE.bF3 %*% mod3+ ACE.bF4
%*% mod4, name="meanBF"),
     mxAlgebra(cbind(meanAF,meanBF), name="expMeanF"),

     # Data & Objective
     mxData(observed=DZFdata, type="raw"),
     mxExpectationNormal( covariance="expCovDZF", means="expMeanF",
dimnames=selvars),
     mxFitFunctionML()
),

mxModel("DZO",
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[1],sep=""), name="modA1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",selvars[3],sep=""), name="modB1"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[1],sep=""), name="mod2"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[2],sep=""), name="mod3"),
     mxMatrix( type="Lower", nrow=nv, ncol=nv, free=FALSE,
labels=paste("data.",modvars[3],sep=""), name="mod4"),

     # Matrices A, C, and E compute variance components
     mxAlgebra((ACE.aM + modA1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2) %*%
t(ACE.aM + modA1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2), name="AM1" ),
     mxAlgebra((ACE.cM + modA1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2) %*%
t(ACE.cM + modA1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2), name="CM1" ),
     mxAlgebra((ACE.eM + modA1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2) %*%
t(ACE.eM + modA1 %*% ACE.eIM1 + mod2 %*% ACE.eIM2), name="EM1" ),

     mxAlgebra((ACE.aF + modB1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2) %*%
t(ACE.aF + modB1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2), name="AF2" ),
     mxAlgebra((ACE.cF + modB1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2) %*%
t(ACE.cF + modB1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2), name="CF2" ),
     mxAlgebra((ACE.eF + modB1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2) %*%
t(ACE.eF + modB1 %*% ACE.eIF1 + mod2 %*% ACE.eIF2), name="EF2" ),

     mxAlgebra((ACE.aM + modA1 %*% ACE.aIM1 + mod2 %*% ACE.aIM2) %*%
t(ACE.aF + modB1 %*% ACE.aIF1 + mod2 %*% ACE.aIF2), name="AO12" ),
     mxAlgebra((ACE.cM + modA1 %*% ACE.cIM1 + mod2 %*% ACE.cIM2) %*%
t(ACE.cF + modB1 %*% ACE.cIF1 + mod2 %*% ACE.cIF2), name="CO12" ),

     # Algebra for expected variance/covariance matrix in OSDZ
     mxAlgebra(rbind ( cbind(AM1+CM1+EM1      , 0.5%x%AO12+CO12),
                       cbind(0.5%x%AO12+CO12 , AF2+CF2+EF2)),
name="expCovDZO" ),

     mxAlgebra(ACE.muM + ACE.bM2 %*% mod2 + ACE.bM3 %*% mod3+ ACE.bM4
```

```
%*% mod4, name="meanAM"),
     mxAlgebra(ACE.muF + ACE.bF2 %*% mod2 + ACE.bF3 %*% mod3+ ACE.bF4
%*% mod4, name="meanBF"),
     mxAlgebra(cbind(meanAM,meanBF), name="expMeanO"),

     # Data & Objective
     mxData(observed=DZOdata, type="raw"),
     mxExpectationNormal( covariance="expCovDZO", means="expMeanO",
dimnames=selvars),
     mxFitFunctionML()
),

mxAlgebra( expression=MZM.objective + DZM.objective + MZF.objective +
DZF.objective + DZO.objective, name="neg2sumll" ),
mxFitFunctionMultigroup(c("MZM","DZM","MZF","DZF","DZO"))
)

univModACEFit <- mxRun(univModACEModel,intervals=F)
#univModACEFit <- mxTryHard(univModACEModel,intervals=F)
univModACESumm <- summary(univModACEFit)
univModACESumm


#########################
# # Model Solution Check #
# #########################
# This code runs the same model with varying start values to help
check whether you've converged on the right solution
# n    <- 25                # How many permutations of the model do
you want to run.
# test <- univModACEFit     # Model name - what you specify in your
mxRun statement
# lab <- names(omxGetParameters(test))
#
# resCP1  <- matrix(NA, n, 2*length(lab)+2)
# cm   <- 1e10
# for (i in 1:n){
#   param <- runif(length(lab), -1, 1)    # Range of start values that
you want to sample from
#   test  <- omxSetParameters(test,
#                             labels=lab,
#                             values=param
#   )
#   tr <- mxRun(test)
#   resCP1[i,] <- c(param,
#                   omxGetParameters(tr),
#                   tr@output$Minus2LogLikelihood,
#                   tr@output$status[[1]])
#   if (tr@output$Minus2LogLikelihood<cm){
#     best <- tr
```

```
#     cm <- tr@output$Minus2LogLikelihood
#   }
#   print(i)
# }
#
# resCP1 <- data.frame(resCP1)
# names(resCP1) <- c(
#   paste("start", lab, sep=""),
#   paste("est",   lab, sep=""),
#   "M2LL",
#   "status"
# )
#
# write.csv(resCP1, "IDCheck.csv")
#
#
```

```
############################
### Tests of SubModels ###
############################
### Collapse A effects across Sex ###
# Collapse a matrix
collapseMF_Aonly_sex <- mxRename(univModACEFit,
"collapseMF_Aonly_sex")
collapseMF_Aonly_sex$ACE.aM <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=2, name="aM" , label=c("a11","a12","a22"),
lbound=-20, ubound=20 )
collapseMF_Aonly_sex$ACE.aF <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=2, name="aF" , label=c("a11","a12","a22"),
lbound=-20, ubound=20 )
collapseMF_Aonly_sex_Fit <- mxRun(collapseMF_Aonly_sex,intervals=F)
#collapseMF_Aonly_sex_Fit <-
mxTryHard(collapseMF_Aonly_sex,intervals=F)
noASumm <- summary(collapseMF_Aonly_sex_Fit)
tableFitStatistics(univModACEFit,c(collapseMF_Aonly_sex_Fit))

# Collapse a for moderator 1
collapseMF_A1 <- mxRename(univModACEFit, "collapseMF_A1")
collapseMF_A1$ACE.aIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="aIM1",
label=c("aI1_11","aI1_12","aI1_22"), lbound=-10, ubound=10 )
collapseMF_A1$ACE.aIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="aIF1",
label=c("aI1_11","aI1_12","aI1_22"), lbound=-10, ubound=10 )
collapseA1Fit <- mxRun(collapseMF_A1,intervals=F)
noASumm1 <- summary(collapseA1Fit)
```

```
tableFitStatistics(univModACEFit,c(collapseA1Fit))

# Collapse a for moderator 2
collapseMF_A2 <- mxRename(univModACEFit, "collapseMF_A2")
collapseMF_A2$ACE.aIM2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,T,T), values=0, name="aIM2",
label=c("aI2_11m","aI2_12","aI2_22"), lbound=-10, ubound=10 )
collapseMF_A2$ACE.aIF2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,T,T), values=0, name="aIF2",
label=c("aI2_11f","aI2_12","aI2_22"), lbound=-10, ubound=10 )
collapseA2Fit <- mxRun(collapseMF_A2,intervals=F)
noASumm2 <- summary(collapseA2Fit)
tableFitStatistics(univModACEFit,c(collapseA2Fit))


## Collapse C effects across Sex
collapseMF_Conly_sex <- mxRename(univModACEFit,
"collapseMF_Conly_sex")
collapseMF_Conly_sex$ACE.cM <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=0, name="cM" , label=c("c11","c12","c22"),
lbound=-20, ubound=20 )
collapseMF_Conly_sex$ACE.cF <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=0, name="cF" , label=c("c11","c12","c22"),
lbound=-20, ubound=20 )
collapseMF_Conly_sex_Fit <- mxRun(collapseMF_Conly_sex,intervals=F)
noCSumm <- summary(collapseMF_Conly_sex_Fit)
tableFitStatistics(univModACEFit,c(collapseMF_Conly_sex_Fit))

collapseMF_C1 <- mxRename(univModACEFit, "collapseMF_C1")
collapseMF_C1$ACE.cIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="cIM1",
label=c("cI1_11","cI1_12","cI1_22"), lbound=-10, ubound=10 )
collapseMF_C1$ACE.cIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="cIF1",
label=c("cI1_11","cI1_12","cI1_22"), lbound=-10, ubound=10 )
collapseC1Fit <- mxRun(collapseMF_C1,intervals=F)
noCSumm <- summary(collapseC1Fit)
tableFitStatistics(univModACEFit,c(collapseC1Fit))

collapseMF_C2 <- mxRename(univModACEFit, "collapseMF_C2")
collapseMF_C2$ACE.cIM2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,T,T), values=0, name="cIM2",
label=c("cI2_11m","cI2_12","cI2_22"), lbound=-10, ubound=10 )
collapseMF_C2$ACE.cIF2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,T,T), values=0, name="cIF2",
label=c("cI2_11f","cI2_12","cI2_22"), lbound=-10, ubound=10 )
collapseC2Fit <- mxRun(collapseMF_C2,intervals=F)
noCSumm2 <- summary(collapseC2Fit)
tableFitStatistics(univModACEFit,c(collapseC2Fit))
```

```
## Collapse E effects across Sex
collapseMF_Eonly_sex <- mxRename(univModACEFit,
"collapseMF_Eonly_sex")
collapseMF_Eonly_sex$ACE.eM <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=0, name="eM" , label=c("e11","e12","e22"),
lbound=-20, ubound=20 )
collapseMF_Eonly_sex$ACE.eF <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=0, name="eF" , label=c("e11","e12","e22"),
lbound=-20, ubound=20 )
collapseMF_Eonly_sex_Fit <- mxRun(collapseMF_Eonly_sex,intervals=F)
#collapseMF_Eonly_sex_Fit <-
mxTryHard(collapseMF_Eonly_sex,intervals=F)
noESumm <- summary(collapseMF_Eonly_sex_Fit)
tableFitStatistics(univModACEFit,c(collapseMF_Eonly_sex_Fit))

collapseMF_E1 <- mxRename(univModACEFit, "collapseMF_E1")
collapseMF_E1$ACE.eIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="eIM1",
label=c("eI1_11","eI1_12","eI1_22"), lbound=-10, ubound=10 )
collapseMF_E1$ACE.eIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="eIF1",
label=c("eI1_11","eI1_12","eI1_22"), lbound=-10, ubound=10 )
collapseE1Fit <- mxRun(collapseMF_E1,intervals=F)
#collapseE2Fit <- mxTryHard(collapseMF_E1,intervals=F)
noESumm <- summary(collapseE1Fit)
tableFitStatistics(univModACEFit,c(collapseE1Fit))

collapseMF_E2 <- mxRename(univModACEFit, "collapseMF_E2")
collapseMF_E2$ACE.eIM2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,T,T), values=0, name="eIM2",
label=c("eI2_11m","eI2_12","eI2_22"), lbound=-10, ubound=10 )
collapseMF_E2$ACE.eIF2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,T,T), values=0, name="eIF2",
label=c("eI2_11f","eI2_12","eI2_22"), lbound=-10, ubound=10 )
collapseE2Fit <- mxRun(collapseMF_E2,intervals=F)
noESumm2 <- summary(collapseE2Fit)
tableFitStatistics(univModACEFit,c(collapseE2Fit))


## Collapse mean effects across Sex
collapseMF_mean <- mxRename(univModACEFit, "collapseMF_mean")
collapseMF_mean$ACE.muM <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(T,T), values=c(0,0), name="muM",
label=c("mean_M_ed","mean_flu"), lbound=-10, ubound=10 )
collapseMF_mean$ACE.muF <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(T,T), values=c(0,0), name="muF",
label=c("mean_F_ed","mean_flu"), lbound=-10, ubound=10 )
collapseMF_meanFit <- mxRun(collapseMF_mean,intervals=F)
noMeanSumm <- summary(collapseMF_meanFit)
#noASumm
```

```
tableFitStatistics(univModACEFit,c(collapseMF_meanFit))

# commented out because there is no b1 in this mdoel
# collapseMF_b1 <- mxRename(univModACEFit, "collapseMF_b1")
# collapseMF_b1$ACE.bM1 <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(F,T), values=c(0,1), name="bM1", label=c("bM1_ed","b1_flu"),
lbound=-10, ubound=10 )
# collapseMF_b1$ACE.bF1 <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(F,T), values=c(0,1), name="bF1", label=c("bF1_ed","b1_flu"),
lbound=-10, ubound=10 )
# collapseMF_b1Fit <- mxRun(collapseMF_b1,intervals=F)
# noMeanSumm <- summary(collapseMF_b1Fit)
# #noASumm
# tableFitStatistics(univModACEFit,c(collapseMF_b1Fit))

collapseMF_b2 <- mxRename(univModACEFit, "collapseMF_b2")
collapseMF_b2$ACE.bM2 <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(T,T), values=c(0,0), name="bM2", label=c("bM2_ed","b2_flu"),
lbound=-10, ubound=10 )
collapseMF_b2$ACE.bF2 <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(T,T), values=c(0,0), name="bF2", label=c("bF2_ed","b2_flu"),
lbound=-10, ubound=10 )
collapseMF_b2Fit <- mxRun(collapseMF_b2,intervals=F)
noMeanSumm2 <- summary(collapseMF_b2Fit)
tableFitStatistics(univModACEFit,c(collapseMF_b2Fit))

collapseMF_b3 <- mxRename(univModACEFit, "collapseMF_b3")
collapseMF_b3$ACE.bM3 <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(T,T), values=c(0,0), name="bM3", label=c("bM3_ed","b3_flu"),
lbound=-10, ubound=10 )
collapseMF_b3$ACE.bF3 <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(T,T), values=c(0,0), name="bF3", label=c("bF3_ed","b3_flu"),
lbound=-10, ubound=10 )
collapseMF_b3Fit <- mxRun(collapseMF_b3,intervals=F)
noMeanSumm3 <- summary(collapseMF_b3Fit)
tableFitStatistics(univModACEFit,c(collapseMF_b3Fit))

collapseMF_b4 <- mxRename(univModACEFit, "collapseMF_b4")
collapseMF_b4$ACE.bM4 <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(T,T), values=c(0,0), name="bM4", label=c("bM4_ed","b4_flu"),
lbound=-10, ubound=10 )
collapseMF_b4$ACE.bF4 <- mxMatrix( type="Full", nrow=1, ncol=nv,
free=c(T,T), values=c(0,0), name="bF4", label=c("bF4_ed","b4_flu"),
lbound=-10, ubound=10 )
collapseMF_b4Fit <- mxRun(collapseMF_b4,intervals=F)
noMeanSumm4 <- summary(collapseMF_b4Fit)
tableFitStatistics(univModACEFit,c(collapseMF_b4Fit))


# Collapse ACEs at the same time
```

```
collapseMF_ACE_sex <- mxRename(univModACEFit, "collapseMF_ACE_sex")
collapseMF_ACE_sex$ACE.aM <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=TRUE, values=0, name="aM" , label=c("a11","a12","a22"),
lbound=-20, ubound=20 )
collapseMF_ACE_sex$ACE.aF <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=TRUE, values=0, name="aF" , label=c("a11","a12","a22"),
lbound=-20, ubound=20 )
collapseMF_ACE_sex$ACE.cM <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=TRUE, values=0, name="cM" , label=c("c11","c12","c22"),
lbound=-20, ubound=20 )
collapseMF_ACE_sex$ACE.cF <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=TRUE, values=0, name="cF" , label=c("c11","c12","c22"),
lbound=-20, ubound=20 )
collapseMF_ACE_sex$ACE.eM <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=TRUE, values=0, name="eM" , label=c("e11","e12","e22"),
lbound=-20, ubound=20 )
collapseMF_ACE_sex$ACE.eF <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=TRUE, values=0, name="eF" , label=c("e11","e12","e22"),
lbound=-20, ubound=20 )
collapseMF_ACE_sex_Fit <- mxTryHard(collapseMF_ACE_sex,intervals=F)
noACESumm <- summary(collapseMF_ACE_sex_Fit)
tableFitStatistics(univModACEFit,c(collapseMF_ACE_sex_Fit))

collapseMF_ACE1 <- mxRename(univModACEFit, "collapseMF_ACE1")
collapseMF_ACE1$ACE.aIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="aIM1",
label=c("aI1_11","aI1_12","aI1_22"), lbound=-10, ubound=10 )
collapseMF_ACE1$ACE.aIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="aIF1",
label=c("aI1_11","aI1_12","aI1_22"), lbound=-10, ubound=10 )
collapseMF_ACE1$ACE.cIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="cIM1",
label=c("cI1_11","cI1_12","cI1_22"), lbound=-10, ubound=10 )
collapseMF_ACE1$ACE.cIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="cIF1",
label=c("cI1_11","cI1_12","cI1_22"), lbound=-10, ubound=10 )
collapseMF_ACE1$ACE.eIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="eIM1",
label=c("eI1_11","eI1_12","eI1_22"), lbound=-10, ubound=10 )
collapseMF_ACE1$ACE.eIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,T,T), values=0, name="eIF1",
label=c("eI1_11","eI1_12","eI1_22"), lbound=-10, ubound=10 )
collapseACE1Fit <- mxRun(collapseMF_ACE1,intervals=F)
noACEsumm1 <- summary(collapseACE1Fit)
tableFitStatistics(univModACEFit,c(collapseACE1Fit))


collapseMF_ACE2 <- mxRename(univModACEFit, "collapseMF_ACE2")
collapseMF_ACE2$ACE.aIM2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=T, values=0, name="aIM2", label=c("aI2_11m","aI2_12","aI2_22"),
```

```
lbound=-10, ubound=10 )
collapseMF_ACE2$ACE.aIF2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=T, values=0, name="aIF2", label=c("aI2_11f","aI2_12","aI2_22"),
lbound=-10, ubound=10 )
collapseMF_ACE2$ACE.cIM2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=T, values=0, name="cIM2", label=c("cI2_11m","cI2_12","cI2_22"),
lbound=-10, ubound=10 )
collapseMF_ACE2$ACE.cIF2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=T, values=0, name="cIF2", label=c("cI2_11f","cI2_12","cI2_22"),
lbound=-10, ubound=10 )
collapseMF_ACE2$ACE.eIM2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=T, values=0, name="eIM2", label=c("eI2_11m","eI2_12","eI2_22"),
lbound=-10, ubound=10 )
collapseMF_ACE2$ACE.eIF2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=T, values=0, name="eIF2", label=c("eI2_11f","eI2_12","eI2_22"),
lbound=-10, ubound=10 )
collapseACE2Fit <- mxRun(collapseMF_ACE2,intervals=F)
noACEsumm2 <- summary(collapseACE2Fit)
#noASumm
tableFitStatistics(univModACEFit,c(collapseACE2Fit))


### Summary of previous models: Collapse ACEs across sex
tableFitStatistics(univModACEFit,c(collapseMF_Aonly_sex_Fit,
                                   collapseMF_Conly_sex_Fit,
                                   collapseMF_Eonly_sex_Fit,
                                   collapseMF_ACE_sex_Fit))
### Summary of previous models: Collapse Moderators and Means across
sex
tableFitStatistics(univModACEFit,c(collapseA1Fit, collapseA2Fit,
                                   collapseC1Fit, collapseC2Fit,
                                   collapseE1Fit, collapseE2Fit,
                                   collapseACE1Fit, collapseACE2Fit,
                                   collapseMF_meanFit,
collapseMF_b2Fit, collapseMF_b3Fit,
                                   collapseMF_b4Fit,
collapseMF_b5Fit))



#########################
#### Tests within Sex ####
#########################
## Drop rA for education - Males
noAModel_M <- mxRename(univModACEFit, "noAModel_M")
noAModel_M$ACE.aM <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,T), values=0, name="aM", lbound=-10, ubound=10 )
noAFit_M <- mxRun(noAModel_M,intervals=F)
noASumm_M <- summary(noAFit_M)
tableFitStatistics(univModACEFit,c(noAFit_M))
```

```
## Drop rA for education - Females
noAModel_F <- mxRename(univModACEFit, "noAModel_F")
noAModel_F$ACE.aF <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,T), values=0, name="aF", lbound=-10, ubound=10 )
noAFit_F <- mxRun(noAModel_F,intervals=F)
noASumm_F <- summary(noAFit_F)
tableFitStatistics(univModACEFit,c(noAFit_F))

# No A mod education - Males
noA1Model_M <- mxRename(univModACEFit, "noA1Model_M")
noA1Model_M$ACE.aIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="aIM1", lbound=-10, ubound=10 )
noA1Fit_M <- mxRun(noA1Model_M,intervals=F)
noA1Summ_M <- summary(noA1Fit_M)
tableFitStatistics(univModACEFit,c(noA1Fit_M))

# No A mod education - Females
noA1Model_F <- mxRename(univModACEFit, "noA1Model_F")
noA1Model_F$ACE.aIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="aIF1", lbound=-10, ubound=10 )
noA1Fit_F <- mxRun(noA1Model_F,intervals=F)
noA1Summ_F <- summary(noA1Fit_F)
tableFitStatistics(univModACEFit,c(noA1Fit_F))

# No A mod age - Males
noA2Model_M <- mxRename(univModACEFit, "noA2Model_M")
noA2Model_M$ACE.aIM2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,F), values=0, name="aIM2", lbound=-10, ubound=10 )
noA2Fit_M <- mxRun(noA2Model_M,intervals=F)
noA2Summ_M <- summary(noA2Fit_M)
tableFitStatistics(univModACEFit,c(noA2Fit_M))

# No A mod age - Females
noA2Model_F <- mxRename(univModACEFit, "noA2Model_F")
noA2Model_F$ACE.aIF2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,F), values=0, name="aIF2", lbound=-10, ubound=10 )
noA2Fit_F <- mxRun(noA2Model_F,intervals=F)
noA2Summ_F <- summary(noA2Fit_F)
tableFitStatistics(univModACEFit,c(noA2Fit_F))


######## C ########
## Drop rC for education
noCModel_M <- mxRename(univModACEFit, "noCModel_M")
noCModel_M$ACE.cM <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,T), values=0, name="cM", lbound=-10, ubound=10 )
noCFit_M <- mxRun(noCModel_M,intervals=F)
noCSumm_M <- summary(noCFit_M)
tableFitStatistics(univModACEFit,c(noCFit_M))
```

```
noCModel_F <- mxRename(univModACEFit, "noCModel_F")
noCModel_F$ACE.cF <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,T), values=0, name="cF", lbound=-10, ubound=10 )
noCFit_F <- mxRun(noCModel_F,intervals=F)
noCSumm_F <- summary(noCFit_F)
tableFitStatistics(univModACEFit,c(noCFit_F))

# No C mod education
noC1Model_M <- mxRename(univModACEFit, "noC1Model_M")
noC1Model_M$ACE.cIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="cIM1", lbound=-10, ubound=10 )
noC1Fit_M <- mxRun(noC1Model_M,intervals=F)
noC1Summ_M <- summary(noC1Fit_M)
tableFitStatistics(univModACEFit,c(noC1Fit_M))

noC1Model_F <- mxRename(univModACEFit, "noC1Model_F")
noC1Model_F$ACE.cIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="cIF1", lbound=-10, ubound=10 )
noC1Fit_F <- mxRun(noC1Model_F,intervals=F)
noC1Summ_F <- summary(noC1Fit_F)
tableFitStatistics(univModACEFit,c(noC1Fit_F))


# No C mod age
noC2Model_M <- mxRename(univModACEFit, "noC2Model_M")
noC2Model_M$ACE.cIM2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,F), values=0, name="cIM2", lbound=-10, ubound=10 )
noC2Fit_M <- mxRun(noC2Model_M,intervals=F)
noC2Summ_M <- summary(noC2Fit_M)
tableFitStatistics(univModACEFit,c(noC2Fit_M))

noC2Model_F <- mxRename(univModACEFit, "noC2Model_F")
noC2Model_F$ACE.cIF2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,F), values=0, name="cIF2", lbound=-10, ubound=10 )
noC2Fit_F <- mxRun(noC2Model_F,intervals=F)
noC2Summ_F <- summary(noC2Fit_F)
tableFitStatistics(univModACEFit,c(noC2Fit_F))


## Drop rE for education
noEModel_M <- mxRename(univModACEFit, "noEModel_M")
noEModel_M$ACE.eM <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,T), values=0, name="eM", lbound=-10, ubound=10 )
noEFit_M <- mxRun(noEModel_M,intervals=F)
noESumm_M <- summary(noEFit_M)
tableFitStatistics(univModACEFit,c(noEFit_M))

noEModel_F <- mxRename(univModACEFit, "noEModel_F")
noEModel_F$ACE.eF <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
```

```
free=c(T,F,T), values=0, name="eF", lbound=-10, ubound=10 )
noEFit_F <- mxRun(noEModel_F,intervals=F)
noESumm_F <- summary(noEFit_F)
tableFitStatistics(univModACEFit,c(noEFit_F))

# No E mod education
noE1Model_M <- mxRename(univModACEFit, "noE1Model_M")
noE1Model_M$ACE.eIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="eIM1", lbound=-10, ubound=10 )
noE1Fit_M <- mxRun(noE1Model_M,intervals=F)
noE1Summ_M <- summary(noE1Fit_M)
tableFitStatistics(univModACEFit,c(noE1Fit_M))

noE1Model_F <- mxRename(univModACEFit, "noE1Model_F")
noE1Model_F$ACE.eIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="eIF1", lbound=-10, ubound=10 )
noE1Fit_F <- mxRun(noE1Model_F,intervals=F)
noE1Summ_F <- summary(noE1Fit_F)
tableFitStatistics(univModACEFit,c(noE1Fit_F))


# No E mod age
noE2Model_M <- mxRename(univModACEFit, "noE2Model_M")
noE2Model_M$ACE.eIM2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,F), values=0, name="eIM2", lbound=-10, ubound=10 )
noE2Fit_M <- mxRun(noE2Model_M,intervals=F)
noE2Summ_M <- summary(noE2Fit_M)
tableFitStatistics(univModACEFit,c(noE2Fit_M))

noE2Model_F <- mxRename(univModACEFit, "noE2Model_F")
noE2Model_F$ACE.eIF2 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(T,F,F), values=0, name="eIF2", lbound=-10, ubound=10 )
noE2Fit_F <- mxRun(noE2Model_F,intervals=F)
noE2Summ_F <- summary(noE2Fit_F)
tableFitStatistics(univModACEFit,c(noE2Fit_F))


tableFitStatistics(univModACEFit,c(noAFit_F,  noAFit_M,  noCFit_F,
noCFit_M,  noEFit_F,  noEFit_M,
                                   noA1Fit_F, noA1Fit_M, noC1Fit_F,
noC1Fit_M, noE1Fit_F, noE1Fit_M,
                                   noA2Fit_F, noA2Fit_M, noC2Fit_F,
noC2Fit_M, noE2Fit_F, noE2Fit_M))



## Drop moderation effects on both M and F together - Education
Educ_noAModel_MF <- mxRename(univModACEFit, "Educ_noAModel_MF")
Educ_noAModel_MF$ACE.aIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="aIM1", lbound=-10, ubound=10 )
```

```
Educ_noAModel_MF$ACE.aIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="aIF1", lbound=-10, ubound=10 )
Educ_noAFit_MF <- mxRun(Educ_noAModel_MF,intervals=F)
Educ_noASumm_MF <- summary(Educ_noAFit_MF)
tableFitStatistics(univModACEFit,c(Educ_noAFit_MF))

Educ_noCModel_MF <- mxRename(univModACEFit, "Educ_noCModel_MF")
Educ_noCModel_MF$ACE.cIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="cIM1", lbound=-10, ubound=10 )
Educ_noCModel_MF$ACE.cIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="cIF1", lbound=-10, ubound=10 )
Educ_noCFit_MF <- mxRun(Educ_noCModel_MF,intervals=F)
Educ_noCSumm_MF <- summary(Educ_noCFit_MF)
tableFitStatistics(univModACEFit,c(Educ_noCFit_MF))

Educ_noEModel_MF <- mxRename(univModACEFit, "Educ_noEModel_MF")
Educ_noEModel_MF$ACE.eIM1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="eIM1", lbound=-10, ubound=10 )
Educ_noEModel_MF$ACE.eIF1 <- mxMatrix( type="Lower", nrow=nv, ncol=nv,
free=c(F,F,F), values=0, name="eIF1", lbound=-10, ubound=10 )
Educ_noEFit_MF <- mxRun(Educ_noEModel_MF,intervals=F)
Educ_noESumm_MF <- summary(Educ_noEFit_MF)
tableFitStatistics(univModACEFit,c(Educ_noEFit_MF))

## Drop moderation effects on both M and F together - Age
# Note: Ignore the word "young". Some versions of this script had
separate effects for younger and older (regression spline)
Age_young_noAModel_MF <- mxRename(univModACEFit,
"Age_young_noAModel_MF")
Age_young_noAModel_MF$ACE.aIM2 <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=c(T,F,F), values=0, name="aIM2", lbound=-10, ubound=10 )
Age_young_noAModel_MF$ACE.aIF2 <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=c(T,F,F), values=0, name="aIF2", lbound=-10, ubound=10 )
Age_young_noAFit_MF <- mxRun(Age_young_noAModel_MF,intervals=F)
Age_young_noASumm_MF <- summary(Age_young_noAFit_MF)
tableFitStatistics(univModACEFit,c(Age_young_noAFit_MF))

Age_young_noCModel_MF <- mxRename(univModACEFit,
"Age_young_noCModel_MF")
Age_young_noCModel_MF$ACE.cIM2 <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=c(T,F,F), values=0, name="cIM2", lbound=-10, ubound=10 )
Age_young_noCModel_MF$ACE.cIF2 <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=c(T,F,F), values=0, name="cIF2", lbound=-10, ubound=10 )
Age_young_noCFit_MF <- mxRun(Age_young_noCModel_MF,intervals=F)
Age_young_noCSumm_MF <- summary(Age_young_noCFit_MF)
tableFitStatistics(univModACEFit,c(Age_young_noCFit_MF))

Age_young_noEModel_MF <- mxRename(univModACEFit,
"Age_young_noEModel_MF")
Age_young_noEModel_MF$ACE.eIM2 <- mxMatrix( type="Lower", nrow=nv,
```

```
ncol=nv, free=c(T,F,F), values=0, name="eIM2", lbound=-10, ubound=10 )
Age_young_noEModel_MF$ACE.eIF2 <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=c(T,F,F), values=0, name="eIF2", lbound=-10, ubound=10 )
Age_young_noEFit_MF <- mxRun(Age_young_noEModel_MF,intervals=F)
Age_young_noESumm_MF <- summary(Age_young_noEFit_MF)
tableFitStatistics(univModACEFit,c(Age_young_noEFit_MF))


tableFitStatistics(univModACEFit,c(Educ_noAFit_MF,
Educ_noCFit_MF,      Educ_noEFit_MF,
                                  Age_young_noAFit_MF,
Age_young_noCFit_MF, Age_young_noEFit_MF))



## Collapse A effects across sex
## Similar to the first set of submodels but this time drops only part
of the matrix at a time
collapseMF_Aonly_sex_11 <- mxRename(univModACEFit,
"collapseMF_Aonly_sex_11")
collapseMF_Aonly_sex_11$ACE.aM <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=2, name="aM" ,
label=c("a11","a12M","a22M"), lbound=-20, ubound=20 )
collapseMF_Aonly_sex_11$ACE.aF <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=2, name="aF" ,
label=c("a11","a12F","a22F"), lbound=-20, ubound=20 )
collapseMF_Aonly_sex_Fit_11 <-
mxRun(collapseMF_Aonly_sex_11,intervals=F)
#collapseMF_Aonly_sex_Fit_11 <-
mxTryHard(collapseMF_Aonly_sex_11,intervals=F)
noASumm <- summary(collapseMF_Aonly_sex_Fit_11)
tableFitStatistics(univModACEFit,c(collapseMF_Aonly_sex_Fit_11))

collapseMF_Aonly_sex_12 <- mxRename(univModACEFit,
"collapseMF_Aonly_sex_12")
collapseMF_Aonly_sex_12$ACE.aM <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=2, name="aM" ,
label=c("a11M","a12","a22M"), lbound=-20, ubound=20 )
collapseMF_Aonly_sex_12$ACE.aF <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=2, name="aF" ,
label=c("a11F","a12","a22F"), lbound=-20, ubound=20 )
collapseMF_Aonly_sex_Fit_12 <-
mxRun(collapseMF_Aonly_sex_12,intervals=F)
#collapseMF_Aonly_sex_Fit_12 <-
mxTryHard(collapseMF_Aonly_sex_12,intervals=F)
noASumm <- summary(collapseMF_Aonly_sex_Fit_12)
tableFitStatistics(univModACEFit,c(collapseMF_Aonly_sex_Fit_12))

collapseMF_Aonly_sex_22 <- mxRename(univModACEFit,
"collapseMF_Aonly_sex_22")
```

```
collapseMF_Aonly_sex_22$ACE.aM <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=2, name="aM" ,
label=c("a11M","a12M","a22"), lbound=-20, ubound=20 )
collapseMF_Aonly_sex_22$ACE.aF <- mxMatrix( type="Lower", nrow=nv,
ncol=nv, free=TRUE, values=2, name="aF" ,
label=c("a11F","a12F","a22"), lbound=-20, ubound=20 )
collapseMF_Aonly_sex_Fit_22 <-
mxRun(collapseMF_Aonly_sex_22,intervals=F)
#collapseMF_Aonly_sex_Fit_22 <-
mxTryHard(collapseMF_Aonly_sex,intervals=F)
noASumm <- summary(collapseMF_Aonly_sex_Fit_22)
tableFitStatistics(univModACEFit,c(collapseMF_Aonly_sex_Fit_22))


########################################
######        Plots       ##############
########################################
source("univmodplots_education.R") #put in working directory
univmodplots(univModACEFit, univModACESumm)
univModACESumm


source("univmodplots_Age_Linear.R") #put in working directory
univmodplots(univModACEFit, univModACESumm)
univModACESumm
```