**Mediation Analyses (SAS)**

if group='DBT' then DBT=**1**;

else if group='TAU' then DBT=**0**;

age = (date\_randomised - ddf\_2b\_1)/**365.25**;

\*Interpersonal functioning composite;

interpersonal\_func\_B = mean(iip\_total\_B\_Z, ssq\_SATIS\_B\_Z);

interpersonal\_func\_3M = mean(iip\_total\_3M\_Z, ssq\_SATIS\_3M\_Z);

interpersonal\_func\_7M = mean(iip\_total\_7M\_Z, ssq\_SATIS\_7M\_Z);

interpersonal\_func\_12M = mean(iip\_total\_12M\_Z, ssq\_SATIS\_12M\_Z);

interpersonal\_func\_18M = mean(iip\_total\_18M\_Z, ssq\_SATIS\_18M\_Z);

\*Psychological flexibility;

psychological\_flex\_B = aaq2\_total\_B;

psychological\_flex\_3M = aaq2\_total\_3M;

psychological\_flex\_7M = aaq2\_total\_7M;

psychological\_flex\_12M = aaq2\_total\_12M;

psychological\_flex\_18M = aaq2\_total\_18M;

\*Regressions to get residuals;

**proc** **glm**; model interpersonal\_func\_3M = interpersonal\_func\_B;

output out=int\_fun\_Bto3M r=interpersonal\_func\_Bto3M\_resid; **run**;

**proc** **glm**; model interpersonal\_func\_7M = interpersonal\_func\_B;

output out=int\_fun\_Bto7M r=interpersonal\_func\_Bto7M\_resid; **run**;

**proc** **glm**; model interpersonal\_func\_12M = interpersonal\_func\_B;

output out=int\_fun\_Bto12M r=interpersonal\_func\_Bto12M\_resid; **run**;

**proc** **glm**; model aaq2\_total\_3M = aaq2\_total\_B;

output out=psy\_flex\_Bto3M r=psychological\_flex\_Bto3M\_resid; r**un**;

**proc** **glm**; model aaq2\_total\_7M = aaq2\_total\_B;

output out=psy\_flex\_Bto7M r=psychological\_flex\_Bto7M\_resid; **run**;

**proc** **glm**; model aaq2\_total\_12M = aaq2\_total\_B;

output out=psy\_flex\_Bto12M r=psychological\_flex\_Bto12M\_resid; **run**;

\*Merge datasets;

**data** Gilbert\_Codd\_dataset; merge Gilbert\_Codd\_dataset int\_fun\_Bto3M int\_fun\_Bto7M int\_fun\_Bto12M

psy\_flex\_Bto3M psy\_flex\_Bto7M psy\_flex\_Bto12M; by participant\_\_id;

**Mediation Analyses using Multiple Imputation and Bootstrap (SAS)**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*\*\* Mediation Analysis with Missing Data through Multiple Imputation and Bootstrap \*\*\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*\*\* Zhang Z., Wang L., Tong X. (2015) Mediation Analysis with Missing Data Through \*\*\*

\*\*\* Multiple Imputation and Bootstrap. In: van der Ark L., Bolt D., Wang WC., \*\*\*

\*\*\* Douglas J., Chow SM. (eds) Quantitative Psychology Research. Springer \*\*\*

\*\*\* Proceedings in Mathematics & Statistics, vol 140. Springer, Cham. \*\*\*

\*\*\* https://doi.org/10.1007/978-3-319-19977-1\_24 \*\*\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*;

/\*Read data into sas\*/

**DATA** dset; set Gilbert\_Codd\_dataset;

\*\*\* In code below, use only 1 set of x, m, y, and a1 values at a time. Comment out the others. \*\*\*;

\*\*\* DBT vs. TAU group and 7-month depressive symptoms, mediated by 3-month interpersonal functioning and psychological flexibility residuals \*\*\*;

x=DBT; m=interpersonal\_func\_Bto3M\_resid; y=hd\_total\_7M; a1=hd\_total\_B;

x=DBT; m=psychological\_flex\_Bto3M\_resid; y=hd\_total\_7M; a1=hd\_total\_B;

\*\*\* DBT vs. TAU group and 12-month depressive symptoms, mediated by 7-month interpersonal functioning and psychological flexibility residuals \*\*\*;

x=DBT; m=interpersonal\_func\_Bto7M\_resid; y=hd\_total\_12M; a1=hd\_total\_B;

x=DBT; m=psychological\_flex\_Bto7M\_resid; y=hd\_total\_12M; a1=hd\_total\_B;

\*\*\* DBT vs. TAU group and 18-month depressive symptoms, mediated by 12-month interpersonal functioning and psychological flexibility residuals \*\*\*;

x=DBT; m=interpersonal\_func\_Bto12M\_resid; y=hd\_total\_18M; a1=hd\_total\_B;

x=DBT; m=psychological\_flex\_Bto12M\_resid; y=hd\_total\_18M; a1=hd\_total\_B;

**RUN**;

/\*\*\* Setup the global parameters \*\*\*/

/\*The parameters below should be changed accordingly\*/

%LET varname=x m y a1 /\*a2\*/;

%LET nimpute = 50; \*define the number of imputations K;

%LET nboot = 1000; \*define the number of bootstraps B;

%LET alpha = 0.95; \*define the confidence level;

%LET seed = 4865; \*random number seed;

/\*\*\* End of setup of global parameters \*\*\*/

/\*In general, there is no need to change the codes below\*/

/\*Use multiple imputation to obtain point estimates of the model parameters based on the original data set\*/

/\*Imputing the original data set multipe times\*/

**PROC** **MI** DATA=dset SEED=&seed NIMPUTE=&nimpute OUT=imputed NOPRINT;

VAR &varname;

**RUN**; **QUIT**;

/\*Estimating model parameters for each imputed data set\*/

**PROC** **REG** DATA=imputed OUTEST= est NOPRINT;

MODEL y = x m;

MODEL m = x;

BY \_Imputation\_;

**RUN**; **QUIT**;

/\*Collecting results from mutiple imputations\*/

**DATA** temp;

SET est;

id =INT((\_N\_-**.1**)/**2**)+**1**;

modelnum = MOD(\_N\_+**1**, **2**)+**1**;

**RUN**;

**DATA** temp1;

SET temp;

ARRAY int[**2**] iY iM;

ARRAY xpar[**2**] c a;

ARRAY mpar[**2**] b tmp1;

ARRAY sigma[**2**] sy sm;

RETAIN a b c iY iM sy sm;

BY id;

IF FIRST.id THEN DO I = **1** to **2**;

int[I] = **.**;

xpar[I] = **.**;

mpar[I]=**.**;

sigma[I]=**.**;

END;

int[modelnum] = intercept;

xpar[modelnum] = x;

mpar[modelnum] = m;

sigma[modelnum] = \_RMSE\_;

IF LAST.id THEN OUTPUT;

KEEP \_imputation\_ a b c iY iM sy sm;

**RUN**;

/\*Calcuating mediation effects\*/

**DATA** temp2;

SET temp1;

ab=a\*b;

**RUN**;

/\*Saving the point estimates of model parameters and mediation effect from multiple imputation into a data set named 'pointest'\*/

**PROC** **MEANS** DATA=temp2 NOPRINT;

VAR a b c ab iY iM sy sm;

OUTPUT OUT=pointest MEAN(a b c ab iY iM sy sm)=a b c ab iY iM sy sm;

**RUN**;

/\*\*\* Bootstraping data to obtain standard errors and confidence intervals \*\*\*/

**DATA** bootsamp;

DO sampnum = **1** to &nboot;

DO i = **1** TO nobs;

ran = ROUND(RANUNI(&seed) \* nobs);

SET dset

nobs = nobs

point = ran;

OUTPUT;

END;

END;

STOP;

**RUN**; **QUIT**;

/\*\*\* Imputing K data sets for each bootstrap sample \*\*\*/

**PROC** **MI** DATA=bootsamp SEED=&seed NIMPUTE=&nimpute OUT=imputed NOPRINT;

EM MAXITER = **500**;

VAR &varname;

BY sampnum;

**RUN**; **QUIT**;

/\*Estimate model parameters for each imputed data set (in total, there are B\*K imputed data sets.)\*/

**PROC** **REG** DATA=imputed OUTEST= est NOPRINT;

MODEL y = x m;

MODEL m = x;

BY sampnum \_Imputation\_;

**RUN**; **QUIT**;

/\*Collecting results from different imputed data sets\*/

**DATA** temp;

SET est;

id =INT((\_N\_-**.1**)/**2**)+**1**;

modelnum = MOD(\_N\_+**1**, **2**)+**1**;

**RUN**;

**DATA** temp1;

SET temp;

ARRAY int[**2**] iY iM;

ARRAY xpar[**2**] c a;

ARRAY mpar[**2**] b tmp1;

ARRAY sigma[**2**] sy sm;

RETAIN a b c iY iM sy sm;

BY id;

IF FIRST.id THEN DO I = **1** to **2**;

int[I] = **.**;

xpar[I] = **.**;

mpar[I]=**.**;

sigma[I]=**.**;

END;

int[modelnum] = intercept;

xpar[modelnum] = x;

mpar[modelnum] = m;

sigma[modelnum] = \_RMSE\_;

IF LAST.id THEN OUTPUT;

KEEP sampnum \_imputation\_ a b c iY iM sy sm;

**RUN**;

**DATA** temp2;

SET temp1;

ab=a\*b;

**RUN**;

/\*Compute point estimates of model parameters and mediation effect for each bootstrap sample and the results are saved in the data file named 'bootest'. \*/

**PROC** **MEANS** DATA=temp2 NOPRINT;

BY sampnum;

VAR a b c ab iY iM sy sm;

OUTPUT OUT=bootest MEAN(a b c ab iY iM sy sm)=a b c ab iY iM sy sm;

**RUN**;

/\*\*\* Calculate the BC intervals based on the point estimates from different bootstrap samples and produce a table containing the points estimates, standard errors, confidence intervals in the output window.\*\*\*/

**PROC** **IML**;

START main;

USE pointest;

READ ALL INTO Y;

USE bootest;

READ ALL INTO X;

n=NROW(X);

m=NCOL(X);

bc\_lo=J(**1**,m-**3**,**0**);

bc\_up=J(**1**,m-**3**,**0**);

se=J(**1**,m-**3**,**0**);

alphas=**1**-(**1**-&alpha)/**2**;

zcrit = PROBIT(alphas);

DO j=**1** TO m-**3**;

se[j]=SQRT((SSQ(X[,j+**3**]) -(SUM(X[,j+**3**]))\*\***2**/n)/(n-**1**));

number=**0**;

DO i=**1** TO n;

IF X[i,j+**3**]<Y[j+**2**] THEN number=number+**1**;

END;

p=number/n;

z0hat=PROBIT(p);

q1=z0hat+(z0hat-zcrit);

q2=z0hat+(z0hat+zcrit);

alpha1=PROBNORM(q1);

alpha2=PROBNORM(q2);

vec=X[,j+**3**];

CALL SORT(vec,{**1**});

low=int(alpha1\*(n+**1**));

up=int(alpha2\*(n+**1**));

IF low<**1** THEN low=**1**;

IF up>n THEN up=n;

bc\_lo[j]=vec[low];

bc\_up[j]=vec[up];

END;

result=Y[**3**:**10**]||se`||(bc\_lo`)||(bc\_up`);

MATTRIB result ROWNAME=({a, b, c, ab, iy, im, sy, sm})

COLNAME=({estiamtes se CI\_lo CI\_up})

LABEL='MEDIATION ANALYSIS RESULTS' FORMAT=f10.5;

PRINT result;

FINISH;

**RUN** main;

**QUIT**;

**Latent Growth Curve Modeling (R)**

#Load Package

library(lavaan)

library(parameters)

############################

#Univariate Growth Curves

############################

############################

#Interpersonal Functioning

############################

modelIF <- ' i =~ 1\*interpersonal\_func\_B + 1\*interpersonal\_func\_7M + 1\*interpersonal\_func\_12M + 1\*interpersonal\_func\_18M

s =~ 0\*interpersonal\_func\_B + 7\*interpersonal\_func\_7M + 12\*interpersonal\_func\_12M + 18\*interpersonal\_func\_18M'

#Treatment

fit <- growth(modelIF, data=roDBTTreatment, missing = "fiml")

summary(fit, fit.measures=TRUE)

parameterEstimates(fit)

#TAU

fit <- growth(modelIF, data=roDBTTau, missing = "fiml")

summary(fit, fit.measures=TRUE)

parameterEstimates(fit)

############################

#AAQ

############################

modelAAQ <- ' i =~ 1\*aaq2\_total\_B + 1\*aaq2\_total\_7M + 1\*aaq2\_total\_12M + 1\*aaq2\_total\_18M

s =~ 0\*aaq2\_total\_B + 7\*aaq2\_total\_7M + 12\*aaq2\_total\_12M + 18\*aaq2\_total\_18M'

#Treatment

fit <- growth(modelAAQ, data=roDBTTreatment, missing = "fiml")

summary(fit, fit.measures=TRUE)

#TAU

fit <- growth(modelAAQ, data=roDBTTau, missing = "fiml")

summary(fit, fit.measures=TRUE)

modelAAQ <- ' i =~ 1\*aaq2\_total\_B + 1\*aaq2\_total\_7M + 1\*aaq2\_total\_12M + 1\*aaq2\_total\_18M'

fit <- growth(modelAAQ, data=roDBTTau, missing = "fiml")

summary(fit, fit.measures=TRUE)

############################

#HAM-D

############################

modelHAMD <- ' i =~ 1\*hd\_total\_B + 1\*hd\_total\_7M + 1\*hd\_total\_12M + 1\*hd\_total\_18M

s =~ 0\*hd\_total\_B + 7\*hd\_total\_7M + 12\*hd\_total\_12M + 18\*hd\_total\_18M'

fit <- growth(modelHAMD, data=roDBTTreatment, missing = "fiml")

summary(fit, fit.measures=TRUE)

fit <- growth(modelHAMD, data=roDBTTau, missing = "fiml")

summary(fit, fit.measures=TRUE)

############################

#Cross-Domain Growth Curves

############################

############################

#Interpersonal functioning to depression (all time points)

############################

modelIFDep <- ' i =~ 1\*interpersonal\_func\_B + 1\*interpersonal\_func\_7M + 1\*interpersonal\_func\_12M + 1\*interpersonal\_func\_18M

i1 =~ 1\*hd\_total\_B + 1\*hd\_total\_7M + 1\*hd\_total\_12M + 1\*hd\_total\_18M

s =~ 0\*interpersonal\_func\_B + 7\*interpersonal\_func\_7M + 12\*interpersonal\_func\_12M + 18\*interpersonal\_func\_18M

s1 =~ 0\*hd\_total\_B + 7\*hd\_total\_7M + 12\*hd\_total\_12M + 18\*hd\_total\_18M

i1 ~~ i

s ~ i1

s1 ~ i

s1 ~~ s'

fit <- growth(modelIFDep, data=roDBTTreatment, missing = "fiml")

summary(fit, fit.measures=TRUE)

parameterEstimates(fit)

fit <- growth(modelIFDep, data=roDBTTau, missing = "fiml")

summary(fit, fit.measures=TRUE)

parameterEstimates(fit)

############################

#Psychological flexibility to depression (four time points)

############################

modelFlexDepFull <- ' i =~ 1\*aaq2\_total\_B + 1\*aaq2\_total\_7M + 1\*aaq2\_total\_12M + 1\*aaq2\_total\_18M

i1 =~ 1\*hd\_total\_B + 1\*hd\_total\_7M + 1\*hd\_total\_12M + 1\*hd\_total\_18M

s =~ 0\*aaq2\_total\_B + 7\*aaq2\_total\_7M + 12\*aaq2\_total\_12M + 18\*aaq2\_total\_18M

s1 =~ 0\*hd\_total\_B + 7\*hd\_total\_7M + 12\*hd\_total\_12M + 18\*hd\_total\_18M

s ~ i1

s1 ~ i'

fit <- growth(modelFlexDepFull, data=roDBTTreatment, missing = "fiml")

summary(fit, fit.measures=TRUE)

parameterEstimates(fit)

standardizedSolution(fit)

standardizedSolution(fit, type = "std.all",output="text")

fit <- growth(modelFlexDepFull, data=roDBTTau, missing = "fiml")

summary(fit, fit.measures=TRUE)

parameterEstimates(fit)

standardizedSolution(fit, type = "std.all",output="text")